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Developing a Toolkit for Disability Inclusion in Sportswear Design Practice: *Focusing on Consumers with an Upper Limb Impairment or Difference*

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Abstract

This research investigates how sportswear industry designers can better understand consumers with an upper limb impairment or difference to create adaptive or inclusive sportswear. Recently, an increase of inclusive and adaptive apparel has appeared on the market, but many disabled consumers remain underserved. Although the Paralympics have increased in popularity and more companies are embracing disability inclusion, adaptive and inclusive sportswear remains limited. Consistent exclusion can have a negative psychological influence akin to facing repeated rejection, and barriers to participation in sport can impact well-being. Yet there remains a gap in research on design practice for adaptive or inclusive sportswear on an industry level. The aim of this study is to develop pragmatic guidance for industry designers to consider sportswear inclusion of people with an upper limb impairment or difference. Applying the social model of disability, barriers of sportswear exclusion were examined on industry, social, and garment levels. A literature review was conducted on functional and adaptive apparel design, apparel industry practice, and inclusive design. Within a participatory design approach, primary research entailed iterative stakeholder engagement. Individuals with an upper limb impairment or difference (users), sportswear designers, and a biomechanics researcher were interviewed about perspectives on adaptive sportswear design. User workshops were conducted to ideate challenges, needs, and solutions for mainstream sportswear inclusion. Findings were thematically mapped and validated with stakeholders. A desire for greater inclusion and representation existed with both users and industry, but a disconnect remained in how and where to begin designing with this consumer community. Thus, the final output is a toolkit to guide sportswear designers in better understanding and collaborating with this consumer group for more relevant product offerings. Broader implications include application of this framework and toolkit to facilitate design inclusion of other marginalised groups in apparel industry, fashion design education, or design research.

Key words: sportswear, disability, participatory design, inclusive design, adaptive apparel

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Glossary

Adaptive Apparel – The term adaptive apparel is used within the apparel industry, media, and academic writing to refer to clothing or accessories that have been designed to meet needs specific to certain disabled consumers. Often, these needs are met through garment fit, construction, or function that is different than previous mainstream apparel offerings. An example would be trousers that have a lower front rise and higher back rise to fit a seated posture -- more suitable for wheelchair users.

Biomechanics – This is a field of study that concerns the effect of forces in and on the body, in terms of movement and structure. Sports biomechanics focuses on how the body moves during sport. Biomechanics is one of the systems considered in *ergonomics*, which is the study of human factors and interactions with internal and external environments. Both biomechanics and ergonomics knowledge is required for high performance sportswear design.

Co-design (or co-creation) – Co-design refers to bringing users directly into design sessions. With appropriate design tools and collaborative methods, users (or research participants) are able to generate design ideas or outputs relevant to their point-of-view.

Functional Apparel – Functional apparel refers to clothing or accessories that are built-for-purpose. The main goal for these items is to meet the functional needs and context of the user; they are based on extensive user research and testing. At times, they might also be fashionable (i.e. follow trends or be expressive of social values) depending on the producer, like popular sportswear brands. Other examples of functional apparel are adaptive apparel, military attire, or work-related uniforms.

ICF – This is an acronym for the World Health Organisation's (WHO) International Classification of Functioning, Disability and Health. The ICF is a framework used by WHO and its member states to measure and document health and disability. The *bio-psycho-social model*, from the ICF, states that health and disability are related to a combination of medical, socio-environmental, and psychological factors.

Ideation – Ideation is a creative brainstorming process to generate and explore conceptual new ideas and solutions within design practice. This generally takes place after a project brief and could involve methods, like trend research, visualisation activities, or customer journey mapping.

Inclusive (or universal design) – Inclusive design, sometimes called universal design, is a practice for designing products, services, or spaces that can be used by a wider scope of people by incorporating needs of previously marginalised users. Nike, for instance, designed a shoe that can be donned and doffed hands-free (the Go FlyEase) that was marketed as universal design – a shoe for "anyone".

Mass customisation – Within the apparel industry, mass customisation refers to methods for mass manufacturing that allow consumers some level of individual customisation. This could be, for instance, offering one style of shoe with a choice of colours and materials for the laces, sole, or brand logo to create a personalised aesthetic.

Medical model – Within the medical model of disability, disability is defined by clinical diagnosis, and a focus is placed on curing or treating the individual.

Participatory design – Participatory design is a framework and set of methods for designing or researching *with* participants to achieve results that are relevant and meaningful to their lives. It prioritises the active voices and direct contributions of users, community members, or research subjects who will be impacted by a project output.

Social model – The social model of disability is a framework that describes disablement as a result of restrictive social constructs and environments. For instance, someone might be disabled by discriminatory views or inaccessible design that limit access or participation. In this sense, disability is different from *impairment*, which refers to how the mind or body functions.

Sportswear – Within this text, sportswear broadly refers to garments or clothing that are designed for any sporting or fitness activity (e.g. cycling, weight training, or yoga).

Stakeholders – Within design practice, stakeholders are the people with an interest in a particular output. Examples of stakeholders, in this study, are sportswear designers, biomechanics researchers, and the users. (See definition for users).

Upper limb – For this dissertation, upper limb refers to the hand, arm, or shoulder.

Users – This is a common term, within design practice, for the group of people who will use a particular output. When dealing with apparel design research, the terms *wearers* or *participants* serve a similar purpose. *Consumers* is used when discussing end-users, or customers, for apparel industry design and manufacturing.

User-centred design (UCD) – UCD is a practice and set of methods for designing and researching *for* users (rather than *with* users, as is in participatory design). For UCD projects, designers or engineers focus on a specific need, set of needs, or use of a product or service from the point-of-view of the determined users. Extensive user research and testing is done to ensure context and end-of-use requirements are met.

Wearables (or wearable products) – Wearables are items that are worn on, around, or in the body. This can range from fashion and accessories to functional apparel to medical devices.

Wearable technology – Wearables with embedded smart textiles, health and fitness monitoring, or other technological functioning are wearable technology. This may include Apple smartwatches or clothing with built-in sensors.

Chapter 1: Introduction

Although perspectives on disability and clothing design have shifted throughout the decades towards greater equality and inclusion, much apparel exclusion still remains (Lamb, 2001; Carroll, 2010b). This is particularly true in the mainstream apparel industry and, perhaps, even more so in the mainstream sportswear industry. Scholarly research on apparel availability, needs, and wants of disabled consumers has increased in the mid - 2010s onwards. But many knowledge gaps remain in various areas of disability, sectors of the apparel industry, and guidance for mainstream industry design practice. This thesis, in particular, explores the causes of exclusion and investigates solutions for mainstream sportswear design practice for disability inclusion, specifically for individuals with an upper limb impairment or difference. Broader implications for apparel design and disability inclusion research will also be discussed. Terminology used in this study follows UK-focused inclusive language guidelines and disability studies perspectives (Goodley, 2017; Shakespeare, 2018; Disability Unit, 2021).

To begin, this introductory chapter delineates the multidisciplinary scope of this research, which spans disability studies, adaptive apparel, and design research. First, disability is defined from multiple perspectives: in relation to clothing, from a clinical point-of-view, and within a socially constructed context. Disability sport, relevant apparel industry terminology, and the adaptive apparel market are explained. After illuminating a gap in a daptive and inclusive sportswear design research and industry knowledge, the pragmatic design research framework is clarified. Finally, this chapter concludes with the research questions, aims, and objectives that guide this dissertation.

1.1 Disability and Apparel Exclusion

Twigg (2013) states that “clothes lie at the interface between the body and its social presentation, one of the ways whereby bodies are made social, given identity and meaning…” (p. 96). But what if the clothing available does not ac curately reflect an individual’s identity, let alone their needs and values? In partnership with disability rights organisation Leonard Cheshire (2019), online community magazine Disability Horizons surveyed people in the UK with a disability, or long-term health condition, about their views on mainstream fashion. Of the 206 respondents, 75% felt that their needs were not being met by mainstream fashion in the UK. Certain aspects, according to respondents, that make mainstream clothing inaccessible include seams, buttons, and zippers that are uncomfortable or cumbersome and sizes that do not have an appropriate fit. While specialist

adaptive apparel brands do exist, only 11% of respondents indicated buying from them. Respondents reported that these retailers were significantly more expensive and less trendy than mainstream brands. It was mentioned that the offerings appeared old fashioned and primarily aimed at young children or older consumers. 96% believed that there was not enough representation of disabled people in the fashion industry .

Foster (2021) writes that while disability has long been neglected from the fashion industry, some efforts towards inclusion are apparent. He found that in 2018 and 2019 the fashion content of *Teen Vogue* published many editorials on the importance of disability representation and disability rights. The magazine also showcased profiles of individuals related to disability, and often the editorials were done by disabled individuals for insider perspectives. Still, he notes, representation of disability remains short -lived or neglected in many areas of fashion. Writing on the impact, he states:

> *The underrepresentation and erasure of people with a disability carry significant implications for the reproduction and maintenance of inequality. Specifically, their erasure and underrepresentation further stigmatize people with a disability while blinding everyday consumers to the cultural, political, and economic realities that the disability community continues to face.* (p. 13)

Representation within the apparel industry can take many forms. This can include who is visible within modelling campaigns or in fashion media (Foster, 2021). It can also relate to who is reflected in the product offerings, who is considered a mainstream consumer, and whose voices are incorporated into the design process. This thesis focuses on the latter – how disabled consumers can (and should) be included within mainstream apparel design practice and product ranges. It also lo oks at where embedded disability exclusion may stem from and what barriers exist for mainstream inclusion.

According to Sport England (no date), one in five people in England have a long -standing illness or disability described as limiting. The UK Departm ent of Work and Pensions reported that 14.1 million people in the UK – 22% of the population – indicated they were living with a disability in 2019/20 (Department for Work & Pensions , 2021). These numbers are further broken down by impairment type of: mobility, stamina/breathing/fatigue, dexterity, mental health, memory, hearing, vision, learning, social/behavioural, and other. In 2020, 61 million adults in the US were living with a dis ability, according to the Centers for Disease Control and Prevention (CDC) (2020c). And worldwide, over 1 billion people – roughly 15% of us – experience disability (World Health Organisation , 2022).

So, there are potentially vast numbers of people who are underrepresented or excluded from the mainstream apparel industry. An area of apparel particularly lacking in offerings that include consumers living with a disability or long-term health condition is sportswear. Benefits of sports' participation are universal and can be applicable to us all (Carroll, 2010a). DePauw and Gavron (2005), however, write that while professional disabled athletes can often obtain corporate sponsorship for apparel and equipment, disabled people who want to practice sport for general fitness or social benefits are excluded from the market.

1.1.1 Defining Disability and the Body

Understandings of disability may depend on how we define, react to, and perceive it. Historically, disability partly consisted of social exclusion exacerbated by certain issues, such as lack of government assistance or discriminatory views. But there is a lack of historical documentation from the perspectives of disabled people. Older medical sources focus more on the clinical case rather than the person, themselves, or the context in which they lived (Carroll, 2010b).

Shakespeare (2018), a professor of disability research, writes that "most lives are touched by disability in some way" (p. 1) when you include extended networks of friends and family. And, he notes, "disability is an experience that can affect anyone" (p. 1) as any one of us can be injured or possibly become disabled as we age. Similarly, professor of disability studies Goodley (2017) states that everyone is touched by disability, and the World Health Organisation (2011) describes disability as a component of the human condition.

Most governing bodies and organisations define disability within specific parameters (Goodley, 2017). The CDC defines *disability* as a condition of the mind or body (*impairment*) that limits certain activities and restricts social participation (Centers for Disease Control and Prevention, 2020b). And according to the UK's 2010 Equality Act:

> *You're disabled… if you have a physical or mental impairment that has a 'substantial' and 'long-term' negative effect on your ability to do normal daily activities." For the purpose of this act, "'substantial' is more than minor or trivial, e.g. it takes much longer than it usually would to complete a daily task like getting dressed," and "'long-term' means 12 months or more, eg. a breathing condition that develops as a result of a lung infection.* (UK Government, no date, paras.1-3)

For this research, physical disability and mobility impairments are considered, so the following definition will apply.

According to Disabled World (2022), mobility impairment is:

> *A category of disability that includes people with varying types of physical disabilities. This type of disability includes upper or lower limb loss or disability, manual dexterity and disability in co-ordination with different organs of the body. Disability in mobility can either be a congenital or an acquired with age problem. This concern could also be the consequence of disease. People who have a broken skeletal structure also fall into this category of disability.* (para. 1)

How a body operates relates to the field of *biomechanics* -- the study of external and internal forces on living organisms and the physical effects of these forces on said organisms (Watkins, 2014). The study of biomechanics in relation to sport and exercise relates to:

> *The internal forces (muscle forces and the forces in bones and joints that result from transmission of the muscle forces through the skeleton), the external forces (e.g. the ground reaction force) that result from the internal forces, the effects of the internal forces on the size, shape and structure of the musculoskeletal components (structural adaptation) and the effects of the external forces on the movement of the body (biomechanics of movement) in sport and exercise.* (Watkins, 2014, p. 207)

Finally, functional design practice involves elements of *ergonomics* (or human factors):

> *The scientific discipline concerned with the understanding of interactions among humans and other elements of a system … Physical ergonomics is concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity.* (International Ergonomics Association, no date, paras.1-2)

Physical disability was chosen as a focus due to the researcher's background in sportswear technical design and construction, which considers body movement and physical functionality. A gap was perceived in apparel design research for individuals with an upper limb impairment or difference, so this area was chosen. Within this research scope, the upper limb includes the shoulder, arm, and hand. Research participants mainly included individuals with limb loss, a limb difference, muscle or nerve damage, dexterity restrictions, or paralysis.

Recognising such parameters is necessary when designing apparel that meets end-user requirements (Watkins and Dunne, 2015). But, clinical-focused problem solving within

disability research or design can exacerbate social stigmas and inhibit true inclusion (Pullin, 2009; Goodley, 2017). A more complex picture of disability, body diversity, and social context is needed.

1.1.2 A Disability Studies Perspective

Disability studies is a complex area of research with viewpoints that revolve around pathology, society, cultural values, and many other intricacies. As just described, general definitions and classifications of disability exist. But why might these generalisations be dangerous? Goodley (2017) writes that official definitions of disability stem from government needs to define population and from institutions for bureaucratic purposes. Shakespeare (2018) explains that "everyone is limited in some way, whether it's a minor blemish or an allergy or something more serious," (p. 5) and the array of disabilities that exist affect people on a spectrum of severity. Human perfection, he writes, does not exist.

Disability discrimination can come in the form of ableism or disablism, as indicated by the UK disability equality charity Scope (no date-b). They define *ableism* as "discrimination in favour of non-disabled people" and *disablism* as "discrimination or prejudice against disabled people" (paras. 2-3). Ableism is an ideology that promotes the perceived ideal of a "normative" individual and distinguishes this concept of perfected humanity from others who appear to deviate from it (Campbell, 2009). According to Berger and Lorenz (2015), ableism is an unconscious bias that is ingrained in society and that affects the lives of disabled people. Disablism, as described by Goodley *et al*. (2019) is "the exclusion of people with sensory, physical and cognitive impairments" (p. 986). In our current world, disablism is generated, and ableist beliefs are upheld, they postulate. "The societal omission of disability runs deep," states Holmes (2018) "[s]o deep that entire populations of people are virtually invisible in society" (p. 31).

There are multiple models for considering disability. Within the long-standing *medical model*, disability is attributed as a problem with the person, according to the World Health Organisation's International Classification of Functioning, Disability and Health (ICF). In this model, an adjustment of the individual, or a change to their behaviour, is understood as the "cure" to disability. Within the *social model*, however, the ICF describes disability as a socially created problem. People, thus, are disabled or excluded due to a variety of *barriers* constructed by society. Social action, as the collective responsibility of society at large, is identified as a means to eliminate disability. Disability, in this sense, is distinct from *impairment*, which references body function, structure, or underlying health factors (World Health Organisation, 2001; Shakespeare, 2018). The word impairment is reflected in

contemporary writing around disability, at times, to separate the social context from the individual. It may be, however, that a word with less of a clinical connotation could be more appropriate in challenging ableist dynamics.

According to Goodley (2017), with the social model "disabled people develop a counter-view that social, cultural, historical, economic, relational and political factors *dis*able people." Perhaps a more British approach, Goodley notes, the social model is applied in academic, activist, policy making, and political areas. Barriers that can challenge an individual's right to participation or daily functioning come from many factors. Attitudinal barriers – stereotypes or discrimination – are the most basic and lead to other barriers. Additional barriers might come from physical obstacles, like stairs-only access to a building, or from a misunderstanding or lack of policy enforcement, such as denying reasonable accommodations (Centers for Disease Control and Prevention, 2020a).

The ICF promotes an integration of both models to form a conceptual framework for viewing disability from a biological, individual, and social perspective – the *bio-psycho-social model*. The purpose of this bio-psycho-social model is to provide a more holistic view of disability and considers the interaction of our bodies, our personalities and experiences, and our society (World Health Organisation, 2001). Goodley (2017) suggests, however, that:

> *definitions such as the ICF are in danger of ignoring the culturally specific conditions on which impairment, disability and disablism are created. And disability studies devised in Anglo-Nordic/North American contexts may have limited value in the rest of the world.* (p. 20)

As this study focused on sportswear (and apparel) design mainly in the UK and US, the social model of disability provided the main lens for this research. This model was applied to look at removing barriers or challenges of sportswear exclusion through design practice. So, for instance, if a zipper requires two hands to close, how can this garment be redesigned for one-handed use? Also, barriers of social views or industry practices that exclude disabled consumers are considered.

Following the social model, as well as contemporary disabilities terminology in the UK, the term *disabled people* is used in this dissertation (Disability Unit, 2021). This phrasing refers to people's disablement by society, rather than considering disability as something possessed by the individual (Goodley, 2017). At times, sources referenced in the literature and practice review use the term *people (or person) with disabilities* (PWD,) which is often used in the US for its people-first language (McBee-Black, 2021; Paganelli, 2021).

Community engagement, in this study, refers to interactions with various stakeholder groups – designers, researchers, or users who can influence adaptive sportswear design. The *disability community* is used to collectively reference individuals who participate in disability-related groups, who contributed this research, or who may benefit from adaptive or inclusive sportswear. As MacQueen *et al*. (2001) note in their research on participatory public health, *community* may be "experienced differently by people with diverse backgrounds" (para. 3) – similar to the complexity of disability studies (Shakespeare, 2018). So, while *user, consumer,* or *disability communities* may be referred to, this is not to suggest homogenous groups. Rather, the terms are meant to delineate the scope encompassed within this research framework.

1.2 Disability Sport

Since the late 1800s, sport has been upheld as an essential method for keeping in good health, as well as being a recreational activity (Bielefeldt Bruun and Langkjær, 2016). Beginning as a sport for rehabilitation, athletics for disabled people eventually evolved into a sporting and competition culture. In the 1980s and 1990s, disabled athletes began to receive acclaim (DePauw and Gavron, 2005).

Sporting opportunities designed for disabled athletes range from elite-level Paralympic games to recreational community programs. At the Paralympics, the International Paralympic Committee recognises ten impairment categories. They have identified these as: "impaired muscle power, impaired passive range of movement, limb deficiency, leg-length difference, short stature, hypertonia, ataxia, athetosis, vision impairment, and intellectual impairment" (Carroll, 2010a, para. 2).

Some organisations promote community sport at a more recreational level and prioritise inclusion and social benefits. Activity Alliance (2022) in the UK, for instance, "pushes for inclusion to be at the heart of all plans in sport and activity and disabled people to be prioritised, locally and nationally" (para. 1). In team sports, Hall (2012) writes that an element of cooperation is introduced. Socialising off-pitch is common as well and extends to family members and other friends of team members, both with and without disability. Also:

> *The feeling of belonging, and more importantly of acceptance by others for who they are, is a key element of why team sport in particular is a valuable tool or resource for those involved in the rehabilitation of trauma victims…* (Hall, 2012, p. 28)

Hutzer and Bar-Eli (2007, cited in Hall, 2012) state that sport for disabled people boosts:

a. Performance accomplishments and functional efficiency
b. Perceived self-efficacy
c. Self-concept and self-esteem
d. Personality disorders, mood states and locus of control
e. Activity level and social acceptance

Barriers may still exist, however, for disabled people to take part in sport or social recreation. Advanced technologies are now available to aid and enhance disabled athletes, but these have such high costs that non-professional disabled athletes may have no access. And as mentioned, disabled people engaged in casual sport or fitness have been excluded from the apparel market (DePauw and Gavron, 2005).

Furthermore, media narratives that present a socially constructed distinction between non-disabled and disabled athletes can be observed in Olympic and Paralympic coverage, write Martínez-Bello *et al*. (2021). The authors state that misrepresentative media portrayals, as such, can perpetuate social inequalities. A further look into media coverage of disability and Paralympic athletes will be addressed in the next chapter, along with a review of adaptive apparel and sportswear design practice.

1.3 Apparel Industry and Inclusion Terminology

First, this section delineates the terms used throughout this thesis relating to sportswear and adaptive apparel. A focus on mainstream sportswear industry design was chosen to match the researcher's previous experience working as a technical apparel designer for a large, international sportswear company. Employment was US-based, hence the UK and US scope of this dissertation, which was undertaken in the UK. In this study, the main primary research focus was on mass market, consumer-level product.

The term *apparel*, in this thesis, refers to "clothes, esp. of a special type," which can include "sports apparel" (Cambridge Dictionary, 2022a). The term *sportswear* is used for sports apparel – clothing that is designed to support the body in sport, fitness, or training activities. This includes performance, athletic, sport-specific, or basic fitness apparel. Athleisure and lifestyle sportswear are excluded. Participants included in the research were involved in many types of sport and fitness, so the findings are not sport specific. Many garments types were discussed, including base-layers, bottoms, tops, and outerwear, and the results are non-gender specific.

The last three decades of the 20th century saw a sharp increase in sport and fitness engagement, leading to the expansion of sport-specific clothes (McCann, 2005). McCann asserts that sportswear design involves meeting users' needs through form and function. Sportswear designers are known for creating "aesthetically pleasing and ergonomically viable" collections (Shishoo, 2005, p. 5), where performance and comfort are valued. "Evolv[ing] at a faster pace than ready-to-wear" (Bramel, 2005, p. 25), this field has led to advances in functional fabrics and smart textiles (Shishoo, 2005). Offerings can provide protection, maintain body heat, and allow for moisture management (Shishoo, 2005). Innovation in the field includes body mapping, digital sensors for biometrics , heat sealed seams, laser cutting, hi-stretch fabrics, and moisture wicking (McCann, 2016). Performance enhancement and reduced fatigue can be achieved through targeted muscle compression in sportswear (Gupta, 2011a).

Referring to the companies designing, making, and selling apparel, *apparel industry*, or *sportswear industry*, are used. When discussing adaptive apparel or the industry, at large, c*lothing* is sometimes used in place of apparel, which can be distinguished from *fashion*. Loschek (2009) suggests that clothing becomes fashion when it goes beyond the intent of function and aesthetics. She writes:

> *Clothing, including accessories, are products which are realised by means of a design process. Which of the products are accepted and become fashion is determined by the society, a group within society or a single community… Fashion extends far beyond the objective aspect of the product, clothing.* (p. 134)

Sams and Black (2013) state that "fashion is about people's dreams and aspirations, about our sense of self" (p. 503). There is, accordingly, a strong connection between fashion, identity, and inclusion, which is further discussed in section 1.5. Sportswear can become fashion when reflecting social trends in fitness, widespread global adoption of a sporting aesthetic, or style of pop or sports icons (Loschek, 2009).

The term *mainstream* appears many times throughout this thesis. According to the Cambridge Dictionary (2022b), mainstream means "considered normal, and having or using ideas, beliefs, etc. that are accepted by most people" (para. 1). In business, mainstream is used to describe:

> *Companies which have wider presence in different markets, catering to a wide array of customers are mainstream companies. These companies' offerings are available*

> *to [the] masses. Microsoft, Pepsi, Unilever, Amazon are good example[s] of mainstream companies*. (Business Concepts Team, 2015, para. 2)

The focus of this research and output are mainstream sportswear companies (for example adidas, Nike, or New Balance) that have a wide market presence with an assortment of offerings. Inclusion of disabled consumers by mainstream brands is essential to removing barriers to choice, belonging, and representation for this community. As will be discussed, this could mean mainstream brands have adaptive sportswear collections, or they might incorporate inclusive design strategies.

Adaptive apparel is the frequent term used for clothing designed to address specific needs of disabled consumers, not often considered by mainstream apparel design (McBee-Black and Ha-Brookshire, 2020). Shaping the pattern of a pair of trousers specifically for a seated posture, such as for wheelchair users, is an example of this. The term *inclusive design*, on the contrary, is used for a product, service, or space that is designed to serve the widest possible audience (Eikhaug and Gheerawo, 2010, 2021). For example, a fabric loop attached to a zipper pull may work well for someone with arthritis in their fingers, and it can also be adopted by non-disabled consumers for its convenience. The distinction between adaptive and inclusive apparel is not always so simple, however, and terms vary greatly in marketing and in literature.

McBee-Black and Ha-Brookshire (2020) surveyed the terms adaptive, functional, universal design, and inclusive design within the marketplace and relevant literature. Through a content analysis, it was determined that the term adaptive was most often used on the market. According to the literature, however, this seemed to reflect a mostly medicalised view. “That is, most adaptive apparel in the marketplace was designed to help ease a specific disability or impairment” (McBee-Black and Ha-Brookshire, 2020, p. 174). As will be highlighted in the following section, many traditional adaptive apparel retailers do have a prominent functional, clinical perspective. But several newer SMEs offer fashionable, trendy adaptive apparel.

The term functional had little marketplace relevance for disabled consumers, conclude McBee-Black and Ha-Brookshire (2020). In the literature, it referred to practical, fit-for-purpose apparel. Finally, the authors found that the terms universal and inclusive design appeared frequently in the literature but almost never in the marketplace for this consumer group. These findings do reflect what was observed through this research, both currently on the market and in the up-to-date literature. Throughout this dissertation the terms adaptive and inclusive apparel, or sportswear, will be used to reference industry offerings -

- either for a specific disabled consumer base or for a widened audience that includes more disabled consumers. *Universal design* is used at times, when originating from a specific brand or author, with the same intent as inclusive design. *Functional apparel design*, as will be described in the next chapter, is applied as an umbrella term for sportswear, adaptive apparel, and other types of garment design that is fit-for-purpose (Watkins and Dunne, 2015).

The terms *disability inclusion* or *sportswear inclusion* will be used to indicate apparel readily available from mainstream brands for disabled consumers. In reference to the apparel industry, *disabled consumers* (similar to social model terminology), is often used to indicate an area of exclusion from the mainstream sportswear marketplace at the time of writing this thesis. A long-term goal may be that, eventually, mainstream sportswear design will encompass a more accurate reflection of our diverse society that a label distinguishing disabled and non-disabled consumers is not necessary. Such is a tenet of inclusive design (Engineering Design Centre, 2017). Other arguments, however, support such a distinction to ensure certain consumers are not further removed from the marketplace (Tesfaye, 2021; Virdi and Jackson, 2021). These points will be discussed further into this thesis.

1.4 The Adaptive Apparel and Sportswear Market

A market review of adaptive and inclusive apparel was conducted and continuously updated throughout this study. Several adaptive apparel SMEs and brand offerings were launched within the timespan of this research, which reflects an exciting period for innovative thinking around disability inclusion in apparel. The market review was narrowed to commercial ready-to-wear fashion, casual clothing, and sportswear. Purely clinical apparel or hygiene aids, like incontinence underwear, were excluded. Sources were:

- Google searches of key works, such as “adaptive apparel” and “clothing for disability”
- Blog/resource lists of adaptive apparel sellers
- News articles about emerging brands working on clothing for disabled consumers
- Brand recommendations or adverts on Instagram and LinkedIn
- Visit to Naidex (disability innovation trade show)
- Word-of-mouth

The results fall into three general categories:

1. Established adaptive apparel retailers
2. Mainstream brands offering newer adaptive apparel ranges
3. Emerging SMEs in the adaptive/inclusive apparel market

As of 2021, most adaptive apparel could only be purchased online (Esmail *et al*., 2022). Certain barriers to in-store shopping for disabled consumers are mentioned in the next chapter (section 2.1.1). Traditionally, adaptive clothing has been provided by mostly small companies, such as Buck and Buck or Silverts, which designs clothes for consumers with rheumatoid arthritis, stroke survivors, or wheelchair users (Friedman, 2016). In line with the findings from the Leonard Cheshire (2019) survey noted above, these offerings appear to exclude a younger demographic, and the styles do not follow high street trends. There is also no sportswear available at these retailers.

A few mainstream brands, such as Tommy Hilfiger and Marks & Spencer (M&S), have begun to offer ranges of adaptive clothing. The adaptive apparel line from Tommy Hilfiger provides more comfort and makes dressing easier through functional modifications designed into the garments (McBee-Black, 2022; Tommy Hilfiger, 2022b). For instance, trousers for wheelchair users have more coverage at the back for a seated posture, and there is less fabric at the front to prevent bunching (Tommy Hilfiger, 2022a). M&S (no date) offers a "Kids Easy Dressing" line, which is "all about comfort;" garments are made of soft cotton fabrics. Some have discreet openings for feeding tubes. The US retail brand Target (2022) also has a selection of adaptive kids wear, using comfortable silhouettes and hidden openings for abdominal access.

Some innovative and on-trend SMEs and designers creating fashionable solutions for consumers with health conditions or impairments have emerged on the market. Kintsugi Clothing (2022) is a British enterprise offering inclusive ready-to-wear fashion, taking suggestions from the disability community. Their website states that their clothing "can be worn and enjoyed to the greatest extent possible by all people, regardless of age/size/disability" (para. 5). (Due to workload, the founder has announced closing the company as of late 2022.) Unhidden (2022a) clothing features socially responsible universal designs. For one, the women's "Silk Shirt" has concealed arm and chest openings for port access (Unhidden, 2022b). Slick Chicks (2022) and Elba London (no date) offer adaptive bras and underwear.

Some major sportswear brands have entered this market as well, but their offerings, at the time of this study, are very limited. In 2014, Under Armour launched garments with MagZip

-- a magnetic locking zipper that can be manipulated with one hand. It was designed by Scott Peters to assist his relatives with myotonic dystrophy (Regenold, 2014). Subsequent searches for Under Armour MapZip, however, show the product has been discontinued. Nike, inspired by a 16-year-old customer with cerebral palsy, began a line of sneakers with wraparound zips to provide an easier opening. (Friedman, 2016). The 2021 version, Go FlyEase, was marketed as universal design and boasts hands-free access (Tesfaye, 2021).

As of 2013, Carroll (2010a) writes that a handful of SMEs were selling adaptive sportswear, mainly sold online and marketed through word-of-mouth. It proved challenging finding such companies within this market review. One is Reverse Gear (2022), a company launched in Toronto in 2008 that designs cycling clothing for recumbent bike riders. This fills a gap since other cycling clothing does not address the needs of cyclists in a reclined position. On their website, it is stated that:

> *The founding principle behind our recumbent gear is that you don't have to compromise with your clothing when you ride recumbent or reclined. You shouldn't have to cut the pockets from the rear of a regular jersey, you shouldn't have to unpick the thick pad from regular shorts. There are numerous reasons you chose to ride a recumbent bike – our products will best suit your needs when riding it.* (para. 3)

So, a selection of SMEs and ranges from mainstream brands do offer clothing for some disabled consumers. The apparel industry as a whole, however, still lags behind on disability inclusion, particularly in sportswear. As Carroll (2010a) writes, " [t]he potential is great for further development of athletic wear targeted to both recreational and competitive athletes with disabilities, so that it becomes more widely accessible" (para. 7).

1.5 The Gap: Exclusion and Awareness

Despite the possibility that disability can touch each and every one of us (Goodley, 2017), clothing design around this area remains a specialist field. *Apparel-related barriers*, as termed by Kabel, McBee-Black, and Dimka (2016), can precipitate social exclusion. They state that a lack of appropriate apparel increases barriers to community participation and can also impede rehabilitation. As mentioned, this also pertains specifically to sport and sportswear (DePauw and Gavron, 2005). Tsakalidou (2016) notes that, while consumers are apt to self-blame if clothing does not fit their bodies, poor fit is really due to the industry not producing clothing suitable for all their customers. She claims that:

> *If people with divergent body figures, who currently face problems finding ready-to-wear clothing suitable for them, could get clothes that fit them - in terms of style, comfort, fit, and appearance – it would improve their participation in social activities and in life, in general.* (p. 98)

Holmes (2018) links repeated exclusion to on-going feelings of rejection. Kabel (2019) writes that the way a person dresses communicates to others personality, individual style, and appropriateness. She notes that:

> *Appropriate clothing is required to maintain an acceptable (subjectively defined) level of participation, including work/professional apparel, athletic or exercise wear, coats, jackets, and other outerwear, and footwear such as shoes or boots.* (p. 732)

Esmail *et al*. (2020) write that "one could argue that individuals without appropriate attire are unable to engage meaningfully in their everyday life activities and social roles" (p. 10). Similarly, Kabel, Dimka, and McBee-Black (2017) state that, "in addition to special occasions, everyday life events were made more difficult for people with mobility challenges due to the lack of appropriately designed clothing" (p. 167). They suggest that there is a need for innovation in design approaches to address apparel-related barriers to participation and reduce social stigma of adaptive apparel.

A lack of apparel for disabled consumers could stem from embedded assumptions held by the industry that inclusive design is too costly or that it will not be aesthetically pleasing (Eikhaug and Gheerawo, 2010). Also, designers may not be equipped with the skills or tools needed to address these marginalised consumers' needs, and, thus, they may not be aware of them (Clarkson *et al*., 2003). Esmail *et al*. (2022) state:

> *The slow uptake of adapted clothing in the fashion industry may be due to a lack of understanding of the importance of clothing in the lives of persons with a physical disability and of their specific needs in terms of clothing design.* (p. 78)

Kosinski, Orzada, and Kim (2018) suggest that most fashion designers have not been trained in adaptive apparel design and that this market needs to be ready to serve consumers beyond a limited view of body types, making diversity the "new normal." Previous literature suggests a participatory design methodology may be beneficial for apparel design research involving underrepresented consumers by breaking down knowledge and communication barriers between stakeholders (Kidd, 2006; McCann, 2016). This approach relies on collaborative exploration with users to incorporate insider

knowledge based on lived experiences. The intent is to challenge potential preconceptions or misunderstandings of marginalised groups through their direct involvement (Holmes, 2018). As mentioned, misrepresentations of disabled athletes may perpetuate socially constructed ideologies of disability and can lead to inequalities (Martínez -Bello *et al*., 2021).

A small amount of design research was found on sportswear for marginalised consumers. This includes: sportswear for so-called "active aging" consumers (McCann, 2016); and adaptive sportswear specific to wheelchair rugby players (Bragança *et al*., 2018). Also, limited design research appears on apparel for individuals with an upper limb impairment (Azher, Saeed, and Kalsoom, 2012). Since no previous literature has been found on mainstream sportswear industry design for individuals with an upper limb impairment or difference, this study addresses that precise gap.

Inclusion, in part, correlates with the intersection of fashion, social construction, and identity – theorised from multiple perspectives that reflect the cultural context of this study. Simmel (1957) writes that fashion exists through an instinct to imitate and, at the same time, through a desire for individuality. According to Simmel, when upper classes adopt a fashion to differentiate themselves, inclusion is created within that group (or class), and, so, others are excluded. Fashions then spread through imitation and an aspiration for social equalisation, after which new cycles begin when initiators again differentiate. Relating to fashion, Bourdieu (1984) purports that judgements on taste in art and culture (form or function, quality or quantity) arise from hierarchical ideologies of class differentiation. Taste, here, "is one of the key signifiers and elements of social identity" (Kawamura, 2005, p. 28). Concerning identity, Simmel suggests that fashion is sometimes adopted as a mask to conceal, or preserve, one's inner self. And, on gender-differentiated fashion and identity, Woodward (2007) describes dressing as "involv[ing] the construction of the self through socially acceptable modes of dressing" (p. 20).

Linking post-structuralist theory with fashion and consumption, Lipovetsky (2005, cited in Rocamora, 2015) suggests that contemporary fashion dynamics allow for an individual to continuously refine their own fluid identity. It has also been argued that fashion is simply a desire to express emerging trends and keep current in an ever-changing world (Blumer, 1969, cited in Kawamura, 2005). Returning to fashion inclusion, then, adaptive apparel that does not follow contemporary fashion trends or dynamics, consider variations in taste, or allow for expression of individual or group identities can contribute to the marginalisation of disability. The availability of fashion to influence and express a sense of self, group belonging or diverging, and identity must reach everyone for wider inclusion. For functional

apparel design (inclusive of sportswear and adaptive apparel), L amb and Kallal's (1992) model for melding function and fashion needs is presented in the next chapter.

1.6 Research Questions

This study was exploratory and inductive to investigate a relatively undocumented subject area (Saunders, Lewis, and Thornhill, 2012). More awareness is needed for industry designers to identify barriers to inclusion and to offer practical guidance for building a better understanding with this consumer group. Adhering to the social model of disability (World Health Organisation, 2001), barriers to mainstream sportswear inclusion for this consumer group were examined on apparel, industry, and social -related levels. A participatory design approach was applied to give an active voice to an underrepresented group (Ehn, Nilsson, and Topgaard, 2014). As such, the research questions were:

1. (a.) What are the barriers to mainstream sportswear design for this consumer group?

   (b.) What guidance is needed for industry designers to realise and overcome these barriers?

2. (a.) How can participatory design contribute to sportswear industry design fo r individuals with an upper limb impairment or difference?

   (b.) What guidance is needed for industry designers to adopt a participatory design component to their practice?

1.7 Aims and Objectives

The aims of the study were: 1.) to develop tool s, or a toolkit, to guide sportswear designers in understanding the scope and needs of consumers with an upper limb impairment or difference, and 2.) to contextualise this guidance within the practices of sportswear industry design, adaptive and inclusive apparel, and disability inclusion.

A *toolkit*, in this sense, references those established by leading design and innovation organisations, such as IDEO (2022), Microsoft (2016a), and the University of Cambridge Engineering Design Centre (2017). These kits contain interrelated tools and resources to assess and address complex social issues through de sign. IDEO's *The Field Guide to Human-Centered Design* is a set of teaching tools, design methods, worksheets, and

mindsets rooted in the practice of human centred design for impact in the social sector. Microsoft and University of Cambridge offer inclusive design toolkits, containing a suite of underpinning mindsets, processes, and user research tools to widen the reach of services and products through inclusive thinking. The final toolkit output for this thesis, presented in detail in chapter six, is comprised of user scoping, awareness building, and design strategy tools to understand and actualise the cohesion of sportswear and disability inclusion.

Thus, the research objectives were:

1. To establish a relevant multidisciplinary research framework within the context of the social model of disability, apparel industry practice, and participatory design research;
2. To conduct a critical literature and practice review of functional apparel design, adaptive apparel design, sportswear design, and inclusive design;
3. To identify potential gaps in awareness between sportswear industry practice and the user community;
4. To iteratively engage stakeholders in an exploration of the perceptions of, barriers to, and solutions for sportswear design for people with an upper limb impairment or difference;
5. To distil findings into pragmatic guidance for sportswear design inclusion, evaluate with stakeholders, and refine results based on feedback.

1.8 Design Research Framework

A pragmatic, practice-informed design research paradigm was chosen to generate results that are meaningful and applicable to users, industry, and future researchers (Saunders, Lewis, and Thornhill, 2012; Chynoweth, 2013; Koskinen and Krogh, 2015). Both research and design, Stappers (2007) states, can involve iterations of idea generation and exploring their relevance within the world around us – a process that guided this study. The aspect of design research applied for this study is based on design practice so as to be relevant to practitioners. Within this parameter, the research must connect various aspects of design, as well as: work with theory; work with methodology; and maintain a balance between research and practical design. This framework also meant that language and research should be understandable to design professionals (Koskinen and Krogh, 2015).

Much mapping, diagramming, and visualising emerging concepts, user-led insights, and design tools was conducted throughout this research exploration. Technical apparel flat sketching, from sportswear industry practice, was also used to visualise potential

sportswear inclusion design options. Koskinen and Krogh (2015) reference the benefits of this type of practice within this area of design research:

> *As Pieter Jan Stappers (2007, [cited in Koskinen and Krogh, 2015]) has written 'Prototypes and other types of expressions such as sketches, diagrams, and scenarios, are the core means by which the designer builds the connection between fields of knowledge and progresses toward a product. Prototypes serve to instantiate hypotheses from contributing disciplines, and to communicate principles, facts and considerations between disciplines.'* (p. 125)

Thematic mapping during the primary research data analysis, the use of design collaboration software Miro, and infographic visualisations played a primary role in generating results for this study, as will be documented further into this dissertation.

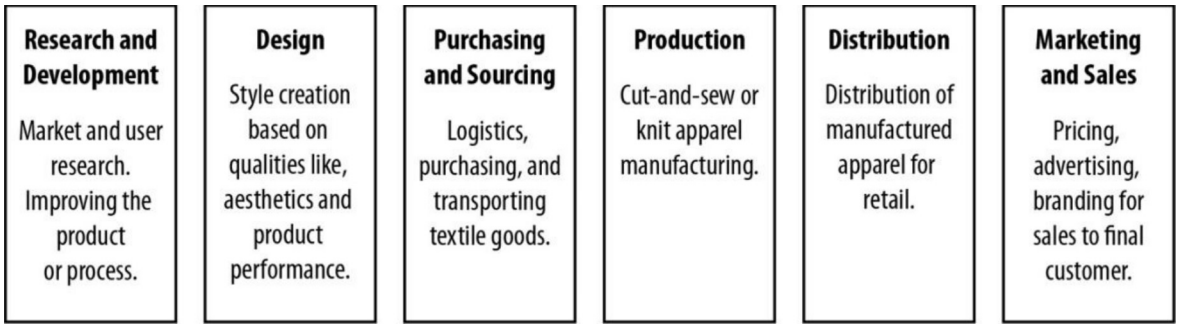
There was a practice-informed element to this research in which: 1.) experiential knowledge influenced the project development and output; and 2.) a focus was placed on addressing timely needs of the sportswear industry and adaptive apparel practice (Chynoweth, 2013). The researcher is fashion design trained and spent several years working as an apparel technical designer for men's and women's sportswear -- team uniforming, professional athlete apparel, retail takedowns, and fan gear for American football, hockey, baseball, football (soccer), basketball, and training. This industry experience was in the US, while this academic research was UK-based. The researcher, herself, is disabled in relation to an invisible, acquired, physical impairment. Her role as a disabled design researcher is reflected upon in the discussion chapter.

In-line with the participatory design approach and social model of disability, participant-led insights influenced the research direction and results. Participant-led (or user-led) direction involves prioritising the needs of those affected (particularly with marginalised groups) to shape the project and outputs to reflect lived experiences (Compass Disability Services, 2011; Faulkner and Thomas, 2002). So, while the final guidance addresses a sportswear industry audience, the content reflects user needs and values. As will be discussed in the conclusion, the final results also offer guidance beyond the scope of this study. Findings are applicable to other areas of adaptive or inclusive apparel design research, disability inclusion, and fashion design education. The outcomes may find relevance in further areas of industry practice, such as inclusive marketing.

Figure 1.1 below shows the key stages of the apparel industry process in which sportswear design is located (Fernandez-Stark, Frederick, and Gereffi, 2011). While all components

are integral to apparel industry operations and brand success, this study primarily focused on the designer's role, which is further defined in the next chapter. For sportswear and adaptive apparel designers, an expanded skillset pertaining to contextual user research and awareness of production capabilities may be required (Watkins and Dunne, 2015; Morris and Ashdown, 2018; McBee-Black, 2021). As will be shown in the findings for this study, some primary research participants did raise questions around business considerations not always allocated to a designer's role, like pricing and distribution planning. An analysis on business and commercial factors, outside the immediate scope of this design research, is recommended as a future research opportunity for progressing sportswear inclusion.

Fig. 1.1 – Stages in the Apparel Industry Process.



Finally, sustainability is acknowledged as a value driver and area of importance for sportswear design (Bielefeldt Bruun and Langkjær, 2016; Claussen *et al*., 2022). The topic of sustainability, however, largely remained outside this specific research scope in order to focus in detail on personal adaptive and inclusive sportswear needs, like function and inclusion-related values. Inclusive design and sustainability can work together, and they may even enhance one another (Eikhaug and Gheerawo, 2010; Park *et al*., 2014). Thus, a sustainable practice is certainly encouraged and can work alongside this research output.

1.9 Conclusion

Thus, the overall research scope and framework are defined. Millions of people in the UK and the US experience disability and so may be excluded from mainstream design offerings (Centers for Disease Control and Prevention, 2020c; Department for Work & Pensions, 2021). The overview of official disability definitions and models of disability provided a lens for this research, with the social model providing direction to address barriers to sportswear design inclusion. The market survey of adaptive apparel showed approaches companies are taking to reach these marginalised consumers but also highlighted how limited commercial adaptive apparel, and sportswear, still is. From this contextual exploration, a gap (or barrier) was determined in awareness and knowledge exchange between the

disability community and the sportswear industry. Thus, the resulting research questions, aims, and objectives were structured to address this problem. A participatory design approach was chosen for this pragmatic design research with a practice -informed and user-led perspective.

The following two chapters form the practice and literature review. Chapter two overviews contemporary states of practice that surround the topic of adaptive and inclusive sportswear design. Areas such as, functional apparel design, apparel industry practice, participatory design, and inclusive design are introduced and explored in relevance to this thesis. Chapter three delves into the recent research published on adaptive and inclusive apparel to hone research gaps, as well as to take cues from others involved in parallel work. Chapter four then plots out this original research design. Methodology, methods, and accompanying areas of qualitative research, like ethics and researcher role, are covered.

The second half of this dissertation reports the findings, the final output, and an analysis of the research. Chapter five explicates the findings from various phases of data collection and analysis. In chapter six, the sportswear inclusion design tools are presented and p laced within the context of existing inclusive design toolkits. Chapter seven follows with a discussion of the implications of the tools and research findings in terms of adaptive apparel research, sportswear design practice, and disability studies. Finall y, the concluding chapter (chapter eight) will summarise the research as a whole, answer the research questions, and delineate the original contribution to knowledge.

Chapter 2: Functional Apparel Design Practice Review

Following the presentation of the research context and framework from the introduction, these next two chapters provide critical practice and literature reviews. Within this chapter, areas, such as functional apparel design and apparel industry practice, a re investigated for relevance to and limitations towards adaptive and inclusive sportswear. Approaches, like inclusive design and participatory design, are then introduced and explored for their contributions to disability inclusion.

Sources used for review included academic journal articles, books on apparel design practice, and virtual resources, such as a Design Management Institute webinar and the University of Cambridge's inclusive design toolkit. No single area of design practice was found that precisely addresses adaptive and inclusive sportswear industry design for this target consumer. But, a range of relevant design practices were identified and evaluated, along with the key authors that are mentioned in this chapter (Table 2.1). The readings also encompassed potential influential factors (Table 2.2) on sportswear inclusion, such as media portrayals of disability and mass manufacturing parameters. Throughout this chapter, the areas of practice are examined for solutions and barriers to sportswear inclusion.

Table 2.1 - Areas of Design Practice Identified as Relevant to Adaptive and Inclusive Sportswear Design

Area of Design Practice	Key Authors
Functional Apparel Design	Lamb and Kallal, 1992; Watkins, 1995; Gupta, 2011a, 2011b; Watkins and Dunne, 2015; LaBat and Ryan, 2019
Adaptive Apparel Design	Watkins, 1995; Lamb, 2001; Watkins and Dunne, 2015; Kabel, 2016; Esmail *et al*., 2022
Sportswear Design	Bramel, 2005; McCann, 2005, 2016; Shishoo, 2005; Carroll, 2010a; Basant *et al*., 2013; Bielefeldt Bruun and Langkjær, 2016; Kabel, 2016; Bairagia and Bhuyan, 2021; Claussen *et al*., 2022
Apparel Industry Practice	Press and Cooper, 2003; Carroll, 2010b; Kawamura, 2010; Taylor and Timmons, 2015; Morris and Ashdown, 2018; Claussen *et al*., 2022
Inclusive Design	*The Principles of Universal Design*, 1997; Clarkson *et al*., 2003; Carroll 2010c; Eikhaug and Gheerawo, 2010; Barnes, 2011; Engineering Design Centre, 2017; Holmes, 2018; Eikhaug and Gheerawo, 2021

Participatory Design	Sanders, 2002; Spinuzzi, 2005; Sanders and Stappers, 2008; Björgvinsson, Ehn, and Hillgren, 2010; Sanders, Brandt, and Binder, 2010; Robertson and Simonsen, 2013; Ehn, Nilsson, and Topgaard, 2014; Fisher and Gamman, 2018; Holmes, 2018; Dandavate, 2020

Table 2.2 - Influential Factors towards Adaptive and Inclusive Sportswear

Influential Factors	Key Authors
Media Portrayals of Disability and Sport	Purdue and Howe, 2012; Silva and Howe, 2012; Zhang and Haller, 2013; Beacom, French, and Kendall, 2016; Maika and Danylchuk, 2016; Martínez-Bello *et al*., 2021
Mass Manufacturing and Mass Customisation	Loker, 2007; Mpampa, Azariadis, and Sapidis, 2009; Carroll, 2010b; Kosinski, 2019; Liu, Chow, and Zhao, 2020; Paganelli, 2021

2.1 Functional Apparel Design

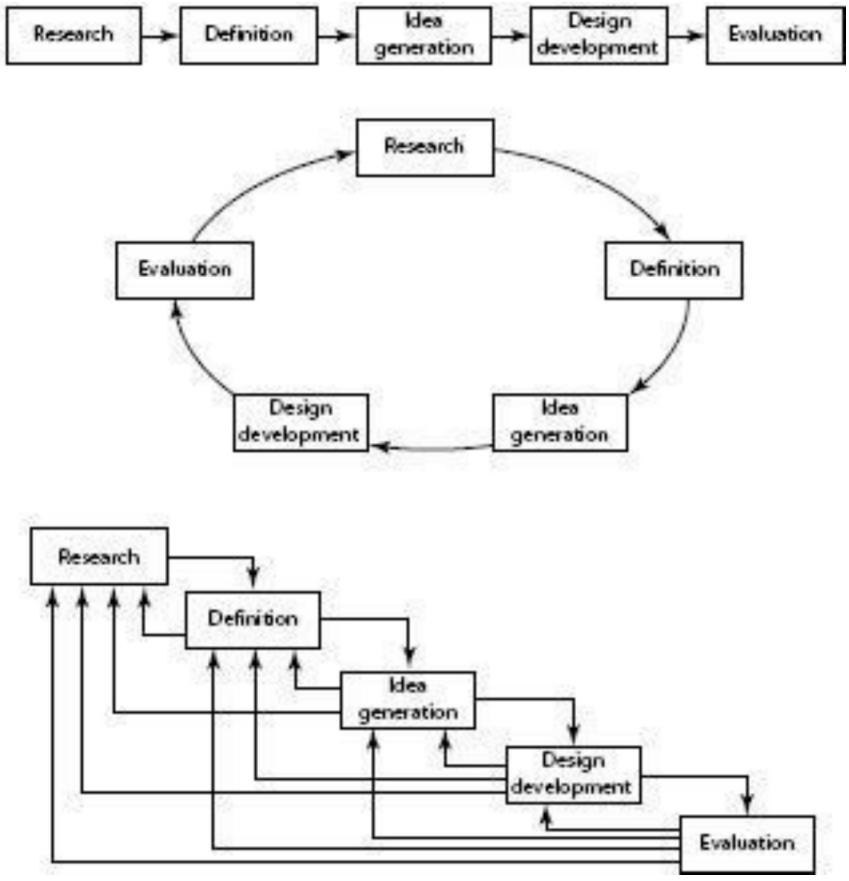
Generally, adaptive apparel and sportswear are both described as functional apparel (Watkins, 1995; Gupta, 2011b; Watkins and Dunne, 2015). Thus, to begin the exploration of practices, challenges, and opportunities for sportswear design for people with an upper limb impairment, functional apparel design will be defined. Watkins (1995) writes that '[t]he ultimate task of a functional apparel designer is to meet the complexity of clothing needs facing an individual in a specific situation" (p. 315). Gupta (2011b) defines functional clothing as apparel that has been precisely engineered to enhance performance of the user beyond regular function. These authors go on to delineate elements of practice that go into the design of functional apparel, which will be outlined below. Additionally, Lamb and Kallal's (1992) framework to assess consumer needs in functional clothing in a way that does not distinguish fashion from function will follow.

Watkins' 1995 book *Clothing: The Portable Environment* thoroughly outlines categories and processes employed in functional apparel design. Then in 2015, an update — *Functional clothing design: from sportswear to spacesuits* — written by Watkins and Dunne was published. Much of the substance is similar in the two books apart from updates pertaining to new technologies used in textiles science and biomechanics research. Functional apparel, according to Watkins (1995) must fit the body properly to allow for ideal function. As she states, "[n]egative reactions to the way a garment feels and the way it looks lead to feelings of discomfort" (p. 265). She also notes that movement is crucial to making apparel

a portable environment, so designers should study movements of the body for specific activities to allow for ease of motion in the garments. Several other scientific fields can contribute to clothing that functions properly with the body, such as anthropometry, kinematics, and kinesiology. Once designs are completed, many tests can be conducted to evaluate mobility.

A notable progression from Watkins' first publication to the second is the repositioned chapter on functional apparel design process to the opening of the 2015 book, rather than the conclusion of the 1995 book. In their illustration, *The design process*, Watkins and Dunne (2015, Fig. 1.1) map out a fashion and engineering based user-centred design (UCD) process as the means for creating functional apparel, shown below in Figure 2.1. It holds the user central to the practice. They show options of: 1.) a linear process, 2.) a circular repetition, and 3.) iterations back to previous stages. Tying together science and art, the authors states that, in functional clothing design, "[t]he evidence-based methods and processes of engineering are combined with the creative, intuitive methods and processes of art and fashion" (Watkins and Dunne, 2015, User-Centered Design chapter).

Fig. 2.1 - The Design Process. © Watkins and Dunne, 2015, Functional clothing design: From sportswear to spacesuits, reprinted by permission of Fairchild Books, an imprint of Bloomsbury Publishing Plc.



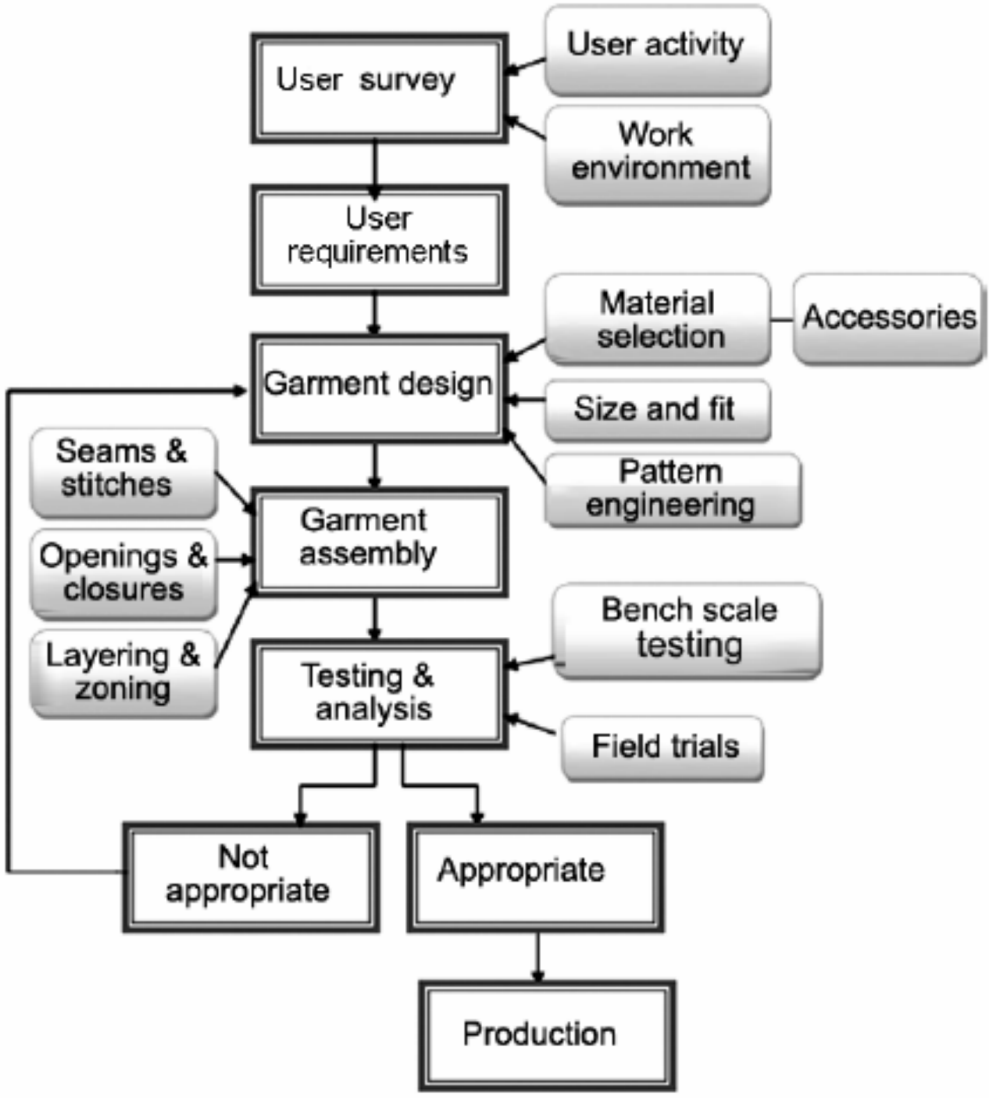
Watkins and Dunne define design process as a step-by-step program of methods to develop creative solutions. The process they highlight begins with "Conducting Research" -- doing exploratory research to study factors related to the problem. "Research…" they write, "exposes designers to the subtle variables of the specific problem at hand so that they can be effectively addressed and manipulated when design solutions are being generated" (2015, User-Centered Design chapter). During the research phase, the designer should learn about the: 1.) user, 2.) task, and 3.) environment, as well as any periphery factors and the lifecycle of the design. Methods they mention are: literature review; market survey; observation; direct communication; and laboratory simulation and experimentation.

The next phase is "Defining the Problem," which considers: "(1) Who are the users? (2) What is the activity? and (3) What are the environmental conditions under which apparel will be used?" (Watkins and Dunne, 2015, User-Centered Design chapter). Other than "creating personas," which entails assigning characteristics of a likely average user to better address design requirements, this section describes necessary parameters rather than practical tools. Some of these parameters include identifying design variables, constraints, and requirements. After this, comes "Generating Ideas," which lists several creative ideation activities, like lateral thinking, sketching, and mind mapping. Watkins and Dunne recommend including several designers from various backgrounds on an ideation team. Next, "Developing Designs" follows in the design process. This involves selecting, shaping, and ranking design ideas into optimal solutions. The final step is "Evaluation."

As will be reviewed in the next section, adaptive apparel has its own description and requirements within Watkins' (1995) and Watkins and Dunne's (2015) texts. It is positioned as a separate category to sportswear, although the above design process the authors present broadly covers functional apparel design. Also writing about functional apparel design practice, Gupta (2011a, 2011b) offers a similar perspective, and sportswear and adaptive apparel appear as separate categories.

Figure 2.2 below shows the functional apparel design process Gupta (2011a) represents in her *Flow chart showing the steps involved in design of functional clothing* (Fig. 1, p. 328) for the article "Design and engineering of functional clothing." She outlines four key requirements for functional clothing: 1.) physiological, 2.) biomechanics, 3.) ergonomics, and 4.) psychological. As designing and engineering is a complex process, she states, traditional systems for fashion design cannot be used for functional clothing design. Multidisciplinary collaboration is needed between engineers, designers, physiologists, ergonomists, and users to design clothing for a defined end use.

Fig. 2.2 - Flow Chart Showing the Steps Involved in Design of Functional Clothing. Gupta © 2011, reprinted by permission of Indian J Fibre Text Res.



Gupta (2011b) presents six classes of typical functional clothing: 1.) protective, 2.) medical, 3.) sports, 4.) vanity, 5.) cross-functional, and 6.) adaptive apparel. While "everyday" sportswear may be designed for moisture management, odour reduction, and temperature regulation, Gupta (2011b) claims these properties do not make this type of sportswear "functional clothing." Sports-functional clothing, she proposes, “represents those performance enhancing clothes that help sportsmen compete at the cutting edge of performance” (p. 324). Design principles include compression to increase blood flow and aerodynamics to reduce drag, she states. For this dissertation, however, functional apparel does include casual sportswear if it is designed for sport or fitness end-use.

“Clothing for special needs”, as Gupta (2011b) describes adaptive apparel, is meant to improve the quality of life for people “whose body shape, size, mobility or dexterity is significantly different from that of so called [mainstream consumers]” (p. 325). This group of

users, as she lists, includes: children, babies, elderly consumers, disabled people, autistic individuals, and pregnant women. She indicates that the needs of each are distinct and should be engineered accordingly. She also suggests that these consumer groups are extremely sensitive about their clothing and appearance. Further exploration of needs, meaning, and perception of clothing for disabled consumers is addressed in the next chapter.

Considering functional apparel, LaBat and Ryan (2019) offer an in-depth look at the human body and its systems for wearable product designers. A wearable product, they write:

> *Is defined as anything that surrounds, is suspended from, or is attached to the human body. In some cases, wearable products are inserted into the body. Many products fit this definition— from fashion apparel [e.g. clothing, hats, gloves] to medical devices [e.g. blood pressure monitor]*. (p. 2)

Wearable technology, the authors define, is "products adding technology of some type, e.g., health monitoring, into a wearable product" (p. 587). Examples they include are wrist and arm bands or watches that monitor health alongside sporting activities.

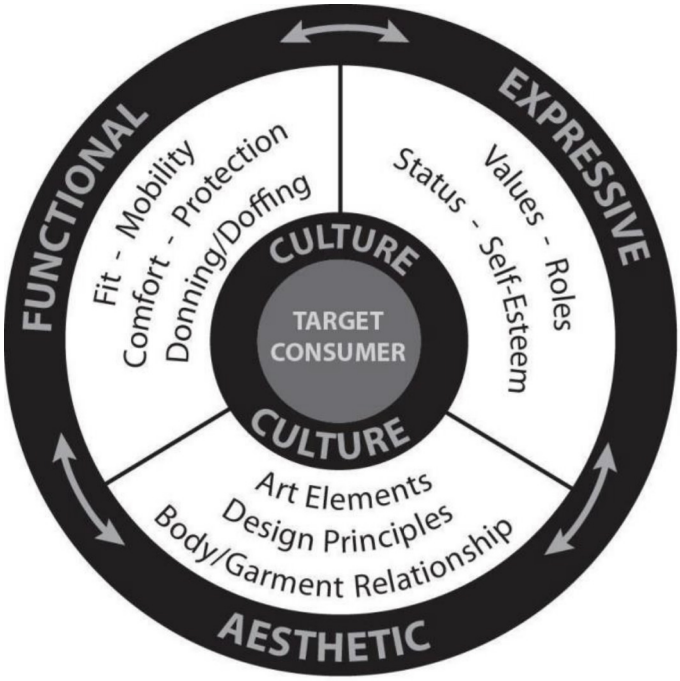
LaBat and Ryan (2019) detail anatomy, physiology, and biomechanics so products can be designed to function well with the body, enhance systems, be comfortable, and not impede motion. Sportswear is frequently mentioned. Charts and diagrams for measuring all areas of the body are included. Both Watkins' 1995 and Watkins and Dunne's 2015 texts are referenced by LaBat and Ryan.

The definitions, instructions, and diagrams included by LaBat and Ryan (2019) can be useful for apparel designers to effectively communicate with medical or bioengineering experts using a shared language. (McCann, 2016, describes building upon a shared language for complex collaborations, which is mentioned in section 3.4.) And sportswear design can certainly benefit from the biomechanical considerations. While a few areas related to disability are noted (such as prosthetics design or considerations of spinal curvature), these mentions are limited. Also, the anatomical illustrations and guides to taking body measurements show symmetrical, non-disabled bodies. When venturing into adaptive or inclusive apparel design, more expert guidance around body variations is needed.

In the early 1990s, Lamb and Kallal (1992, Fig. 1, p. 42) developed the *FEA Consumer Needs Model*, shown below as Figure 2.3, to design clothing that melds both function and

fashion. *FEA* references the functional, expressive, and aesthetic needs that are considered. The target consumer is shown at the centre of this model, which highlights key elements in designing clothing for specific needs. Lamb and Kallal write that previously designed and researched apparel for people with physical disabilities had been labelled as "functional clothing," (a label that persists, as indicated above). But this consumer group, they state, does not want functional clothing that appears unappealing or portrays a stigmatised image.

Fig. 2.3 - FEA Consumer Needs Model. Lamb and Kallal © 1992, reprinted by permission of SAGE Publishing.

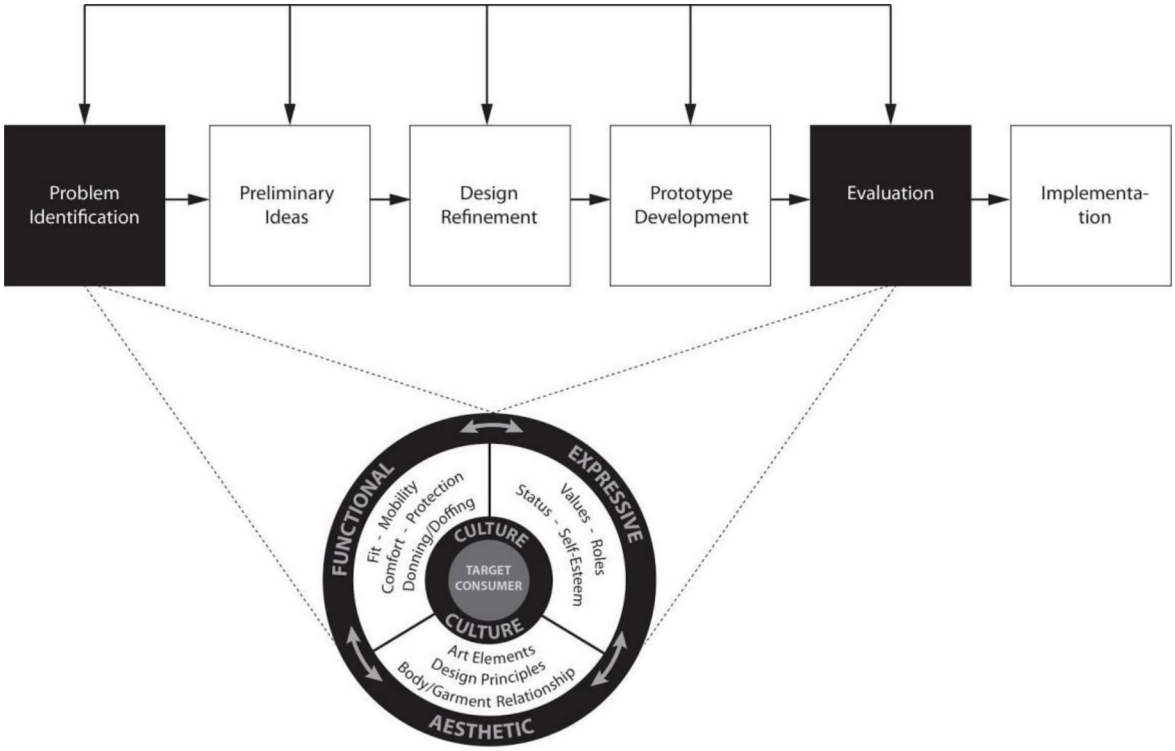


Focusing beyond pure function (fit, mobility, protection, donning/doffing), Lamb and Kallal (1992) place equal substance on the expressive (values, roles, status, self-esteem) and aesthetic (art, design, body/garment relationship) needs of the user. Functional needs, they write, represent the utility of the garment, while expressive considerations deal with symbolic, communicative notions of dress. Aesthetic needs represent a human desire for beauty or pleasing designs. Figure 2.4 below shows how they illustrate an *Apparel design framework* (Fig. 2, p. 44) with the FEA Model corresponding to an apparel design process. FEA needs are established in the problem identification stage, and these criteria are carried through the subsequent phases and finally used for assessment in the evaluation phase.

Lamb and Kallal (1992) indicate that designers should develop a user profile -- including "demographic and psychographic information, physical characteristics, activities, and preferences" (p. 42) -- before analysing target consumer or target market needs. They also

suggest that culture is a filter between the user and their apparel design requirements. They note that “[d]esigners must be alert to cultural ramifications in developing user profiles and in defining their needs" (p. 43). It is suggested that the FEA criteria identified at the start of the design process be determined *with* the user, which would allow the target consumer some central control over the outcomes. Lamb and Kallal recommend that prototypes are evaluated both subjectively and objectively, but they do not specify how this is done or by whom.

Fig. 2.4 - Apparel Design Framework. Lamb and Kallal © 1992, reprinted by permission of SAGE Publishing.



The FEA Model expands the outlook of adaptive apparel beyond purely “functional clothing” and considers a more context-driven, holistic view of the consumer. In a review on adaptive sportswear, Bairagia and Bhuyan (2021) suggest the FEA Model could be applied in this area of design to understand user needs. As this study was practice-informed and exploratory, however, an open-ended, participant-led approach directed the research path (see section 4.1), rather than a specific model like the FEA.

The above-mentioned functional apparel design processes outline practical guidance for designers to create well-researched, systematically defined, and team ideated apparel that meet criteria for end-use. So, if such processes already exist, then why is further research needed? A critical gap within the above processes is that, while users are the central subject

of the research, problem definition, and ideation, they are not directly involved in the design direction and problem scoping. Functional apparel design is very technically complex and does require expert designer and engineering input and guidance (Watkins, 1995; Gupta, 2011a; Watkins and Dunne, 2015). More user collaboration may be necessary, however, when designing clothing for disabled consumers from a social model perspective to challenge potentially limiting views of adaptive apparel (Lamb, 2001). Finally, areas of apparel industry practice (such as standardised sizing guidelines) and social awareness (as perpetuated through media) need examining for their role in disability representation. The rest of this chapter discusses these points.

2.1.1 Adaptive Apparel Design

The following section outlines the intents, benefits, and limitations of evolving adaptive apparel perspectives and practices. To begin, "[t]he origins of research into clothing for people with physical disabilities in the twentieth century are entrenched in this idea of rehabilitation and self-help" (Carroll, 2010b, para. 6). In the US, a push for more functional clothing, along these parameters, was linked to Dr Howard A. Rusk and the rehabilitation of returning war veterans. Through the 1960s and 1970s in the US, a handful of functional and fashionable adaptive apparel designs were created, notably with influence from Helen Cookman of the Clothing Research and Development Foundation Inc. (Bairagia and Bhuyan, 2021). By the later 1900s, adaptive apparel research was also incorporating psychological and expressive needs to remove barriers for disabled people in fully participating in society through jobs and activities (Carroll, 2010b). In the mid-2010s and onwards, adaptive apparel designers Lucy Jones, Maura Horton, and Mindy Scheier became prominent names in the field with launches of their own fashion lines, patents, and successful mainstream brand partnerships (Bairagia and Bhuyan, 2021; McBee-Black, 2021, 2022). Contemporary adaptive apparel literature continues to vary in focus, ranging from the importance of functionality to addressing social needs and values of inclusion.

Returning first to Watkins (1995), she defines adaptive apparel as clothing that is designed to meet needs pertaining to disability and elderly people. She notes that lack of awareness of these marginalised consumers is a reason they are often neglected by the industry. She also writes:

> *One of the biggest problems for commercial production of clothing for the elderly and those with physical disabilities is that the commonalities between problems from one individual to another are often not understood and thus mass manufacturers and distribution systems are not used effectively.* (p. 331)

It is difficult to provide common clothing solutions for disabled consumers, she writes, since everyone's set of needs is distinct. Yet, she suggests, there are situations common to many, like areas of the body that might be weakened or paralysed.

Watkins (1995) describes two ways to design apparel with these accommodations: 1.) make clothing that can aid those with weakened or paralysed limbs, or 2.) adapt designs so those with weakened areas can dress or carry out daily activities independently. Clothing could also be used to prevent falls and must be examined so as not to be a potential hazard, she adds. While those considerations may be crucial for some people with specific physical impairments, it gives a somewhat generalised overview for adaptive apparel. It also groups adaptive apparel users as "disabled and elderly," which is rather broad in outlook. Considering how unique people are in terms of a spectrum of disability, personality, and experiences, this scope for adaptive apparel design leaves room for more flexibility in perspective.

Watkins and Dunne (2015) later present adaptive apparel as "clothing [designed] for people with medical conditions and physical handicaps" (Enhancing and Augmenting Body Functions section). While the text sometimes adopts medicalised language, considerations are more nuanced than that of the 1995 text. The following list includes several aspects that designers may address in adaptive apparel, as reported by Watkins and Dunne:

- Fastening systems that make it easier to self-don and doff
- Accommodation for braces and other medical devices worn on the body
- Contoured garments to fit different body shapes and postures, such as a seated figure
- Greater mobility through fewer restrictions of fabric
- Engineered textiles to regulate body temperature
- Protective points for wearers who may be prone to falls

These ideas match goals of removing barriers in dress (easier fastenings), in choice (garments cut for various body shapes), and in restriction (accommodation for braces and movement), amongst other considerations.

Both books note that a challenge associated with this area of design is:

> *The size and wealth of the groups that need specialised clothing are often not perceived to be great enough to invest in design development or mass production*

and distribution. (Watkins, 1995, p. 331; Watkins and Dunne, 2015, Enhancing and Augmenting Body Functions chapter)

Watkins and Dunne (2015) write that more creative methods are needed for production and distribution of clothing for this group. They suggest certain consumers cannot easily shop in retail stores and are reluctant to order online due to an uncertainty that a garment will not work for them. More personalised accounts of a variety of disabled consumers' retail experiences and expectations would be useful here.

Other studies offer insights on retail accessibility. Findings from the Leonard Cheshire (2019) survey of UK disabled consumer perspectives on mainstream fashion, mentioned in section 1.1, allude to this. Respondents indicated that a lack of representative mannequins and models made it difficult to visualise how clothing would look on them. Dodds and Palakshappa (2022) identified further negative retail experiences of disabled consumers through a narrative approach. Participants expressed barriers of: exhaustion driving to and walking around stores; slippery mall floors; restrictive sizes and spaces of dressing rooms; and restrictive heights of displays or counters. One respondent asserted that it is misinformation to view disabled consumers as different, making different decisions in a retail environment. The experience of all shoppers should be equal, this person suggested, to allow decision-making based on access, agency, and independence. Some examples of questions to ponder were: "How do people who are blind experience the layout of a shop? How does someone who is deaf communicate with a salesperson?" (Dodds and Palakshappa, 2022, p. 149).

Moving beyond the biomechanical and movement-related functional requirements often pinpointed in adaptive apparel design, Kabel (2016) presents a review of design considerations that relate to sensory experiences. The categories of interest she considers are:

> *(1) Overwhelming or "too much" sensation, in other words, situations in which people would like to lessen the intensity of what they feel and (2) Limited sensation, lack of sensation, or circumstances under which people crave sensory input, but are restricted from feeling due to a variety of (typically medical or neurological) reasons.* (p. 206)

Multidisciplinary work of anthropologists, designers, and engineers, she writes, can help reduce apparel-related barriers to participation in society by regulating intrusive sensory experiences through inclusive clothing design. Emerging brands, she states, have begun to

fill the need for seamless socks, soft denim, or garments without a manufacturers tag, but neither mass manufacturing nor mainstream acceptance has taken place.

Kabel (2016) further details sensory considerations involved in considering clothing design for disabled consumers, as follows. For people living along the autism spectrum, sensory sensitivity may be a common occurrence. It is possible for the extreme irritation caused by noticeable seams or a back-neck tag to become so intolerable that it impairs cognitive focus. The difficulties can extend to parents who must search for appropriate textures in clothing for their children with autism or when a child will refuse to try on new clothes due to discomfort. Conversely, some people may wish for more sensory input in cases where they have lost feeling due to stroke or other conditions. In some cases with spinal cord injury (SCI), the ability to regulate one's own body temperature may be compromised. This may require many layers of thermal underwear beneath pants or trousers to maintain warmth, which can complicate dressing and toileting, as well as impede other areas of daily living. Smart textiles may be a solution to regulating body temperature while not over-burdening the individual with too many layers of clothing (Kabel, 2016).

A social-related barrier to apparel inclusion may rest on who is defining disability and adaptive apparel and from what perspective. On this topic, Lamb (2001) discusses "Disability and the Social Importance of Appearance." She recommends research directions for the study of textiles and clothing from a disability studies and social model perspective, claiming earlier research focuses on a medicalised viewpoint. For instance, she ponders if garments (often offered by medical suppliers) designed specifically for disabled people contributed to distress from oppression.

Prior to the 1980s much of the literature on clothing design for disabled people, Lamb writes, reflected the dominant medical view of disability in the US and the UK. Nevertheless, authors often stressed the importance of not further discriminating through clothing design, nor of diminishing self-esteem. Lamb (2001) suggests:

> *The social view of disability suggests that future designs of textile products would be more successful than their predecessors if disabled consumers (expert consultants) were involved throughout the design process.* (p. 137)

This places the focus more on the consumer as an agent for change and on knowledge from experience, rather than on previous assumptions that the medical community or other related "experts" know what is best for the consumer, Lamb claims. Lamb (2001) wonders if the way clothing for disabled consumers is developed and marketed contributes to the

marginalisation of this group. Some areas she poses as potentially discriminatory for these consumers are: extra cost; limited sources of procurement; and limited ranges of offerings, in terms of colours, materials, or sizes. Indeed, high cost and limitations of choice and appropriate sizes were indicated as barriers to mainstream fashion inclusion, as reported in the Leonard Cheshire (2019) survey. On discussing barriers enforced through clothing design, Lamb asks: "Could a 'universal [or inclusive] design' approach make apparel more satisfying for more consumers?" (p. 138). Indeed, this question is pondered throughout this study and will be addressed more fully throughout several subsequent chapters.

Seeking perspectives from practising adaptive apparel designers, Esmail *et al*. (2022) discuss the knowledge gap between health-based research and the fashion industry. From interviews with five adaptive clothing designers, the authors found that similar design processes were followed. Knowledge acquisition (step 1) was done through user research, which revealed design priorities (step 2). Standard processes (step 3) within mass-market clothing design (patternmaking, prototyping, manufacturing) were employed to address the design priorities. The authors then identified industry-related barriers to adaptive clothing design as: time-consuming knowledge acquisition; limited financial, material, and human resources; and manufacturing restrictions. Costing structure, affordability of garments to consumers, and appropriate channels for advertising of adaptive apparel were deemed necessary. Overall, the authors assert a need for better knowledge exchange between researchers and the fashion industry. They write that knowledge and awareness is key to the willingness of companies to design for this consumer group with empathy.

Adaptive apparel design can remove critical barriers that make clothing inaccessible or inadequate for certain consumers. Functional needs, like simpler donning/doffing and access to medical equipment, are considered (Watkins and Dunne, 2015). Adequate fit and increased comfort are also incorporated (Watkins and Dunne, 2015; Kabel, 2016). But a limited view of adaptive apparel, or disabled consumers, may perpetuate stigma. Inclusive options to apparel design warrant investigation (Lamb, 2001). Also, more exploration is needed on consolidating adaptive apparel design with sportswear and industry requirements.

2.1.2 Sportswear Design

This section outlines knowledge, requirements, and practice of sportswear design. It also touches on certain communities that have been neglected from mainstream sportswear design. As indicated in section 1.3, the parameters of sportswear for this dissertation are any clothing that is designed for sport or fitness purposes.

Sportswear requires a knowledge of sourcing, construction methods, and technical textiles; it combines creativity, aesthetics, and technical understanding. Knowledge of human anatomy and physiology, as well as information on the sport in question, is also needed. Patterns for sportswear must take into account extreme posture and body movement, but little guidance is found in textbooks. Most size charts and clothing mannequins come from static fashion poses, so patterns are developed through experimentation and experience. Designers must note the environment in which the sport will be played. Also, they should study the sport through main events, training manuals, videos, observations and participant feedback. User observations and feedback should inform designers about body reactions and conditions of use (McCann, 2005).

Achieving the 3D designs of these garments requires collaboration between engineers and designers (Bramel, 2005). Bielefeldt Bruun and Langkjær (2016) suggest that "sportswear is expected to be convenient and easy, 'leaving every muscle free'" (p. 187). Gupta (2011b) concurs that functional clothing should minimise restrictions on movement, but she adds that it should enhance performance of the user. Furthermore, she writes that functional clothing can protect wearers from hazardous environments during sports activities, or it can enhance stamina or reduce fatigue in athletes. Key considerations in sportswear, according to Bairagia and Bhuyan (2021), include: garment fit, including compression; ergonomic function; seams and stitches (or seamless technology) for function and comfort; application of kinesiology (relating to movement of the body); and aerodynamics of the body and garment. Specialist machines or technologies, areas of study, and testing procedures may be required, they report.

Basant *et al*. (2013) highlight the importance of choosing sportswear that is built for the specific sport that is being practised. Appropriate clothing, they state, allows the body to perform in a certain way, and the wrong choice could even damage the wearer's health. "But too often, people end up forgetting the importance of using clothing fit for each sport and simply use single clothing for all these practices" (p. 193).

Perceived sportswear quality can be subjective and user-orientated, and it can be objective and product-orientated, state Claussen *et al*. (2022). They interviewed 22 professionals from the sportswear industry to assess experts' perspectives on sports clothing quality.

As they found, main attributes for quality are:

- Durability and processing (workmanship, finish)
- Usability (injury prevention, temperature and moisture regulation, performance, comfort, fit)
- Aesthetic (look, haptic)
- Extrinsic (brand, sustainability, safety and compliance, price)

Bairagia and Bhuyan (2021) note: "The [sportswear] category is available with many leading fashion brands showcasing the latest trends" (p. 1062). Self-image and lifestyle are affiliated with sportswear, according to Basant *et al*. (2013). Bielefeldt Bruun and Langkjær (2016) state that:

> *Sportswear in a Western world [is] heavily influenced by popular cults of youth and fitness, sparking health clubs and gyms, and indoor training and commercial fitness centers.* (p. 182)

Some consumers are willing to spend sizable sums on per formance wear in their desires for new features, technology, and increased safety in sportswear. Economic interests are large, and innovation is prioritised. Increasingly popular as everyday wear, sportswear is also tied to certain values. While the functi onal values in sportswear relate to comfort, mobility, fit, and protection, the expressive elements include roles, status, and self -esteem (Bielefeldt Bruun and Langkjær, 2016).

In writing about sportswear and marginalised groups, Bielefeldt Bruun and Langkjær (2016) state, additional aspirational values connected to active sports are relevant. These include:

> *individualism, relaxation, spontaneity, informality, freedom, autonomy and independence, functional practicality... fashionableness, prosperity, dynamism, sophistication, smart image, expressing personal style, and, increasingly: sustainability.* (p. 187)

Bielefeldt Bruun and Langkjær (2016) note that more authors have begun to address the inclusion of previously marginalised groups as participan ts in sport. McCann (2016) and Christel and O'Donnell (2016) employ co -design techniques to design technical sportswear for the "active aging" and the FEA Model to assess design requirements for "plus -size" women's swimwear, respectively. Bragança *et al*. (2018) explore design recommendations for wheelchair rugby players, from an engineering and human -factors perspective. Chau (2012) produced a master's thesis in which user needs were assessed in swimwear for

children fitted with a central venous line. The user analysis was based on the FEA Model, and prototypes were developed.

When designing sportswear appropriate for disability sport, one approach may be to cluster similar needs. For instance, athletes participating in wheelchair sports may prefer raglan sleeves, which provide better ease of movement than set-in sleeves. Athletes with prosthetics may need built-in access added to sportswear design. As mentioned in the previous section, sometimes temperature regulation may be impaired in those who have an SCI. So, materials with temperature management properties may be ideal in avoiding hypothermia or hyperthermia. As in all sportswear design, innovation can be technology-based, like incorporation of biomedical sensors, or less technology-driven, like elimination of seams to reduce friction. Multidisciplinary expertise in wireless tech, textiles, biomedical engineering, and health are essential (Carroll, 2010a; Kabel, 2016).

Bairagia and Bhuyan (2021) suggest certain areas to consider when designing sportswear for wheelchair users. Fit, they write, must be based on anthropometry of disabled athletes. (As described by Watkins, 1995, p. 265, "[a]nthropometry is the science of measurement of the human body"). Ergonomic considerations, like targeted compression, can be specific to wheelchair users' needs, indicate Bairagia and Bhuyan. As with all sportswear, correct seams, stitching, and seamless or stitchless technology must be applied to avoid breakage and maximise comfort. Understanding body movement through kinesiology is important, as is analysing physio-thermoregulation in different athletes who are wheelchair users. Specific aerodynamic factors also need to be considered, Bairagia and Bhuyan write. Finally, the authors state that various user-centric design methods can help determine functional, expressive, aesthetic, and psychological needs for adaptive sportswear.

As outlined above, sportswear can have many purposes and qualities, from allowing unrestricted movement to enhancing performance to regulating physiology during sport (McCann, 2005; Gupta, 2011b). User observations, feedback, and expert collaboration can result in sportswear that meets the functional requirements of the user (Bramel, 2005; McCann, 2005). And sportswear can mean big business with value placed on innovation, self-image, and fitness-culture (Basant *et al*., 2013; Bielefeldt Bruun and Langkjær, 2016).

Reflective of the lack of mainstream sportswear for disabled consumers available on the market, however, published research on adaptive sportswear is somewhat limited. Considerations mentioned by Carroll (2010a), Kabel (2016), and Bairagia and Bhuyan (2021), like cut for ease of movement or seamless technology for comfort, may relate to many areas of disability and categories of adaptive sportswear. No studies were found,

however, specific to context, barriers, needs, and values in sportswear design for people with an upper limb impairment or difference.

2.2 Media Portrayals of Disability and Sport

Certain perceptions around sportswear and disability may stem from specific media coverage. Portrayals of disability and of Paralympic sport can highlight certain narratives of these communities that may contribute to on-going social misperceptions (Martínez-Bello *et al*., 2021). Relevant to disability inclusion, Martínez-Bello *et al*. note, "one way of understanding how inequality is constructed is by analysing how media portrays people" (p. 2).

Zhang and Haller (2013) present a study on how mass media affects the identities of disabled people. Through a survey of 430 Americans who were members of various disability-related organisations, three common disability portrayals in mass media were verified:

1. Supercrip - depicting disabled people as superhuman or inspirational for living with a disability;
2. Disadvantaged - depicting disabled people as looking to the state or society for generous economic support;
3. Ill victim - depicting disabled people as requiring a "cure" provided by health professionals, reflecting the medical model.

The last two portrayals enforce ideas that the lives of disabled people are less-than those of non-disabled people, leading to lower self-esteem. They conclude that:

> *Today, as many content analysis studies show (Haller, 2010 [cited in Zhang and Haller, 2013]), many journalists, videographers, and photojournalists still hold narrow views about people with disabilities, make subconscious assumptions about who they are, and are not trained to report on people with disabilities in a non-stigmatizing way. Today, news media still miss important and diverse stories related to disabled people because of their persistence in the stereotypical portrayals. The best way to portray people with disabilities is to not use a sticker or label, not to focus on their disability, but to report from their perspectives.* (Zhang and Haller, 2013, p. 330)

While the supercrip portrayal has evoked criticism for being over-the-top, Zhang and Haller suggest it can affect self-identity positively.

The supercrip narrative, regarding Paralympic athletes, is debated by Silva and Howe (2012). They write that "[m]edia representations are one of the main tools responsible for the perpetuation of social myths around disability" (p. 178). The supercrip portrayal, as they define it, stereotypes someone as having overcome his or her impairment to achieve success. While a seemingly positive depiction of disability on the surface, they claim, it actually reinforces negative social biases. As Silva and Howe describe:

> *When uncritically interpreted, this type of narrative can be regarded as positive, contesting dominant views regarding disability as "negative" and "inferior." However, it is the negative "ethos" of disability that feeds the low expectations placed on the individual labeled as disabled in a way that any achievement is easily glorified, no matter how insignificant. The difference in expectations between the "abled" and the "disabled" world is well articulated…"* (pp. 178-179)

There is a perceived paradox between elite sport and disability, which leads to the notion of a superathlete (DePauw, 1997, cited in Silva and Howe, 2012). Reflective of the complexity of individual experiences, however, this term may have different meanings to different people. Some athletes may pay little attention to disability representations, while some may find the "super" notion a progressive step away from the view of disability as limiting and of the Paralympics as secondary to the Olympics (Silva and Howe, 2012).

Beacom, French, and Kendall (2016) published a study on "Re-framing impairment? continuity and change in media representations of disability through the Paralympic games." A small-scale content analysis was done on UK newspaper coverage of the 2012 and 2014 Paralympic games, along with a document analysis of the International Paralympic Committee (IPC) frameworks and protocols for media accreditation. Beacom, French, and Kendall found that the "transformation" narrative featured in the 2012 coverage, and there was some presence in 2014. They write: "In the context of disability sport, the transformation subtext is closely linked with the idea of rehabilitation, where sport is used as a vehicle to rehabilitate the person with a disability" (p. 20).

The second narrative confirmed in the analysis by Beacom, French, and Kendall (2016) was "tragedy," in which athletes are meant to be pitied by the audience for having overcome such tragedy in life to reach such remarkable athletic achievements. Thirdly, the theme "normalisation" focuses on "progression and adaption... associated with overcoming the

disability in the attempt to be personified as normal" (p. 22). The authors point out the issue of the word normal being used when discussing disability, in sport in particular, as it promotes an ableist hierarchy. The final theme of "spectacle" highlights disability and bodily dysfunction. From the IPC and other key stakeholders, however, a narrative is promoted that "[p]aralympism is predicated on the notion that engagement in sport is an empowering process" (p. 29). In the impetus to sell news stories, it may be that an apparent triumph over adversity or a supercrip narrative are deemed most newsworthy, Beacom, French, and Kendall claim.

Martínez-Bello *et al*. (2021) seek to understand the unequal representation of Paralympic and Olympic athletes. Their mixed-method analysis of two major Spanish news sources spans the 2012 and 2016 games. Overall, Paralympic athletes were found to be underrepresented compared to Olympic athletes, and women less represented than men. The authors state, "[s]panish newspapers arbitrarily divide athletes participating in the Paralympic Games from those in the Olympic Games, portraying them as having intrinsic properties that make them different" (p. 9). They further suggest that, in these news stories, "the default is the abled athlete while 'the rest' – those who are circulating around the referent – are the disabled ones" (p. 12). Coverage of the Paralympic athletes was centred mostly on their life stories, focusing on "overcoming" disability, scrutiny over their bodies and impairment, and even their career backgrounds. Representation of Olympic athletes, however, centred on athletic achievement, success, and fame.

Maika and Danylchuk (2016) argue that more disabled athletes' voices need to be heard to understand (mis)representation within Paralympic coverage. They write:

> *Ideally, the trend towards realistic and meaningful representations of Paralympic athletes in the media continues as we work to embrace diversity and recognize that human ability exists on a spectrum, regardless of impairment.* (p. 413)

Martínez-Bello *et al*. (2021) conclude that an alternate media narrative could focus on the passion for victory and sporting professionalism shared by all athletes.

Negative or misguided stereotypes are certainly apparent in some media around disability (Silva and Howe, 2012; Zhang and Haller, 2013; Beacom, French, and Kendall, 2016; Maika and Danylchuk, 2016; Martínez-Bello *et al*., 2021). These can be classified as attitudinal barriers (Centers for Disease Control and Prevention, 2020a). Perhaps, a deeper social awareness in the knowledge exchange between the disability community and the

sportswear design industry can counteract some attitudinal barriers than may have perpetuated.

2.3 Apparel Industry Practice

Certain apparel industry processes may also pose barriers to broader disability inclusion. When commercialised for mass consumption by industry, apparel can be considered "industrial fashion". Massive manufacturers dominate industrial fashion, selling many similar items to similar social groups globally. Geared towards the tastes of the young, industrial fashion offerings are designed based on predictions of what consumers will want next season. Many companies driving industrial fashion are huge brands that might produce millions of each style, and, thus, limit risk and true innovation (Kawamura, 2010).

Tight product development timelines, reliance on previous seasons' successes for future sales, and mass sizing systems may restrict the use of more inclusive design thinking and processes. Often in new clothing development, the end-user is not given much attention, as design and style are usually dictated by trend prediction and data from previous season's sales, indicate Taylor and Timmons (2015). Similarly, Carroll (2010b) indicates that involving consumers at the start of the design process has not been commonplace in the fashion industry. Press and Cooper (2003) state that design has to be research-driven to connect culture and technology, science and humanity. But designers, they explain, cannot meet needs of deep research under pressures of fast-moving timelines. Sometimes they may utilise quick tricks, like trying their own products.

Sportswear design does rely more heavily on user research to ensure products meet end-use requirements (Watkins and Dunne, 2015; Morris and Ashdown, 2018). But apparel industry parameters still apply when considering mass manufacturing and commercialisation of sportswear. Morris and Ashdown (2018) explore how user engagement is utilised in performance apparel product development within an industry setting to "ensure product appropriateness while evoking users' aspirational performance goals" (p. 330). With an aim to determine how new design knowledge is gained from user involvement within performance apparel product development, interviews were conducted with 13 industry designers.

Findings from Morris and Ashdown's research showed a variety of methods often applied to collect user knowledge:

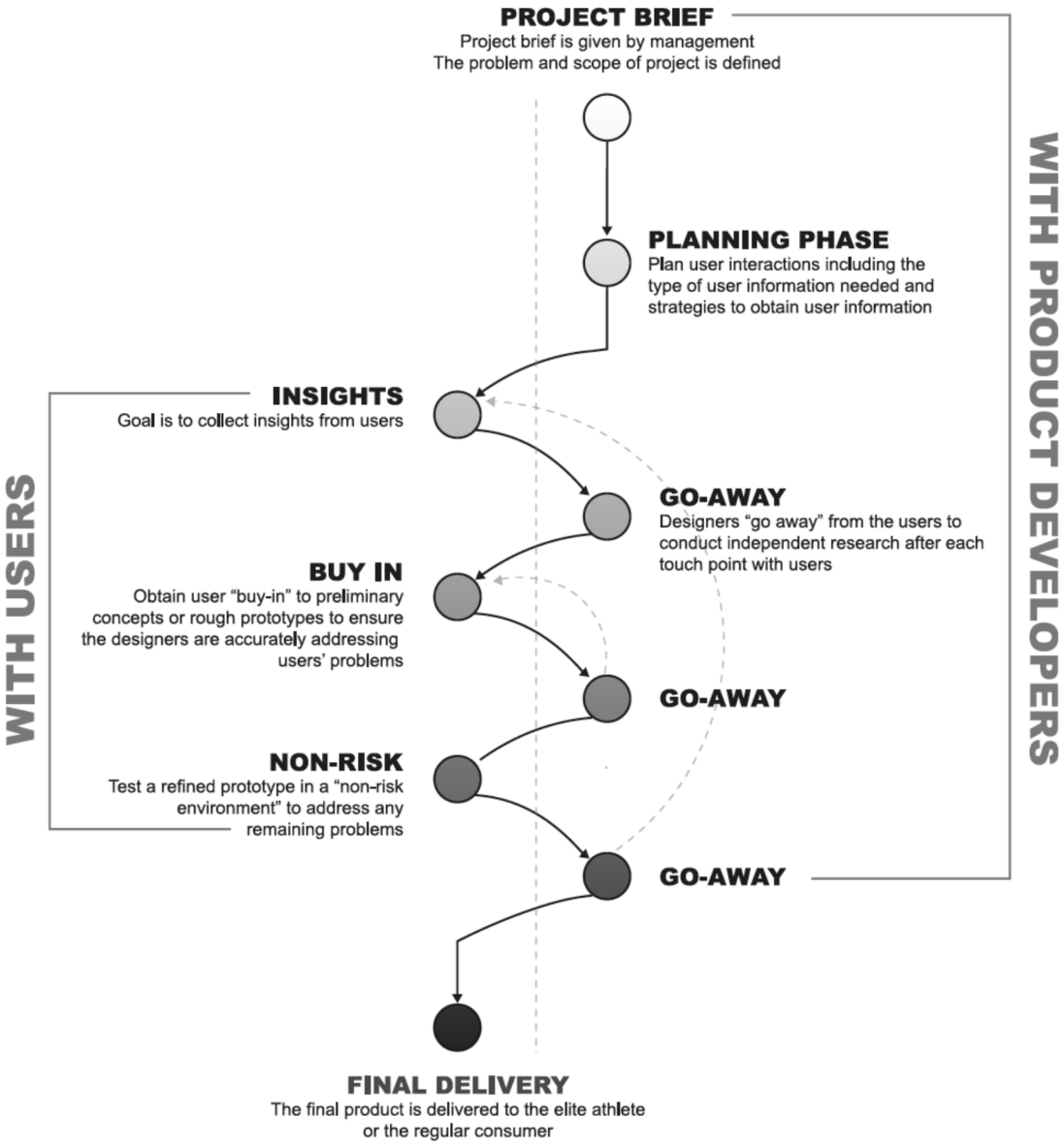
- Observations
- Surveys
- Interviews
- Focus groups
- Workshops
- Fitting sessions
- User performance data
- Anthropometric measurements
- Lab testing
- Fabric wear trials
- Prototype wear trials

Morris and Ashdown (2018) illustrate user engagement touchpoints in a *Procedural diagram of product developers' interactions with users* (Fig. 1, p. 340), replicated in Figure 2.5. The diagram shows that teams mainly conducted checkpoints with users at three phases, sometimes iterated: 1.) insights (or initial performance and market data), 2.) feedback of rough prototypes, and 3.) testing of a final prototype. The types of data collected included, in part, social and cultural frames of mind, unmet needs, perspectives on how to address the problem, and validation of prototypes. Further aspects of the product creation process were conducted by the developers:

> *The product developers did not apply literal user-generated solutions to new product concepts, but rather they combined user-generated knowledge with their intuition, expertise and historical interactions with users while considering the type of user, context of use and production considerations to drive product innovation*. (Morris and Ashdown, 2018, p. 342)

But, when considering a historically neglected consumer group, can product developers effectively rely on intuition or past experience to make design decisions representative of those users? Morris and Ashdown (2018) indicate that user engagement begins after a project brief has been given by management and the problem and scope have been internally defined. They conclude that while users are critical to performance apparel product development, it is the product developers that ultimately influence the final product.

Fig. 2.5 - Procedural Diagram of Product Developers' Interactions with Users. Morris and Ashdown © 2018, reprinted by permission of Informa UK Limited, trading as Taylor & Francis Group, http://www.tandfonline.com.



The authors write, "new ways to engage users throughout the apparel product development process may be necessary so that users may have more impact on the entire product creation process" (p. 349).

Claussen *et al*. (2022), as previously mentioned, found that industry experts assessed sportswear quality based on specific attributes: durability and processing, usability, aesthetic, and extrinsic. The study participants indicated that these quality attributes were generally evaluated by one or more of the following methods:

- Conventional textile testing
- Expert assessment
- Wear Trials
- Advanced lab testing
- Customer and market feedback

Some challenges to these methods were also indicated. The experts acknowledged that company guidelines and standards did not allow for enough differentiation in product ranges and user scenarios. Also, they stated, lab testing cannot accurately mimic real life. Sometimes, for instance, consumers reject garment attributes deemed high quality through lab testing. An expansion of digital tools, resources, and equipment were recommended for a better evaluation process. Increased connection with the user community was also suggested:

> *Other participants raised the need for a deeper understanding of the consumer. The questions that participants asked were how the consumer perceives quality and how the consumer uses the garments. Participants demanded more consumer-focused studies and testing.* (Claussen *et al*., 2022, p. 93)

This may be particularly essential when beginning a new development for adaptive or inclusive sportswear. Another way to enhance representation, as Kabel (2019) asserts, is further involvement of disabled designers within design teams. Teaching inclusive fashion design is also needed in educational programs (Barry, 2020).

As indicated, many methods for user research are already embedded within sportswear industry practice, but these can, at times, be limiting. Perhaps then, greater empowerment, visibility, and awareness of disabled consumers are needed to heighten a user-led knowledge exchange with designers. Further into this chapter, practices of inclusive design, participatory design, and co-design are introduced as possible routes. But a deeper understanding of user needs and values must also be consolidated with apparel production practices.

2.3.1 Mass Manufacturing and Mass Customisation

An area of apparel exclusion may stem from practices used to generate sizing guidelines for clothing and mass manufacturing. In the apparel industry, "[g]arments are manufactured massively using predefined size charts which allow for the reduction of production cost," state Mpampa, Azariadis, and Sapidis (2009, p. 49). Another potential limiting practice is sizing that is based on a fit model (Kosinski, 2019); "This singular person is measured to create one size and then that size is enlarged or shrunk to create other sizes" (Workman, 1991, cited in Kosinski, 2019, p. 1).

Watkins (1995) describes how body measurements and variations of a community are charted and studied through anthropometry studies. She writes that those using anthropometric data naturally lean towards looking for averages or other ways to categorise a population. As more measurements are added, however, predictions of measurements of an individual become less accurate. Designing clothing based on averages alone will end up not fitting one individual person as there is no such thing as an average person, states Watkins. This is reminiscent of Shakespeare's (2018) view of the spectrum of disability; in reality, we represent an immense scope of diversity rather than one image of the body or of disability.

As noted by Mpampa, Azariadis, and Sapidis (2009), the human population changes, so sizing charts and body measurements do not remain accurate over time. The authors go on to recommend mass customised garments:

> *The proposed methodology for the development of sizing systems combined with computer-aided and information technologies can enable the creation of garments, customized for fit, in a very quick and accurate manner. These customized garments can be inserted into normal production lines as an additional "size" and produced like every other garment of the same style... Potential increase in production cost that would occur due to cutting a few garments at a time, rather than hundreds, could be offset with increases in sales and customer loyalty*. (p. 64)

Carroll (2010b) writes that "mass-customization technologies have enabled mainstream retailers to partially involve consumers in the design of products, thus allowing them to purchase something in which their input was a significant factor" (para. 15). For a custom-created (or bespoke) garment, virtual garment technology can be used to capture an individual's unique body measurements, digitally dress an avatar, and generate pattern pieces; a garment can also be digitally knit (Paganelli, 2021). CAD, 3D body scanning,

virtual garment rendering, and big data are key technologies frequently used in mass customisation (Loker, 2007; Liu, Chow, and Zhao, 2020).

A customer could possibly have the choice of “add-on” features when purchasing a garment (Carroll and Kincade, 2007). Or a modular approach to personalising fit and design of ready-to-wear garments can be taken (Loker, 2007; Liu, Chow, and Zhao, 2020). For instance, a bodice block could be prepared with different sleeve styles to choose from, standardised pattern pieces could be resized to fit individual body measurements, or adjustable sizing elements could be designed into garments (Loker, 2007). Watkins and Dunne (2015) write:

> *Modular garments have the added advantage of being able to link different sizes and lengths of segments to fit any body configuration… Mass-production techniques can be used to make custom-fitted clothing by joining different lengths of segments based on individual customers’ measurements.* (Commercial Product Development and Production chapter)

Although mass customisation has been proposed and trialled within the apparel industry for many years (Loker, 2007), it has yet to be adopted for wide mainstream use. This may be due to a variety of factors. Liu, Chow, and Zhao (2020) state that:

> *The reason explaining why there are very few companies applying [mass customisation (MC)] is that the MC program needs a total transformation of the business operations system, which will cost a lot of money to develop. Moreover, this system is also difficult and time consuming for the managers and especially for the workers on the assembling line to accept*. (p. 547)

Loker (2007) references a higher cost to consumers, limitations in technology, and a consumer reluctance to purchase orders that cannot be touched or tried on first as prohibitive factors. Virtual garment technologies are rapidly advancing, however, and have been applied successfully in the example of Kutesmart Co., Ltd. -- China’s largest mass customisation apparel manufacturer (Liu, Chow, and Zhao, 2020). Paganelli (2021) discusses ableist biases that run throughout virtual garment technology, such as difficul ties in scanning seated figures. So, it may be that limitations of mass customisation may be greater for disabled consumers. His research is detailed in the next chapter.

So, while the notion of mass customisation is an intriguing solution to matching more individual body shapes and sizes, it has limitations. Digitally body scanning and knitting could facilitate custom fits, while modular design could offer variations in mass produced

cut-and-sew garments. But, challenges of cost, logistics, and exclusion of disabled users remain. Further research is needed on the feasibility and acceptance of mass customisation in mainstream apparel manufacturing, especially pertaining to disability inclusion.

2.4 Inclusive and Universal Design

Thus far, an adaptive apparel approach has dominated the discussion of sportswear for individuals with an upper limb impairment or difference. Inclusive (or universal) design may offer an additional approach in removing barriers to mainstream access. “An approach to design and a business strategy,” Eikhaug and Gheerawo (2010) write, inclusive design “aims to design mainstream products, services and environments that are accessible and attractive to the largest possible number of people" (p. 6). For instance, they describe that an easy-open package could be designed to aid people with arthritis and also be adopted as beneficial by the mainstream market. In this instance, there is no distinction between non-disabled or disabled consumers, but a wider group of consumers is included. Inclusive and universal design aims are generally considered positive design goals (Clarkson *et al*., 2003).

Disability studies academic Barnes (2011) recognises that both the ICF’s bio-psycho-social model and the social model of disability show how greatly our physical and cultural environments contribute to disablement. This is reflected in mainstream design and the perception of “normal”. Certain thinking throughout history that was intended to “advance” understandings of the human population had detrimental effects of promoting manufactured, hierarchical social divisions. 19th century astronomer and mathematician Quetelet, for instance, associated his creation of bell curves, which charted data on the human body, with what he called a human ideal. This began to influence a notion of normal, which reverberates today when designing for “the average” person. An example is school desks that only match right-handed students (Holmes, 2018).

Universal design, Barnes (2011) writes, has been promoted as a remedy for this. As he states, “a ‘design for all’ approach is widely linked to discourses of social inclusion and human diversity” (p. 68). Universal design promotes inclusivity by creating environments and products that are usable and comfortable for anyone. As user needs can vary so greatly and minutely, however, truly universal design (that encompasses every person) may be an unattainable ideal (Barnes, 2011). Still, this approach can look to include the widest community possible (Engineering Design Centre, 2017).

Ronald Mace at North Carolina State University (NC State) first coined the term universal design in 1989 (Carroll, 2010c). The Center for Universal Design (1997) at NC State delineates seven principles of universal design as follows:

1. Equitable use – The design is marketable and usable to individuals with a range of abilities.
2. Flexibility in use – A large range of preferences and abilities are accommodated by the design.
3. Simple and intuitive use – No matter the user's knowledge, concentration, language, or experience, use of the design is easily understood.
4. Perceptible information – No matter an individual's sensory abilities or the surrounding environment, necessary information is communicated to the user from the design.
5. Tolerance for error – Hazardous results of unintended use of the design are minimised.
6. Low physical effort – Minimal effort is required to use the design properly and comfortably.
7. Size and space for approach and use – No matter anyone's posture, mobility, or size, the design can be comfortably approached, manipulated, reached, and used.

And the intent is described as "[t]he design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (para. 3).

Eikhaug and Gheerawo (2010, 2021) offer a strategic overview and practical framework of inclusive design. While the term universal design originated in the US (and developed further in Norway), they write, the term inclusive design is used in the UK. Inclusive design incorporates multiple perspectives from real people for the creation of innovative and user - friendly products. Traditionally, inclusive design was allocated to older and disabled consumers, but it has since expanded to encapsulate a variety of genders, ages, abilities, and cultures. The authors note that sometimes, however, negative assumptions about inclusive design may impede its adoption in industry. Potential biases and counterp oints they list, are represented in Table 2.3.

Table 2.3 – Negative Assumptions and Counterpoints about Inclusive Design (ID) (Based on: Eikhaug and Gheerawo, 2010)

Assumption	Reality
High Cost	ID can add value and increase profit if built low cost into the design process.
Only about physical objects	ID can be applied to many sectors, like environments and software.
Only concerns accessibility	ID can tackle exclusion related to social, economic, physical, and cognitive factors and through age or gender.
Does not relate to "me"	Most people can be affected by some sort of disability, whether it be from allergies or a broken bone.
Does not look nice	ID does not replace other areas of design, like aesthetics; they are not mutually exclusive.

As proponents of inclusive design, Eikhaug and Gheerawo (2010) assert that "[i]nclusive design is not just about good intentions - it is also about good business" (p. 7). Inclusive design techniques, they write, can be applied at low cost to businesses but yield a high return on investment by reaching more people through innovative solutions. This approach, they describe, can help companies with their social responsibility platforms to enable human rights, promote sustainability, and embrace social inclusion and diversity within and beyond the organisation. Since the solution is better for everyone, the consumer market is widened by keeping the original customers as well as increasing appeal beyond the primary target market. The overlap between satisfying user needs and operating within industry parameters gives designers a platform to innovate in a way that satisfies both social and commercial interests. These arenas need not necessarily conflict, the authors assert.

The Engineering Design Centre (2017) at the University of Cambridge, as mentioned, offers an online inclusive design toolkit that provides an overview, process, and tools for inclusive design. Inclusive design, in the toolkit, is introduced through the British Standards Institute definition:

> *The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible... without the need for special adaptation or specialised design.* (2005, quoted in Engineering Design Centre, 2017)

As it may not be feasible or appropriate to design one solution for the entire population, Cambridge's inclusive design toolkit encourages:

- The creation of a range of products to serve the population as widely as possible.
- Defining distinct users for each product.
- Making the products as accessible as possible to ensure the best user experience for the broadest range of consumers.

There will be times, it is noted, when specialist products are needed to meet certain needs (Engineering Design Centre, 2017).

The possibility of employing an inclusive design approach to sportswear warrants attention. If so-called mainstream apparel were designed to be more accessible (with fewer apparel-related barriers), a wider base of consumers would be included. As introduced in the market survey from section 1.4, the FlyEase shoe from Nike is marketed as universal design (Tesfaye, 2021). It can be donned and doffed hands-free; thus, it excludes fewer people. While inclusive (or universal) approaches are largely underexplored in apparel research, a few key studies will be reviewed in the next chapter.

There is generous room to push both the idea and the available ranges of inclusive sportswear design further. Still, an adaptive apparel approach may be applicable in certain circumstances when a specialist product is the best fit, like sportswear for wheelchair rugby players (Engineering Design Centre, 2017; Bragança *et al*., 2018). Also, guidance for understanding user needs in either inclusive or adaptive apparel design practices needs further detailing.

2.4.1 Understanding the User

For an inclusive design process to be successful, diversity and broad user needs must be recognised. As indicated in the Cambridge toolkit: "Failure to correctly understand people can result in products that cause unnecessary frustration and exclusion, which reduces commercial success because of increased returns and customer support" (Engineering Design Centre, 2017, Understanding User Diversity section). People-centred research techniques can be employed at each phase of ideation, solution generation, and validation, with techniques like observations, storyboarding, and user workshops (Eikhaug and Gheerawo, 2010).

While a similar aim of understanding user needs is central to inclusive or universal design, processes and methods may vary. Carroll (2010c) lists a sequence of activities for a universal design process: “(a) establishing goals, (b) conducting research, (c) uncovering concepts, (d) determining needs, and (e) stating problems" (para. 4). When applied in clothing design, she writes, observations, interviews, and a task analysis are necessary for a rigorous needs assessment.

There are four main phases of inclusive concept design in Cambridge ’s inclusive design toolkit:

1. Manage what to do next based on a review of the evidence.
2. Explore to determine the user needs.
3. Create ideas to meet the needs.
4. Evaluate how well the design concepts meet the needs.

A UCD process is applied for understanding user needs. For instance, the explore phase involves activities, such as:

- Stakeholder mapping of those involved
- User observation
- Persona generation to summarise key users

Evaluation, as indicated in the toolkit, can be done through expert and user testing (Engineering Design Centre, 2017).

Another technique highlighted in Cambridge’s inclusive design toolkit is “capability loss simulation,” in the tools section. The Cambridge simulation gloves, for instance, restrict function of the hand, which is meant to mimic symptoms in certain conditions, like arthritis. Promotion of the gloves suggests that they aid the wearer in empathising with individuals who experience dexterity impairment and simulate the demands of various products related to dexterity. The website explicitly states that these gloves are not meant to represent what it is like to live with capability loss on a daily basis and recommends the gloves’ use within a holistic design process that utilises other user-centred methods (Engineering Design Centre, 2017).

Disability simulation is a controversial practice that has been used in educational and training settings. Some research suggests that results are merely a reflection of the attitudes or perceptions of the person doing the simulation. A simulation will spotlight challenges of

being newly disabled. This can lead people taking part in a simulation to think about how they, themselves, might feel with that immediate barrier in place and no time to adapt. (Barney, 2012; Silverman, Gwinn, and Van Boven, 2015). As Holmes (2018) writes:

> *No degree of wearing a blindfold will ever be equivalent to the experience of being blind. The blindfold can actually give designers a false sense of empathy, especially if they attempt to simulate disability without ever meeting or working alongside people with disabilities*. (p. 51)

Holmes (2018) makes a point that exclusion happens through design mismatches -- barriers to participating in society that are created by how our world is designed. While inclusive design methods can help to remedy this, purpose and point-of-view are just as important. "Without an authentic and meaningful understanding of a person's life experiences," Holmes writes, "stereotypes can prevail" (p. 80). As noted by Shakespeare (2018), there is no one universal experience of disability.

Rather than relying on statistical data or market segmentation to capture general trends, write Eikhaug and Gheerawo (2010), a people-centred approach focuses on individual thinking and people defining themselves. If designers are viewing user groups as "other people," a distance is likely created that positions the people who might use a solution as disadvantaged beneficiaries (Holmes, 2018). The next two sections explore collaborative design techniques intended to empower marginalised groups, break down barriers between stakeholders, and create meaningful outputs (McCann, 2016; Dandavate, 2020).

2.5 Participatory Design

Exclusion can come "from [designers] being new to the topic and from unchecked exclusionary habits" even if the team means well (Holmes, 2018, p. 8). Sometimes, designers will rely on their own needs or assumptions of others, particularly if working within a less diverse environment. When more people can participate in a design capacity – as in a participatory design approach – barriers to exclusion give way to inclusion (Holmes, 2018). The definition and application of participatory design and of user-centred design varies greatly in literature and research projects. In some cases, methods are similar. Collaboration with users is often described in apparel design research as observations, interviews, wear-testing, or feedback on sketches or prototypes (Kidd, 2006; Azher, Saeed, and Kalsoom, 2012; Morris and Ashdown, 2018).

For this thesis, a distinction is made around intent and mindset. As is often written, UCD is designing *for* the user (valuing professional expertise for decision-making along with extensive user research). Participatory design, meanwhile, is designing *with* the user (valuing professional *and* lived expertise for decision-making with extensive user engagement) (Sanders, 2002; Holmes, 2018).

Designing *for* and not *with* could lead to exclusion due to unintentional bias. Holmes (2018) states that even a very empathetic designer might generate a solution based on their own understanding of communication, logic, and sensory perception. This would be an ability bias, she writes; "An ability bias is a tendency to solve problems while using our own abilities as a baseline" (p. 50). A solution would then work well for those with matching abilities and exclude those with abilities that are not in-line with the designer.

As previously mentioned, Shakespeare (2018) highlights the uniqueness of the personal experience of disability, as well as the variety of perceptions that exist around it -- making it a complex phenomenon. Mass media is selective around portrayals of disability, and ideologies of ableism often go unnoticed in society (Berger and Lorenz, 2015; Martínez-Bello *et al*., 2021). To truly understand and value needs not being met in apparel design, thus, may be to consider excluded consumers as active partners within the overall design process.

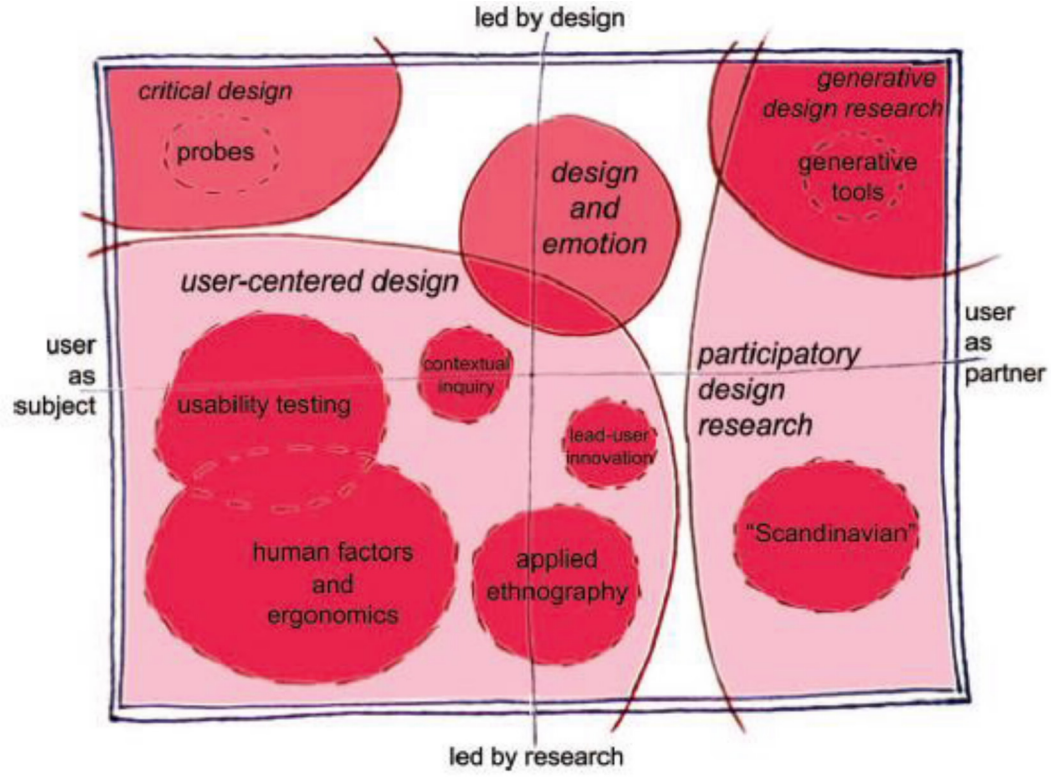
Fisher and Gamman (2018) present a series of essays that deal with the complexities of design when related to social change. Two areas discussed, relating to the ethics of design, are the procedures used in design and the presuppositions that the designer (and design-researcher) bring. Agid's (2018) essay debates how framing a design problem, in the first instance, will affect the outcomes. Designers' practices are based on previous experience and knowledge, Agid writes, and *all* design processes have ideological purposes. Both issues can limit the scope of how users' "problems" are defined. Designing with people, as Agid discusses, may shift problem-definition and design aims so that they are reconciled within complex social systems and multi-perspectives.

The participatory design movement began in the 60s and 70s when certain Western societies were demanding more say in decisions affecting their lives. It corresponds to other social, political and civil rights movements of the time. Scandinavian in origin, the movement first related to the introduction of computers into the workplace and aimed to enable workers with better skills and tools to fulfil the tedious part of their work. Participatory design focused on how things are designed (in partnership) and gave people rights to participate in shaping the world in which they worked (Robertson and Simonsen, 2013).

Participatory design has since expanded into other places and fields of inquiry, from product design to social innovation, as a more democratic and insightful method of human-centred design (Robertson and Simonsen, 2013). Björgvinsson, Ehn, and Hillgren (2010) describe how participatory design eventually shifted from “democracy at work” to “democratic innovation.” As McCann (2016) writes, "[c]ollaborative design methodology has evolved from designing for users to designing with users, in emancipating people by making them active contributors rather than passive recipients" (p. 241).

Figure 2.6 is Sanders and Stappers (2008), *The current landscape of human-centered design research as practiced in the design and development of products and services* (Fig. 1, p. 6), showing a human-centred design research landscape. It makes a distinction between user-centred and participatory design. Sanders (2002) writes: “In the user-centered design process, we are focused on the thing being designed… looking for ways to ensure that it meets the needs of the user” (p. 1). In UCD, she states, the user is spoken for by the researcher and is not really part of the team. “In participatory experiences, the role of the designer and the researcher blur and the user becomes a critical component of the process” (p. 2).

Fig. 2.6 - The Current Landscape of Human-centered Design Research as Practiced in the Design and Development of Products and Services. Sanders and Stappers © 2008, reprinted by permission of Informa UK Limited, trading as Taylor & Francis Group, http://www.tandfonline.com.



This dissertation rests on the balance of being led by design practice, by research requirements, and by the "user as partner". Critical priority was given to the participatory data collection results and interaction with the user community to lead the inductive design direction and perspectives of this research. The sportswear design professionals are an essential element to actualising new garments; they have expert knowledge in technical materials, garment construction techniques, and accommodating sports biomechanics needs (McCann, 2005). But the communities who have been excluded from the mainstream sportswear market have the lived experience of that exclusion. Thus, they possess the knowledge on what aspects of apparel need to change for meaningful inclusion.

2.5.1 Co-creation and Co-design

Participatory design and co-design are directly linked and sometimes used interchangeably in publications; sometimes co-design is used as a tool within a participatory design approach (Sanders, Brandt, and Binder, 2010). Sanders and Stappers (2008) "use [the term] co-design in a broader sense to refer to the creativity of designers and people not trained in design working together in the design development process." They write that "[i]n co-design, the end-user is clearly in the frame, and makes a major contribution to the design process." Sanders and Stappers (2014) discuss the role of making (designers and non-designers together) within design research and practice. Early in the ideation and design process, they write, visualisations and other making activities are used as vehicles for "observation, reflection, interpretation, discussion and expression" as well as "collectively… exploring, expressing and testing hypotheses about future ways of living" (p. 6).

Bielefeldt Bruun and Langkjær (2016) suggest that one solution to reconciling diverging contemporary values in sportswear -- from fashionableness to functionality to sustainability -- is through co-design or a collaborative design process. They write that involving end users "is a necessary consequence of the democratization of high-performance sportswear, as well as of recognition of markets with a certain growth potential" (p. 183). McCann (2016), as previously mentioned, presents a thorough case study on the use of co-design for sportswear for "active aging" consumers. This co-design process, as detailed by McCann, worked to empower the neglected consumers by employing them as equal partners. It also served to break down barriers of communication between the silos of multidisciplinary collaboration. A deep dive of this research project appears in the next chapter of this dissertation.

In a 2020 webinar organised by the Design Management Institute, Dandavate (2020) discussed co-creation in practice, which, he says, has the same values and principles as

participatory design. With 40 years of professional design experience, Dandavate is considered a pioneer of co-creation. He co-founded SonicRim (no date), a business consultancy promoting innovation through co-creation and applying areas of social science and design thinking. Co-creation, as Dandavate (2020) describes, is more focused on future thinking rather than building a product. Being humble is key to involving people, which is essential to innovation going forward, he notes. According to Dandavate, benefits of employing co-creation in the design industry are that it :

- Reduces risks and time in the design and development process ;
- Helps designers create empathy for the users ;
- Motivates collaboration amongst teams and breaks down disparate silos.

On discussing challenges of implementing co-creation in industry, Dandavate (2020) states that:

> *Introducing co-creation in an organization can be difficult because it challenges creative individuals' egos and threatens the power structures of established business models— it particularly disturbs the traditional power balance between a company and its consumers.*

Another challenge is the myth that this type of practice will undermine the creativity of designers. But, as he asserts, co-creation is less about seeking creativity and more about making sure it is meaningful to the user. A further obstacle for co-creators may be convincing design professionals to move out of their comfort zone and embrace ambiguity and to live with questions until they resolve themselves.

Sometimes designers may be trained as ego-centric designers, but to be successful co-creators they must accept that what they know about users is very little. In order to incorporate this mindset into a large, matrixed corporation, like manufacturing, an open mind is necessary. Solutions will not come from quantitative research or be found in provable answers. It may take a long time to change attitudes and for industry to become comfortable with narratives, qualitative dialog, and changes in beliefs, rather than to rely on confirmation of hypotheses (Dandavate, 2020).

So, while participatory design (and co-creation thinking) may be a more meaningful way for the sportswear industry to move forward with inclusionary practices, there can be potential barriers. These may include corporate or designer willingness to embrace change and more flexible ways of thinking (Dandavate, 2020). Benefits of implementing this thinking may be

to challenge designers' worldviews about marginalised communities by valuing lived experiences to influence the design direction (Holmes, 2018). And, as Dandavate (2020) lists, a co-creation mindset could mitigate risks and costs of creating products for a new and untested target market. Furthermore, as functional apparel design is extremely complex and requires much multidisciplinary expert collaboration, an on-going participatory approach may help break down barriers between disparate silos and with users (Watkins and Dunne, 2015; McCann, 2016).

2.6 Conclusion

In summary, each discipline introduced above offers elements of practice necessary to produce adaptive or inclusive sportswear, and all must work in tandem for meaningful and viable results. On their own, however, each area of practice may hold limitations or barriers to meaningful sportswear inclusion (Table 2.4). Functional apparel design focuses on consolidating material science, biomechanics, and technical knowledge to ensure garments are fit-for-purpose (Gupta, 2011a; Watkins and Dunne, 2015). Adaptive apparel can yield garments that are appropriate for consumers whose needs are not currently met by mainstream apparel by removing apparel-related barriers (Lamb, 2001; Watkins and Dunne, 2015). And sportswear design produces the necessary apparel to engage in sports and fitness activities (McCann, 2005; Basant *et al*., 2013). None of these garments could be designed, produced, or distributed for the mass market without apparel industry design considerations, like user needs analyses, sizing, or manufacturing.

However, limitations of mass sizing, mass manufacturing, and potential misunderstanding of marginalised consumers can be barriers to sportswear inclusion. Sometimes, misperceptions of the disability community are exacerbated through inaccurate media portrayals or through an ability bias (Silva and Howe, 2012; Zhang and Haller, 2013; Beacom, French, and Kendall, 2016; Maika and Danylchuk, 2016; Holmes, 2018; Martínez-Bello *et al*., 2021). Inclusive design practices can help to re-examine what is considered "normal" and to extend mainstream design to encompass wider communities (Eikhaug and Gheerawo, 2010, 2021; Engineering Design Centre, 2017; Holmes, 2018). Finally, a participatory design mindset may be beneficial when dealing with marginalised or misunderstood consumer groups. Designing with users can help to overcome unintended exclusionary design biases and value lived experiences for more meaningful results (Sanders, 2002; Agid, 2018; Holmes, 2018; Dandavate, 2020).

Table 2.4 - Areas of Design Practice and Influential Factors Relevant to Adaptive and Inclusive Sportswear Design: Contributions and Barriers to Sportswear Design Inclusion

Area of Design Practice or Influential Factor	**Contributions to Sportswear Design Inclusion**	**Barriers or Limitations to Sportswear Design Inclusion**
Functional Apparel Design	Multidisciplinary and user-centred design process leads to apparel that meets functional requirements and user needs (Watkins, 1995; Gupta, 2011a; Watkins and Dunne, 2015).	Inclusive design is not mentioned. Sportswear and adaptive apparel are discussed as two distinct categories (Watkins, 1995; Gupta, 2011b; Watkins and Dunne, 2015). Sometimes the design process presented is for, not with users (Watkins, 1995; Gupta, 2011a; Watkins and Dunne, 2015). More awareness may be needed (Lamb and Kallal, 1992; Lamb, 2001; Esmail *et al*., 2022).
Adaptive Apparel Design	Clothing is designed to match the needs and wants of disabled consumers, not currently met by the mainstream market (Watkins, 1995; Watkins and Dunne, 2015).	There is a lack of information on consolidating adaptive apparel design and mainstream sportswear industry practice (Esmail *et al*., 2022). The option of inclusive apparel is missing (Lamb, 2001).

Sportswear Design	Apparel is designed for sport and fitness function (McCann, 2005; Basant *et al*., 2013). It also has aesthetic and expressive attributes (Bielefeldt Bruun and Langkjær, 2016; Claussen *et al*., 2022). Adaptive sportswear can consider anthropometry, kinesiology, thermoregulation, and aerodynamics of the athlete (Bairagia and Bhuyan, 2021).	There is limited information on mainstream adaptive and inclusive sportswear industry design for individuals with an upper limb impairment or difference.
Apparel Industry Practice	Apparel can be commercialised and mass produced (Mpampa, Azariadis, and Sapidis, 2009; Kawamura, 2010). It encompasses trends, culture, and technology (Press and Cooper, 2003; Taylor and Timmons, 2015). Sportswear is based on user research and is built-for-purpose (Watkins and Dunne, 2015; Morris and Ashdown, 2018).	There is a disconnect between the apparel industry and disabled consumers (Lamb, 2001; Esmail *et al*., 2022). More opportunities for in-depth user understanding are needed (Press and Cooper, 2003; Carroll, 2010b; Taylor and Timmons, 2015; Morris and Ashdown, 2018; Claussen *et al*., 2022).
Inclusive Design	A wider scope of users is considered, and the notion of mainstream is expanded (Eikhaug and Gheerawo, 2010, 2021; Engineering Design Centre, 2017)	Sometimes adaptive apparel may be appropriate (Engineering Design Centre, 2017; Bragança *et al*., 2018). Sometimes the design process presented is *for,* not *with* users (e.g. disability simulation may produce misguided results) (Barney, 2012; Silverman, Gwinn, and Van Boven, 2015; Engineering Design Centre, 2017; Holmes; 2018).

Participatory Design	Users can actively influence the design direction for results reflective of their perspectives (Sanders, 2002; Sanders and Stappers, 2008; McCann, 2016; Agid, 2018; Holmes, 2018). It can help to overcome potential ability bias in design, even when unintentional, and in breaking down communication barriers in a multidisciplinary collaboration (McCann, 2016; Holmes, 2018; Dandavate, 2020).	Participatory or collaborative approaches must be balanced with sportswear, adaptive and inclusive apparel, and apparel industry requirements for achievable results. There may be designer or corporate pushback if a traditional process or power dynamic feels threatened (Dandavate; 2020).
Media Portrayals of Disability and Sport	Media coverage of disability sport could help to support inclusion and showcase achievements shared by all athletes (Maika and Danylchuk, 2016; Martínez-Bello *et al*., 2021).	Stereotypical or negative narratives about disability are often perpetrated through media coverage (Silva and Howe, 2012; Zhang and Haller, 2013; Beacom, French, and Kendall, 2016; Maika and Danylchuk, 2016; Martínez-Bello *et al*., 2021).
Mass Manufacturing and Mass Customisation	Mass customisation may be one route to facilitate mainstream adaptive and inclusive apparel production by allowing custom or modular fits (Loker, 2007; Mpampa, Azariadis, and Sapidis, 2009; Watkins and Dunne; 2015; Liu, Chow, and Zhao, 2020; Paganelli, 2021).	Mass sizing practices can be limiting (Watkins, 1995; Mpampa, Azariadis, and Sapidis, 2009; Kosinski, 2019). Mass customisation has not yet been widely adopted in industry or developed for disability inclusion (Loker, 2007; Liu, Chow, and Zhao, 2020; Paganelli, 2021).

Chapter 3: Adaptive Apparel Research Literature Review

This chapter presents a literature review of contemporary research studies on adaptive and inclusive apparel. While the previous chapter reviewed areas of relevant apparel and inclusive design practice, this chapter dissects specific research projects. Th e reviewed literature comes from a wide scope of academic journals, with focuses ranging from disability studies to fashion industry to engineering practice, which reflect the multidisciplinary context of this study.

Following Grant and Booth's (2009) typology of reviews, a critical review was done. According to the authors, a critical review "[a]ims to demonstrate [that the] writer has extensively researched literature and critically evaluated its quality" (p. 94). The studies are organised conceptually, rather than chronologically, to highlight themes and methodologies applied in this area of research. This review was source -led, iterative, and inductive. The main research problem, methodology, and conclusion of potential articles were reviewed for relevance to this research framework. Key authors and articles were determined by impact on this study, quality of the research design, timely publication in peer -reviewed journals, and appearances in reference lists of other key authors. A deep dive was then done on the identified impactful studies in the areas of adaptive or inclusive apparel design. Insights from this literature review served to further hone the gap being addressed in this study, as well as to identify pertinent people-centred design research methods to apply for primary data collection.

The themes found in the literature review focus on:

- Apparel-related barriers, needs explorations, and application of the FEA model (Carroll, 2010b; Stokes and Black, 2012; Chang, Hodges, and Yurchisin, 2014; Kabel, McBee-Black, and Dimka, 2016; Dimka, Kabel, and McBee-Black, 2017; Kabel, Dimka, and McBee-Black, 2017; Cho *et al*., 2020; Hobbs-Murphy, Morris, and Park, 2022);
- UCD and user collaboration in adaptive apparel design (Kidd, 2006; Azher, Saeed, and Kalsoom, 2012; McCann, 2016; Bragança *et al*., 2018);
- Inclusive apparel design strategies (Carroll and Kincade, 2007; Carroll, 2010c; Carroll and Gross, 2010; Park *et al*., 2014);
- Manufacturing and mass market considerations for mainstream adaptive apparel (McBee-Black, 2021, 2022; Paganelli, 2021; McBee-Black and Ha-Brookshire, 2022).

Select research centres and conference proceedings that focus on disability inclusion, design for health, and adaptive apparel development were reviewed as well, as discussed next.

3.1 Design Research Practice for Disability Inclusion, Health, and Adaptive Apparel

With an emphasis on participatory engagement and multidisciplinary collaboration, research centres like the Open Style Lab (2022) and the Global Disability Innovation Hub (no date-a) are exploring creative solutions for disability inclusion. The Helen Hamlyn Centre for Design (2021) focuses on inclusive design for business and for social good. And, recent years of textiles conferences and emerging academic practice offer insights on innovations for removing apparel-related barriers.

Originally launched with MIT and the Parsons School of Design, the Open Style Lab in New York City tackles apparel needs of people with disabilities through a cross-industry design platform, pairing a client with groups of design and engineering students (Friedman, 2016). The Open Style Lab (2022) describes themselves as an:

> *…organization dedicated to creating functional, wearable solutions for people of all abilities without compromising style. We team designers, engineers and occupational therapists to conceive and build accessible wearables that address the needs of and with people with disabilities.* (paras. 1-2)

A notable project involved creating an accessible coat for professional racing cyclist, Ryan DeRoche, who lost mobility in his limbs (Chichisan, 2015). Chichisan writes:

> *DeRoche was often times forced to either not wear a coat, or, in the winter, to keep it on even if he felt too warm after entering an enclosed space such as a warm coffee shop.* (para. 7)

Through UCD, the Open Style Lab team worked with DeRoche to design a waterproof jacket that easily slipped on over the arms and could be zipped at the back with a zipper tether or by a friend. The jacket takes only a minute to don and allowed DeRoche to dress more independently and to regulate his temperature, so he could get out and about easier to enjoy his daily activities (Chichisan, 2015).

In London, the Helen Hamlyn Centre (HHC) at the Royal College of Art (RCA) promotes inclusive design research (Carroll, 2010b). Their website states: “We focus on Inclusive Design process and projects, linking this to developments in Design Thinking and Creative Leadership” (The Helen Hamlyn Centre for Design, 2021, para. 1). Two research spaces indicated on their website are Age & Diversity and Healthcare, and two impact areas are Inclusive Design for Business Impact and Inclusive Design for Social Impact. According to the HHC director Rama Gheerawo, inclusive design leadership consists of three critical components: 1.) empathy; 2.) clarity; and 3.) creativity. Within this framework, the HHC concludes that inclusivity is not a free for all; a structured approach is needed. Parameters for inclusive design recognise that it is contextual (within a specific scope) and dimensional (who is included? where does it stop?) (Gheerawo *et al.*, 2021).

A specific research project from the HHC that focuses on apparel for well-being is Silke Hofmann’s dissertation on “[i]mproving post-mastectomy lingerie.” Her work examines the role that post-mastectomy bras play in the emotional and physical recovery of breast cancer patients. Hofmann employs a co-design approach, using fashion design probe toolkits, to gain an understanding of users’ experiences, values, and thoughts (The Helen Hamlyn Centre for Design, no date). Also, a doctoral student at the RCA, Laura Salisbury “began researching how textiles and garments could be used as tools to identify levels of mobility post-stroke and this led her to explore whether they could also facilitate recovery” (Owens, 2021, para. 5). Salisbury founded KnitRegen in 2020, developing smart textiles for stroke rehabilitation. A wearable knit top was created using smart textiles to provide consistent muscle stimulation treatment. This boosts the recovery process as the garment can be worn all day in place of going to an appointment at the hospital or clinic (Owens, 2021).

In 2012, the Innovation Design Engineering degree programme, through the RCA and Imperial College London, ran the Rio Tinto Sports Innovation Challenge. This initiative aimed to conceptualise innovations in the Paralympic sport realm. It was described as:

> *An intensive four-week full-time course aiming to inspire students to propose new sporting opportunities ranging from Paralympic equipment through to radical new sporting events and competition models to facilitate active lifestyles for people with disability.* (Childs, 2012, p. 16)

To meet the challenge, design students were equipped with expert research, workshops, toolkits, and touch points with Paralympic athletes. Of note, one design team conceptualised a sporting prosthetic in which the socket tightness can be adjusted in

response to tissue expansion during physical exertion and with an inner lining that wicks moisture away from the body (Clive-Smith, Wolzak, and Taniguchi, 2012).

Also in London, the Global Disability Innovation Hub (no date-a) – or GDIHub – is "a research and practice centre driving disability innovation for a fairer world" (para. 2). Founded in 2016, the GDIHub conducts global research in the areas of: assistive and accessible technology; inclusive design; culture and participation; climate and crisis resilience; and inclusive educational technology. Disability justice, the Global Disability Innovation Hub (no date-b) proclaims, includes disability innovation that will challenge current thinking and open up future possibilities. In discussing the role of innovation, director Vicki Austen poses the question, "How do we find new solutions to entrenched problems?" (Austen *et al*., 2020).

An example of GDIHub design research (in conjunction with Loughborough University) comes from Vlachaki's (2020) dissertation on emotionally-driven designed prostheses. Her work suggests that, in individualistic countries, emotionally-driven prostheses may help alleviate stigmatisation and shift social attitudes. Also with the GDIHub (in conjunction with University College London), Barbareschi (2018) completed a dissertation to develop a participatory design framework to build assistive technology for wheelchair transfers. The outcome serves to provide focus and encourage equal collaboration between users and designers.

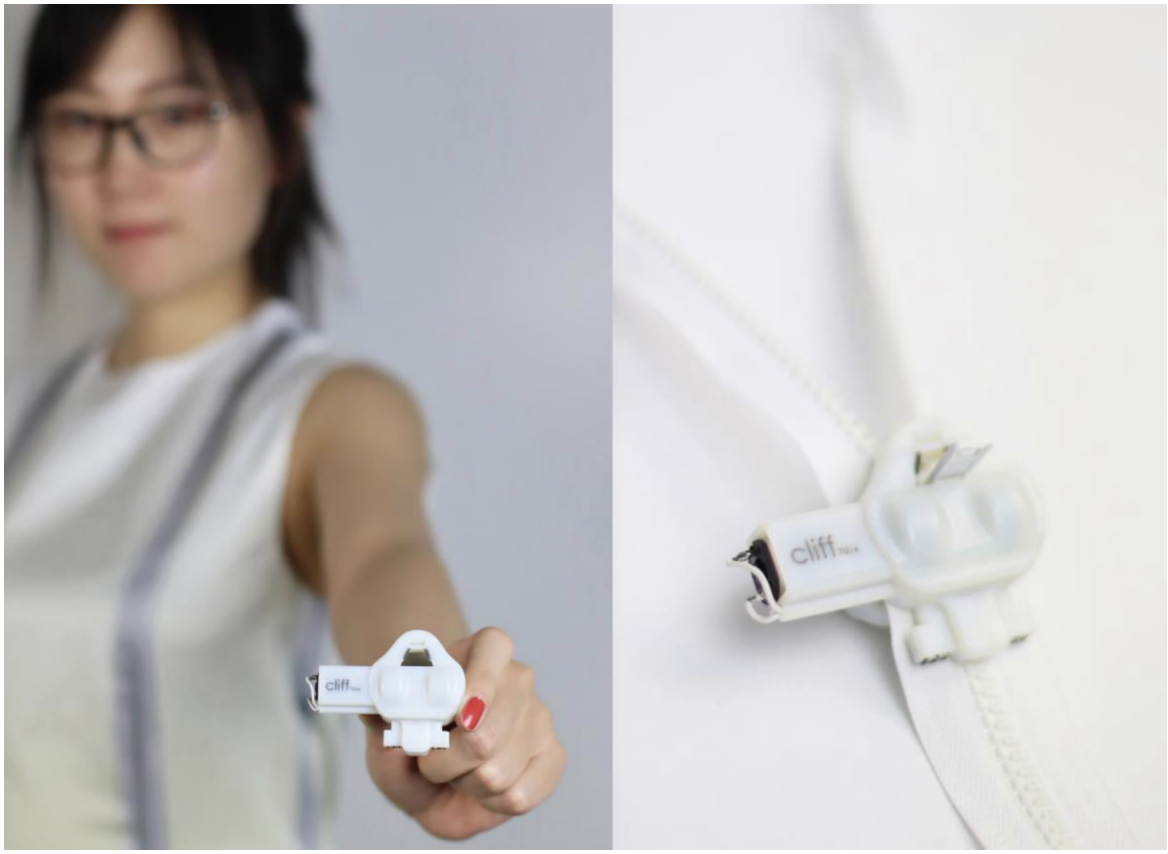
Iterations of the International Textile and Apparel Association (ITAA) Conference have showcased examples of emerging research on adaptive and inclusive apparel. Morris (2020) presented a modular parka developed with wheelchair users in mind. It is inclusive in that the main jacket stops at the waist, and separate bottom options can be zipped on or off -- thus it can be adapted for a seated figure or a standing figure. The design was created from an overview of parkas offered by both adaptive and non-adaptive retailers. Adaptive outerwear designs were reviewed for suitability for seated posture and additional features, like a magnetic zipper. Non-adaptive designs were scoped for the latest trends. In the search, no down parkas were found to be suitable for people with mobility impairments. The best options were adopted and incorporated into the new design. As the designer had no access to a fit model, a seated mannequin was purchased for prototype development. No disabled collaborators or participants were mentioned. So, while this modular design concept is intriguing and fills a need for inclusive parkas, it remains unknown if it is indeed suitable or desirable for the intended consumers.

An adaptive, custom sportswear design approach also appears in ITAA conference proceedings. Hobbs and Morris (2020) focus on a particular gap in the adaptive and inclusive apparel market -- sportswear suitable for participants of wheelchair sports. In this design research, a jacket was created for a Paralympic shooter who uses a wheelchair, referencing Lamb and Kallal's (1992) FEA Model and Watkin and Dunne's (2015) UCD process. After a Paralympic shooter was interviewed on FEA needs, a 3D body scan was done to make a seated model, a prototype was made, and feedback was generated from the athlete. While just one custom piece was made, an in-depth process of understanding user needs was applied. The authors propose that 3D body scanning, and other areas of virtual garment simulation, may be applicable to future custom or mass market adaptive sportswear development. Paganelli's (2021) research on the feasibility of 3D scanning and virtual garment design for disabled consumers, along with ableist biases that were uncovered, is detailed later in this chapter.

For his dissertation at Eindhoven University of Technology, Baharom (2020) applied a pragmatic design research approach with iterations of user feedback in the development of Cliff, an automated zipper. With a focus on accessibility for an older population, the purpose of Cliff was independence in opening and closing a conventional zipper. Within this research, a series of prototypes were developed to progress the mechanical function, miniaturisation, and acceptance of the product. Technical analyses, user evaluations, and design show feedback sessions were applied to refine the device, shown in Figure 3.1 -- a reproduction of Baharom's photograph titled, *The prototype of Cliff: an automatized zipper* (Fig. 1.1, p. 3).

Through the user testing, co-creation session, and evaluation, Barahom was able to go beyond functional requirements and also meet aesthetic and expressive needs. Improvements concerning stigmatisation and aesthetics were made by making the device removable and portable and also by streamlining the size and shape. Additional feedback by a wider audience suggested that this well-received device could be adopted by additional users, such as consumers with physical disabilities. At the time of publication, further iterations were planned to improve features, such as the attachment method, and to consider manufacturing challenges. Still, Cliff was found to be effective, easy to learn, and controllable. It has great potential for a wide and needed application in making dressing more accessible (Baharom, 2020).

Fig. 3.1 - The Prototype of Cliff: An Automatized Zipper. Baharom © 2020, reprinted by permission of the author.



The above design research initiatives highlight contemporary approaches and methods to create meaningful and functional solutions for clients with needs in clothing and wearables that are not actively being met by mainstream apparel design. While some aspects of disability sport and adaptive sportswear are being explored in contemporary research, much more research is needed. A deeper understanding and involvement of marginalised consumers is a start.

3.2 Apparel-related Barriers and User Needs

This section will explore user needs and values, meanings and motivations, and barriers in clothing choices for disabled consumers. As previously described, a main purpose of sportswear is to address functional and physiological needs in sports or fitness activity (McCann, 2005; Gupta, 2011b; Basant *et al*., 2013; Watkins and Dunne, 2015). But sportswear also encompasses values and meaning, such as trend, self-image, and lifestyle (Basant *et al*., 2013; Bielefeldt Bruun and Langkjær, 2016). In functional apparel design, expressive and aesthetic needs must remain balanced with functional requirements (Lamb and Kallal, 1992).

Carroll (2010b) emphasises the importance of examining the meaning of clothing for disabled consumers:

> *Clothing is in part a social phenomenon: people wear clothes to cover nakedness, to satisfy the social mores of the culture in which they live, to express themselves, and to define their place within a larger group. Clothing is part of a person's interface with the outside world. For persons with a defined disability, clothing not only performs these functions but is also used in evaluating disability.* (para. 3)

Her description of the meaning of clothing encompasses self-expression, social expectations, and group belonging.

In their study, Chang, Hodges, and Yurchisin (2014) investigate dress behaviour of disabled female college students. The researchers conducted in-depth interviews with nine young women with a range of disability classifications. Through a phenomenological interpretation, five themes were found to motivate clothing choice. The themes form and function, self-expression, and social identity matched what was previously found in research of both disabled and non-disabled consumer dress behaviour and meanings. Associating clothing with self-efficacy (a perception of one's capabilities) and symbols of victory (the marking of a triumph of overcoming obstacles) were new themes found in this study. As Chang, Hodges, and Yurchisin suggest:

> *Dress can clearly help to encourage feelings of self-efficacy through self-esteem as well as by symbolizing positive life experiences and accomplishments. As the experiences of participants in this study reveal, such symbols can include conquering threats to one's health and well-being by such debilitating diseases as cancer, posttraumatic stress disorder, or anxiety.* (pp. 44-45)

While these findings are insightful, the authors suggest further research is needed to distinguish clothing meaning for different areas of disability and also related to age.

Kabel, McBee-Black, and Dimka (2016) conducted a qualitative study to "explore the often invisible relationship between apparel-related barriers and disablement" (p. 2184). Using focus groups, they engaged disabled people, carers or family members, and health providers (occupational or physical therapists). A constructivist grounded theory analysis found categories of apparel-related barriers that related to functional, cultural, and sensory-based needs. The focus group setting allowed for unanticipated topics to emerge, and themes from the analysis were created inductively.

According to Kabel, McBee-Black, and Dimka (2016), the first key theme that emerged was apparel-related mechanical or functional barriers, such as fastenings, fabric textures, or fit that were a mismatch with the wearer's needs. For instance, a wheelchair user found slippery fabrics were problematic when transferring on to exercise machines due to l ack of traction. In describing the cultural barriers theme, the authors write:

> *Culturally and generationally engrained expectations about the way one should present oneself can lead to disappointment when those expectations are not met due to a lack of suitable apparel options.* (p. 2189)

One participant referenced difficulties finding appropriate formal footwear. Finally, sensory sensitivity barriers were of concern, particularly to parents with children diagnosed along the autism spectrum. A certain respondent mentioned that her children avoided activities requiring uniforms, like team sports. In this study, it was concluded that disablement was exacerbated by the lack of adequate accessible apparel that leads to barriers in community participation. A need is identified, Kabel, McBee-Black, and Dimka suggest, for innovation in design, mass-production, distribution, and sales of adaptive clothing.

Additional apparel-related barriers have been assessed around limitations in appropriate social attire, according to Kabel, Dimka, and McBee-Black (2017). They note that "the lack of appropriately designed clothing [may contribute] toward people with mobility challenges missing out on important cultural milestones, and reinforces feelings of isolation or difference" (p. 166). Furthermore, they found that inaccessible outerwear can contribute to health issues, and concerns were heightened over finding suitable occupation -specific clothing.

Dimka, Kabel, and McBee-Black (2017) continue to explore apparel -related barriers in their article: 'Disability, participation and apparel throughout the life course.' Referencing the ICF's bio-psycho-social model of disability, Dimka, Kabel, and McBee-Black frame the research as such:

> *Neither disability nor aging are solely biological or biomedical characteristics or processes, as both are also strongly influenced by environmental and sociocultural factors. One such factor is clothing or apparel, which can affect, for example, expression or understanding of personal identity, mobility, social engagement, and treatment of or stigma against individuals in professional and personal arenas.* (p. 17)

This research consisted of an online survey of 110 disabled people of varying age groups to determine difficulties in procuring appropriate apparel. The authors also looked at how this affects social participation as we age. Some challenges appeared across multiple age groups, such as difficulty acquiring appropriate shoes or clothing that fits atypical body sizes or proportions. While a higher percentage of respondents from the older groups indicated declining to participate in social activities due to app arel-related challenges, the type of activity declined was consistent amongst the age groups. This included, in part, swimming events and sporting or exercise activities. Fewer older respondents indicated attempting to procure swimwear or sportswear.

Dimka, Kabel, and McBee-Black's (2017) results discussion indicates that:

> *Particular concerns are reported to be more relevant to younger and intermediate age groups, likely due to the shifting priorities of older adults as well as the lack of desirable clothing designed and marketed toward older consumers especially.* (p. 26)

The authors suggest that clothing contributes to the external environmental factors when assessing impairment against the ICF. As participants expressed common concerns with clothing availability, design, and impact on social engagement, the authors suggest that reasonable efforts be made to alleviate apparel-related barriers.

Cho *et al*. (2020) present a 'Development of garment design strategies for women with visual impairments.' Following a needs analysis with participants, results offer new directions for market inclusion of this consumer. The aims of this exploratory study were to identify clothing needs for women with visual impairment, create design strategies for the garments, and to generate prototypes. Functional and symbolic clothing values, based on Rosenblad-Wallin's user-oriented product development framework (1985, cited in Cho *et al*., 2020), were gathered from focus groups of women with visual impairment. Questions were asked about apparel-related issues and areas of selecting, donning/doffing, and styling garments. Researchers then created design sketches from findings, which the tea m turned into garment prototypes. The garments were verbally described to the participants who were then given time with each garment. Finally, feedback was collected.

Functional values determined from the focus groups consisted of comfort, fit, donning and doffing, closure, tactile identification, and storage. Symbolic values included group membership, self-esteem, colour identification, aesthetic beauty, and tactile decoration. Group membership relevance is described by Cho *et al*. (2020) as follows:

> *The participants valued garments that represented their diverse social identities, like gender, race, age, and other social memberships. Moreover, all of the participants in this study felt strongly that their clothing followed the current social standards of dress as a form of appearance management.* (p. 185)

The full findings help address clothing-imposed barriers to participation, the authors claim. Prototype feedback, however, revealed a disconnect between (the interpretation of) the stated needs of the participants and the implemented designs of the research team. While a final feedback stage is integral to identifying such issues, Cho *et al*. (2020) state, the users should also be considered earlier in the design process.

Indeed, involving users early-on and in more of the creative phases is an aspect of participatory design, as mentioned, to generate more authentic results (Holmes, 2018). As the above research shows, considering many aspects of meaning, needs, and values of clothing for a complex disability community can help identify apparel-related barriers (Chang, Hodges, and Yurchisin, 2014; Kabel, McBee-Black, and Dimka, 2016; Dimka, Kabel, and McBee-Black, 2017; Kabel, Dimka, and McBee-Black, 2017; Cho *et al*., 2020). And within adaptive apparel design, a multifaceted needs exploration can take design considerations beyond just functional adaptation (Lamb and Kallal, 1992).

3.3 The Functional, Expressive, and Aesthetic (FEA) Model: Applied and Modified

As presented in section 2.1, Lamb and Kallal's (1992) FEA Consumer Needs Model is meant to assess user needs in a way that gives more meaning to functional clothing by not distinguishing between fashion and function. Since its publication, the FEA Model has been applied as a framework for multiple journal articles focusing on various groups of consumers and product design (Chau, 2012; Christel and O'Donnell, 2016; Orzada and Kallal, 2021). For instance, the FEA Model is used in Bye and Hakala's (2005) case study on the design development of sailing apparel for women. They state:

> *The design combined functional, expressive, and aesthetic attributes to protect the body, maintain health and safety, and improve the wearer's sailing efficiency as outlined by the design criteria*. (p. 54)

Investigating the FEA Model's relevance to disabled consumers, Stokes and Black (2012) propose an updated model based on their study of clothing needs of adolescent girls with disabilities. Their findings suggest the relevance of the model but also highlight further

applications. In their literature review, they reference findings from Bye and Hakala's (2005) study and a case study from Kidd (2006) (to be discussed below) on special occasion wear for young women with spinal curvature. Stokes and Black conclude that safety questions were missing from the original FEA Model. They, therefore, included this area into their needs investigation.

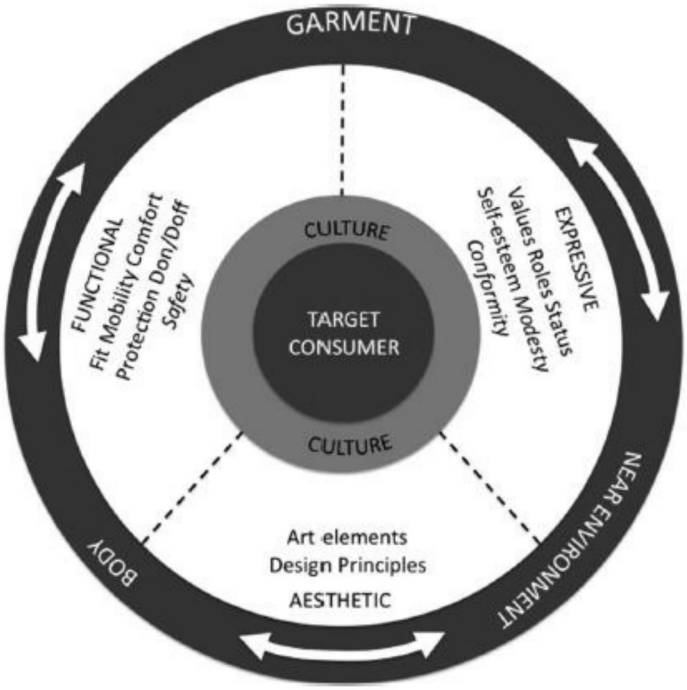
In Stokes and Black's (2012) study, 33 adolescent girls were surveyed with open-ended questions, and answers were analysed based on functional, expressive, or aesthetic considerations. The responses were mostly about functional needs, but expressive and aesthetic needs were mentioned as well. Understanding the body/garment/environment relationship came up as an issue in a few instances. For example, respondents suggested safety could be an issue if clothing became caught in an assistive mobility device, and it could be a potential source of embarrassment. One participant talked about her need for high-waist trousers to conceal her colostomy bag. Stokes and Black (2012) suggest that:

> *The findings of this study illustrate that the body/garment relationship is a complex combination of functional, expressive and aesthetic considerations. An important finding is the need to expand the role of the body/garment relationship into the body/garment/near environment relationship.* (p. 184)

They also found that responses were sometimes a combination of functional, expressive, and/or aesthetic needs. These interrelationships are not acknowledged, they state, in the FEA Model that separates these needs into distinct categories.

Stokes and Black (2012, Fig. 3, p. 185), therefore, illustrate a *Revised FEA Model*, shown in Figure 3.2, with an outer body/garment/near environment ring and dotted (rather than solid) lines between the FEA sections. This serves to remind that needs may be multifaceted. Functional needs may overlap with elements of self-esteem or group belonging, for instance. Also, clothing interaction with assistive or medical devices warrants attention.

Fig. 3.2 - Revised FEA Model. Stokes and Black © 2012, reprinted by permission of Informa UK Limited, trading as Taylor & Francis Group, http://www.tandfonline.com.



With a focus on disability and the original FEA Model (Lamb and Kallal, 1992), Chae (2022) applied the consumer needs model to compare adaptive apparel needs of men and women with mobility impairments. She found that most needs between those two genders overlapped, many of which have been noted in previous writings on adaptive apparel needs. Two needs newly expressed through her work are: 1.) elbow patches to prevent wear-and-tear indicated by male wheelchair users; and 2.) functional pockets for men and women. More functional needs were indicated than expressive or aesthetic for this consumer group. Specific aesthetic considerations were most different between the male and female participants. Overall, she found that participants could not find available clothing that matched their needs, and many did not seem aware of the existing adaptive apparel retailers.

The FEA Model has also been applied for a single user, custom adaptive garment. As noted in section 3.1, Hobbs and Morris' (2020) design and development of a custom Paralympic shooting jacket applied Lamb and Kallal's (1992) FEA Model to assess the athlete's needs. Following their ITAA conference proceedings, Hobbs-Murphy, Morris, and Park (2022) published this design research as a single case study. To begin, the authors claim that typical made-to-measure shooting jackets available for Paralympic athletes do not consider disability (or FEA needs) beyond offering shorter length jackets for a seated figure. Within their framework, they highlight the importance of the central portion of the FEA Model that

pertains to the culture that surrounds the target consumer. Hobbs-Murphy, Morris, and Park state: “Understand athletes’ specific cultural truths prior to understanding other needs” (p. 8), and “[d]isability should be focal in working with disabled people” (p. 8). They also assert that the specific sport should be considered. From there, they proceed to assess functional, expressive, and aesthetic needs, as well as intersectional functional-expressive, expressive-aesthetic, and aesthetic-functional needs of the Paralympic shooter.

Another key component to the process that Hobbs-Murphy, Morris, and Park (2022) follow is the additional touch-points with the athlete. Whereas Lamb and Kallal (1992) recommend five points of contact with the consumer during the design process, Hobbs-Murphy, Morris, and Park applied 17. This was done, in part, to gather more data points to reduce the issue of generalisability in a single case (Yin, 2017, as cited in Hobbs-Murphy, Morris, and Park, 2022). In addition to expressing needs and opinions in interviews, the athlete was able to give feedback on proposed flat sketches, digital renderings, and prototypes. Hobbs-Murphy, Morris, and Park write that:

> *The design process allowed [the athlete] to contribute to the design, adding her voice and expertize to the process and ensuring that her needs were met. (p. 12)*

Hobbs-Murphy, Morris, and Park (2022) state that, in addition to lauding the design process which prioritised communication, the athlete was satisfied with many features of the final shooting jacket prototype. The jacket was not, however, able to be worn for shooting, due to issues with the fit. The authors attribute this to limitations in the digital software (to be commented on below in section 3.6) and to the inability to conduct a final in-person fitting due to COVID-19. But the application of the FEA Model, focusing on the central cultural context and looking at intersectional needs, is recommended by the authors. And, greater involvement and collaboration with the athlete, Hobbs-Murphy, Morris, and Park suggest, may help them feel more connected to and satisfied with the garment. A further look at user involvement within the adaptive apparel design process is presented next.

3.4 User-Centred Design and User Collaboration for Adaptive Apparel Design

In this section, research articles exploring processes of generating adaptive apparel design solutions will be reviewed.

A range of methods are employed to meet user needs through design:

- UCD for wheelchair rugby uniforms (Bragança *et al*., 2018)
- Participant collaboration and wear-testing for women's casual and special occasion wear (Kidd, 2006; Azher, Saeed, and Kalsoom, 2012)
- Co-design sessions for sportswear for the "active ageing" (McCann, 2016)

Throughout all, a central focus is kept on the participants with a goal towards removing barriers of exclusion in apparel design. User collaboration and contributions are managed differently by the researchers, while meeting needs of underserved consumers is prioritised.

With an engineering and human factors approach, Bragança *et al*. (2018) researched wheelchair rugby players' apparel needs and provided appropriate design recommendations for tops, bottoms, and gloves. The study was meant to raise awareness of those needs and promote inclusivity of disabled athletes. As they state:

> *Clothing for people with some kind of disability is a topic that has been explored, but not in a manner that encompases all users especially when it comes to very niche markets, like sportswear.* (p. 9)

Following a UCD approach, Bragança *et al*. (2018) suggest that products should be designed from information gathered from end-users to ensure solutions for real needs. A multimethod approach of a focus group and questionnaire were used to:

1. Assess satisfaction of sportswear items used;
2. Identify problems with the sportswear;
3. Find possible solutions for player needs.

In addition to the function of the garments, this study also looked at issues of fit, comfort, aesthetics, materials, and wearable technology. The focus group was semi-scripted with three participants, and the aim was to understand the general situation of the sportswear used. The questionnaire (completed by 61 wheelchair rugby players from the UK) followed the same aim but was based on findings from the focus group as well as the literature review. In addition to subjective rating scales, many open-ended questions were used for participants to freely express which aspects of sportswear posed problems and needed to be addressed.

As there were only three participants in the focus group, their insights were not deemed representative of all athletes but did provide insights on apparel-related barriers in this area. Participants indicated having to buy garments designed for non-disabled consumers and finding their own way of making them functional and comfortable. Gloves, trousers, and bespoke items were given the most attention. While participants indicated gloves posed a problem since they are not sport-specific, trousers carried issues around function and improper fit for wheelchair use. Respondents also indicated a preference for bespoke items that could be tailored to the sport and to individual wearers. While they acknowledge this would bring a higher cost that might pose a barrier for some, some of the athletes supported this idea of individually customised garments (Bragança *et al*., 2018).

Respondents of the questionnaire had a variety of impairments and played for different clubs around the UK. Responses suggested a preference for considering function over aesthetics. One-third required assistance to don and doff garments. While most of the athletes indicated fair-levels of satisfaction with the garments they already use, one-third were highly dissatisfied. Fit and temperature were the greatest problems, and gloves, trousers, and sleeveless tops and vests (in that order) proved most burdensome. From the questionnaire, garment suitability for wheelchair use seemed more important in choice than being sport specific. Most garment-induced restrictions on the players' movement happened when manoeuvring the wheelchair and throwing the ball. Respondents indicated material comfort needs changed at different parts of the body (Bragança *et al*., 2018).

Design recommendations were then generated for tops, bottoms, and gloves based on data from the focus group, the questionnaire, the literature review, and the expertise of the researchers. Recommendations were divided into four categories: fit and comfort, safety, materials, and special features. The final design outputs from Bragança *et al*. (2018) are shown in Appendix A. When discussing limitations, the authors mention that these design recommendations came largely from the research team's prior knowledge, but it is unclear what this entails. The authors do note that the designs are intended as suggestions – based on needs and requirements of these athletes – to be interpreted creatively by fashion designers.

While bespoke garments are the ideal option, Bragança *et al*. (2018) write, large-scale manufacturers are not set up for such customised orders. Smaller-scale innovators are an option but may have limited access to information about demand, the authors note. Rather than suggesting completely customised garments, the design suggestions are meant to show adaptations that can be done to existing sportswear so that it better suits wheelchair rugby players. Bragança *et al*. suggest:

> *As happens with clothing for the masses in ready-to-wear stores, where customisation depends on each individual, these design recommendations could also be used for large companies to create a clothing line that would better respond to wheelchair users' needs in general.* (p. 20)

This study expands awareness that specialised garments for wheelchair sports are necessary. It provides in-depth pragmatic direction on what apparel-related barriers need to be addressed for this type of uniforming. More collaborative design with the end-users could perhaps assist in finalising the details in these garment proposals. For instance, how would the sleeves and trouser legs separate and reattach to match both user needs and manufacturing requirements? Future work is intended with a larger team that includes experts in sport and design, as well as more end-users from around the world, Bragança *et al*. (2018) conclude. Later in this chapter, research on adaptive apparel manufacturing for customisation and for the ready-to-wear market are discussed.

In Azher, Saeed, and Kalsoom's (2012) study, 'Adaptive clothing for females with arthritis impairment,' garments were designed to address two key questions:

1. *To assess the level of independence of adult female patients when facilitated by adaptive clothing*
2. *To determine change in self-confidence level of adult female patients with the use of adaptive clothing* (p. 53)

As the study was exploratory, a qualitative and inductive approach was used. Three women in Pakistan with rheumatoid arthritis were purposefully sampled from recommendations of an orthopaedic specialist. The methodology consisted of a three-phase progression of data collection and analysis. Phase 1 included data gathering on barriers faced by participants, such as dressing and undressing independently. In-depth interviews were done with the women, and observations were done in their homes, focusing on walking, sitting, eating and grasping objects. Notes were made on types of clothing worn by the women. Medical specialists were also interviewed during this phase.

During Phase 2, designs were created in collaboration with the participants. Azher, Saeed, and Kalsoom (2012) state that:

> *The collaboration involved interactive sessions with the members of the sample to comment on the sketches made in the initial stage of the design, and then finalized the sketch design according to their preferences.* (p. 55)

Drawings of three options of tops (kameez) and bottoms (shalwar) were completed by the designers, and participants narrowed these down to one choice for wear-testing. Phase 3 consisted of wear-testing designs with participants and evaluating the effects on independence and self-confidence through observations and interviews. Azher, Saeed, and Kalsoom report, “all participants found all features very comfortable and convenient that makes them more independent and self-confident” (p. 56). They also claim that “all these features were seen to also be applicable to those who belonged to other groups with [a] similar range of physical disabilities,” (p. 56).

Azher, Saeed, and Kalsoom (2012) found that independence was increased through easy-function styling and fastenings that allowed participants to dress with much less assistance. Self-confidence was boosted by making the function of the garments easier as well as styling them to be aesthetically pleasing. The authors state that participant collaboration helped reduce the amount of issues in the final production. Future research, as indicated by the authors, could include increasing the sample size, including men, and considering readymade products. More exploration into how these designs suit other areas of disability is also suggested. This notion of reaching a wider scope of consumers through identifying common apparel needs is covered in the next section on inclusive design.

Kidd (2006) presents a case study in which special occasion dresses, combining fashion and function, were custom designed for four women with severe spinal curvature. She notes that much available adaptive apparel is functional rather than fashionable, and there is a particular lack in special occasion garments suitable for young women with a physical disability. The student designer, mentored by the author, had no previous experience working with disabled people and began by looking up web and library resources. Many of the resources echoed the importance of adaptive apparel being fashionable and following trends. A review of available adaptive apparel for adults, however, showed few options and often with "styling compromised for function,” writes Kidd (p. 162).

To create the special occasion dress designs, the four women were involved in the design development process. In separate sessions, each participant was:

- Asked open-ended questions to “break the ice” and gather design information;
- Shown pictures of dresses from fashion magazines to aid in communicating fashion terms;
- Consulted on fabric choices.

As primary caregivers, the participants' mothers attended (in most cases), gave recommendations on functional needs in garments, and provided critical advice pertaining to, in part, shoes able to be worn and the effect of the braces worn on clothing. While suggestions were able to be incorporated into the gowns, the input of the mothers sometimes proved challenging when there was disagreement with the daughters on what was fashionable or appropriate. Individual design consultations were d one with prepared design sketches and fabric swatches (Kidd, 2006).

Kidd (2006) writes that "certain characteristics of gowns selected by the participants contradicted recommendations endorsed in the literature" (p. 162). For example, shorter skirt lengths and knit fabrics were often recommended in the literature. The participants, however, selected floor length styles to cover leg braces, and wovens were preferred for their "dressy" quality and better function over leg braces. This supports a need to con sult real users over, or in addition to, previously reported studies on adaptive clothing styling recommendations, Kidd suggests.

After measurements were taken from the participants to draft the final dress patterns, Kidd (2006) notes that she had to stop the fashion student from "redraw[ing] and even[ing] up" (p. 166) the bodice pattern to make it appear more symmetrical. Prototypes were then created and wear-tested, which allowed the designer and the participants to experience first-hand how the fabric draped and moved when worn. Skirt and top designs had to account for the braces worn by the participants, body posture, movement when walking, and types of shoes worn. Kidd states, "it was very important for the student designer and faculty mentor to be aware of the participants' health problems and be flexible when necessary" (p. 169). The fitting stage, in particular, was delayed for various health related factors, including a six-week delay as one participant waited for new waist-to-foot braces.

The particular value of this case study comes from the experiential knowledge that the mentor and student gained through this process. Both were trained in fashion design but not in adaptive apparel. As Kidd (2006) writes, "the fitting process in construct ing [adaptive apparel] is difficult and very time intensive" (p. 170). She notes that the most difficult part for the student was to visualise the participant's body outline as the waist -to-ankle braces and adjust the fitting analysis accordingly. Kidd summarises:

> *Working with people whose bodies represented unusual fitting challenges forced the student to learn to adapt basic skills learned in beginning flat -pattern and draping courses. Her speed in performing fitting alterations and her confidence in wor king*

> *with clients grew dramatically during this project. In particular, she learned to think abstractly and to try new solutions based on traditional methods*. (p. 170)

Kidd stresses the importance of maintaining the personal element in the interaction between designer and client. Open and positive communication channels, as well as keeping the participant informed of every step in the fitting process helped achieve good fit results, maintain participant comfort, and impart a sense of ownership to the participants.

In another collaborative research case study (the "Design for Ageing Well" project,) McCann (2016) discusses the co-design methodology used to design outdoor sportswear for the "active ageing." Very little trend forecasting in fashion and in sportswear exists, McCann claims, to provide guidance for sportswear designers addressing an ageing consumer. She writes:

> *In order to encourage participation in healthy exercise, there is not only a demand for well-designed, age-appropriate sports clothing but also the need for new strategies in addressing older user design needs and in bringing the product to this new market.* (p. 236)

Also needed, she states, are new language sharing strategies to connect disparate branches of expertise (clothing and textile designers, electronics manufacturers, and healthcare experts) necessary for increasingly complex sportswear design.

The aim of McCann's (2016) project was to develop an outdoor sportswear layering system with assistive wearable technology for men and women ages 60-75 to engage in healthy exercise, like walking. Industry stakeholders, cross-disciplinary experts, and users engaged in an iterative co-design process, which is new to apparel development McCann claims. While keeping users central to the cross-disciplinary engagement, three groups of expertise were established:

1. Behaviour - looked at what users were willing to wear and use
2. Clothing - looked at technical and aesthetic components of the garments
3. Technology - looked at tech that would enable "independence, healthy exercise and social engagement" (p. 142)

McCann (2016) recounts that multimethods -- interviews, focus groups, questionnaires, and co-design design sessions -- were employed.

These techniques served to:

- Create a shared language between groups;
- Break down barriers between groups;
- Understand user perceptions of functional sportswear;
- Empower older consumers to voice needs to industry stakeholders.

Further co-design sessions contributed to garment fit, collaboration between the various disciplines, and selection of appropriate technology components. It also:

> *Enabled the industry stakeholders and young researchers, often for the first time, to identify the design requirements of the active ageing in order to bring the benefits of textile innovation to a new market.* (p. 244)

The project, McCann (2016) writes:

> *Provided design guidance for the development of functional, outdoor sports clothing for active ageing men and women. Findings, informed through evolving a co-design process, produced proof-of-concept prototypes to address the range of design requirements identified.* (p. 240)

Though the co-design process was slower than a typical apparel development process, it was also more responsible in developing a fit-for-purpose product. Design preferences were documented in areas of: aesthetics, fit, functional detailing, materials, colour, wearable technology, and garment specifications and prototyping. As McCann (2016) states, this case study:

> *Has pointed to the need for a slower, more considered, user-led design process to be adopted by product developers who have an interest in bringing functional sportswear to a predictable and growing, but neglected, active ageing market.* (p. 252)

Due to its goals of breaking down knowledge barriers and empowering a neglected user group to voice their input, the "Design for Ageing Well" project reaffirmed a user-led mindset for this research.

From UCD to participant feedback in design sessions to co-design sessions, the selection of adaptive apparel design research shows a keen focus on prioritising user needs and

values. Of particular interest are the human-centred data collection methods employed and the emphasis placed on user empowerment, comfort, and inclusion. As will be delineated in the following chapter, many of these methods and mindsets were adopted when engaging with participants in this study.

3.5 Inclusive Apparel Design: Reaching a Wider Scope of Consumers

Apart from Azher, Saeed, and Kalsoom (2012), the design research mentioned focuses on adaptive apparel – creating garments specifically for a marginalised consumer group. Further research on how mass manufacturing may be applied in these instances will be addressed later in this chapter. The notion of reaching a wider base of consumers – current mass market consumers plus those who have been previously excluded – is explored below as inclusive, or universal, apparel design. Carroll (2010c) suggests that:

> *T]he concept of universal design, provides a framework within which an item of clothing could be produced to satisfy many consumers, regardless of their physical ability… Manufacturers, distributors, and consumers could all benefit if a universally designed garment can be successfully produced and marketed to many types of consumers.* (para. 5)

Park *et al*. (2014) apply The Center for Universal Design's seven principles of universal design – mentioned in section 2.4 – within their apparel design projects. The intent was to craft universal design guidance for fashion pieces that are broadly inclusive while also allowing for individual styling preferences. They write that:

> *Apparel must conform to a person's physical individuality imposed by age, weight, gender, body shape and life stage while also meeting practical needs for protection from the environment.* (p. 269)

So, it is not difficult to understand the lack of research on universal design for apparel due to these complex factors, the authors state. Two case-studies of apparel product development with universal design considerations embedded are presented. The final designs were: 1.) a dress with an optional support belt for women transitioning through pregnancy and beyond, and 2.) an ensemble that suits a wide range of women over a lifespan of body changes. Inspiration was taken from cross-cultural and contemporary examples of clothing that are versatile, flexible, and usable to reach a wider audience. The end results are two garments with flexibility in styling and versatile fits, showing that some

aspects of universal design can be embedded in fashion. Of the first garment, Park *et al*. (2014) write:

> *The indeterminate front and back of the design limit confusion and fault while dressing. The belt accessory is simple in design for the same reason. Not only does the belt provide the ability to manipulate the silhouette, but it also acts as a functional support accessory to provide the wearer with the desired support and compression during her pregnancy.* (p. 280)

Some universal design principles are targeted here: flexibility in use and low physical effort. The second dress, Park *et al*. (2014) claim, was highly flexible and versatile in use to suit many differently shaped and sized wearers throughout life-cycle changes. They also write that "no matter how she wraps the scarf, the created look is still guaranteed to be acceptable. This fulfils the principle of tolerance for error" (p. 283). The garments were developed and evaluated, however, at the design research team's discretion without user research or feedback. Feedback was given by exhibition staff at an international juried design exhibition on ease of assembling the second garment (Park *et al*., 2014). Further exploration and testing with an array of real end-users would be insightful.

From a disability inclusion perspective, the universal designs presented by Park *et al*. (2014) may be inaccessible for some disabled consumers. The second garment, for instance, has a zipper on one side of the body, which means it may be inconvenient to don or doff for some wearers -- both due to zipper manipulation and the reach required to access it. The accompanying scarf is shown to be draped over the shoulders from the front and crossed at the shoulder blades before being brought around to the front again, threaded through slits in the fabric, wrapped around the waist, and knotted at the waist. An argument can be made that this style may not be easily donned or doffed or accommodating of upper limb impairments or differences.

Still, application of universal design principles within an apparel product development process is intriguing, and Park *et al*.'s (2014) study shows that more versatility can be designed into single garments. The authors do recommend, however, that a more demographic approach to universal design for apparel may be best practice. This is due to the proximity of clothing to the body, which renders a "design for all" goal too idealistic, they state.

Focusing specifically on disability inclusion, Carroll and Kincade (2007) suggest that an inclusive design approach could be a successful model for developing apparel for disabled

people. The authors address apparel needs of working women with physical di sabilities, citing the lack of appropriate office attire for this consumer group available in the traditional retail environment. This dearth, they note, is because “a lack of interaction exists between the constraints of the consumer with disabilities and those of the apparel industry” (p. 294).

As a framework, Carroll and Kincade (2007) adapted six of the seven principles of universal design from The Center for Universal Design for clothing design:

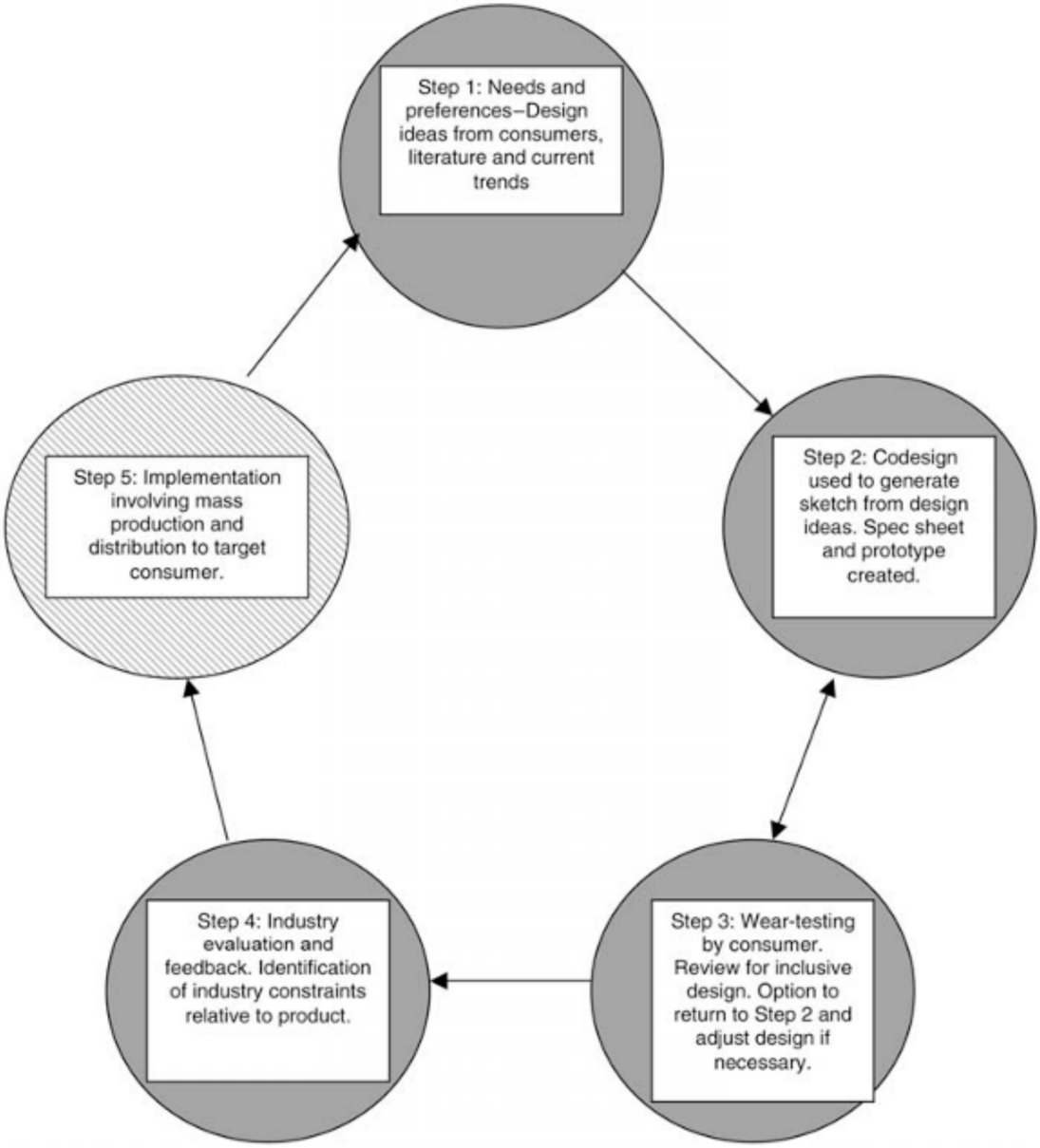
1. Equitable use - Clothing can be used by people of varying abilities.
2. Flexibility in use - Clothing can adapt to fit varying body types.
3. Simple and Intuitive use - Clothing will not be mistaken in the way it can be worn.
4. Tolerance for error - Clothing has minimal risks with use.
5. Low physical effort - Clothing is easy to don, doff, and wear.
6. Size and space for use - Clothing has enough room for comfort and mobility.

Two areas of research were: 1.) Can the needs of specific consumer groups be addressed in inclusive apparel? and 2.) Will the apparel industry be able to actualise these products? Based on their literature review, Carroll and Kincade generated a product development model (Figure 3.3) to guide the research process. Their diagram is called the *Proposed framework for inclusive apparel product development for working women who have physical disabilities* (Fig. 1, p. 298). Steps 1 through 4 were explored in their study.

Step 1 included interviews with nine working women with physical disabilities on clothing needs, as well as co-design sessions for design ideation. Ease of movement and easy-to-manage fastenings were given priority overall. In Step 2, researchers used data from the interviews and co-design sessions to generate one single sketch and prototype meant to suit all participants. This was easier than expected, the authors state, due to the similarities in apparel-related barriers found in Step 1.

The evaluation in Step 3 consisted of wear-testing by the interview participants (users) and by six working women without physical limitations (evaluators), as well as evaluation of the design against the six criteria previously listed for universal design. A universal design expert and a study researcher concluded that all pre-determined universal design criteria had been followed. The user and evaluator wear-testers indicated that fastenings exceeded expectations but that aesthetics and construction, however, fell below expectations (Carroll and Kincade, 2007).

Fig. 3.3 - Proposed Framework for Inclusive Apparel Product Development for Working Women who Have Physical Disabilities. Carroll and Kincade © 2007 American Association of Family and Consumer Sciences, reprinted by permission of Wiley Publishing.



Step 4 consisted of in-depth interviews with six apparel manufacturers, as described by Carroll and Kincade (2007). The manufacturers were each sent a specifications sheet of the prototype with measurements and construction details. They were then asked to assess feasibility according to four parameters (Cohen, 1991, cited in Carroll and Kincade, 2007): 1.) company operations, 2.) engineering and production, 3.) finance, and 4.) marketability.

Generally, the manufacturers indicated that:

1. The product was not compatible with current operations;
2. The product would be easy to produce;
3. Costing could not be determined with the information provided;
4. Marketing was not compatible with current sales and marketing operations.

Carroll and Kincade (2007) conclude that a co-design process with an inclusive design approach could address consumer constraints. They also suggest that grouping consumers with dissimilar disabilities but similar effects on the body can facilitate apparel product development. A large barrier, the authors state, to more widely available clothing for this consumer group is the apparel industry's preconceived notion that catering to disabled consumers is too costly and conflicts with existing apparel lines and brand image. In the Step 4 industry evaluation phase, manufacturers were made aware that the product was intended for use by consumers with physical disabilities, which the authors surmise, biased the manufacturers' perception and responses. This is made evident in Carroll and Kincade's summary of company operations responses:

> *A common concern for all manufacturers (n=6) was that the product was incompatible with their current operations. Each manufacturer stated that his or her company did not produce or market similar types of products, even when a review by the researchers concluded that the product was similar in style to some manufacturers' product lines. Manufacturers also felt that they would not have the support within their companies necessary to meet after-sales requirements they perceived that this type of customer might need.* (p. 310)

Carroll and Kincade highlight additional industry-related challenges for inclusive apparel design, such as cost and deeper awareness of disabled consumers' needs and values. Price-point desired by users, for instance, did indicate production or marketing costs would need to be reduced. The authors suggest selling direct to consumers from the manufacturer instead of going through a brick-and-mortar retailer to reduce margins. But "manufacturers generally were unsure about whether production of this type of product would generate enough sales to turn a profit" (p. 312). The authors note that the sample size should be expanded in the future and that Step 5 would yield further results about reaching and satisfying consumers on a wider scale. Also, the findings state that more focus should be placed on aesthetics. It is possible that by evaluating the inclusiveness of the product by the six pre-determined universal design criteria, the authors write, too much emphasis was

placed on functionality. While functionality is crucial for inclusive design, it needs to be better balanced with a wider set of user values and needs (Carroll and Kincade, 2007).

Building on the above findings, Carroll and Gross (2010) designed a subsequent study to broaden the user base and further investigate a product development solution for mass-production level. They claim that the apparel industry cannot economically cater to individual size and fit, let alone complex individual needs. Instead, they suggest that an inclusive approach might make it easier for the industry to address consumers with physical disabilities. The aim of the study was to find if groupings of similar physical disabilities in working women were related to groupings of product development challenges.

While the previous study developed one jacket that suited nine working women with a variety of physical disabilities, the authors suggest that one solution is not practical for all working women with physical disabilities. They state, "the researchers intend to bridge the gap between customization and a mass market approach, achieving a readily accessible solution for users and industry alike" (p. 5). Inclusive products, they write, can also be worn by consumers without disabilities. In addition, they follow Jordan's (1999, cited in Carroll and Gross, 2010) assertion that disability, rather than segmenting ability, is simply another dimension of how all people may differ from one another. Inclusive design, then, serves to widen the consumer base to encompass more aspects of humanity.

Data was collected through email and mail surveys from 117 respondents -- disabled women who were working, retired, or planning to re-enter the workforce. Two measures were used in the survey. The first measure determined the degree of physical limitation, defined by 17 variables. These variables are illustrated in *The Enabler* (Carroll and Gross, 2010, Fig. 2, p. 8), shown in Figure 3.4 below. Such is often used in universal design (Null and Cherry, 1996, cited in Carroll and Gross, 2010).

The second measure was to determine existing clothing problems, defined by 10 variables based on findings from previous literature. These variables are listed in the authors' table titled, *Clothing dimensions used to evaluate level of difficulty* (Table 1, p. 9), shown below in Figure 3.5. Open-ended, write-in responses were also included to expand on areas not covered in the measured variables. Three areas of clothing problems were determined: design, materials performance, and dressing. A further analysis determined which physical differences predicted clothing-related barriers (Carroll and Gross, 2010).

Fig. 3.4 – The Enabler: Used in Conjunction with Areas of Physical Limitations to Identify Body Areas Affected by Disability. Carroll and Gross © 2010 American Association of Family and Consumer Sciences, reprinted by permission of Wiley Publishing.

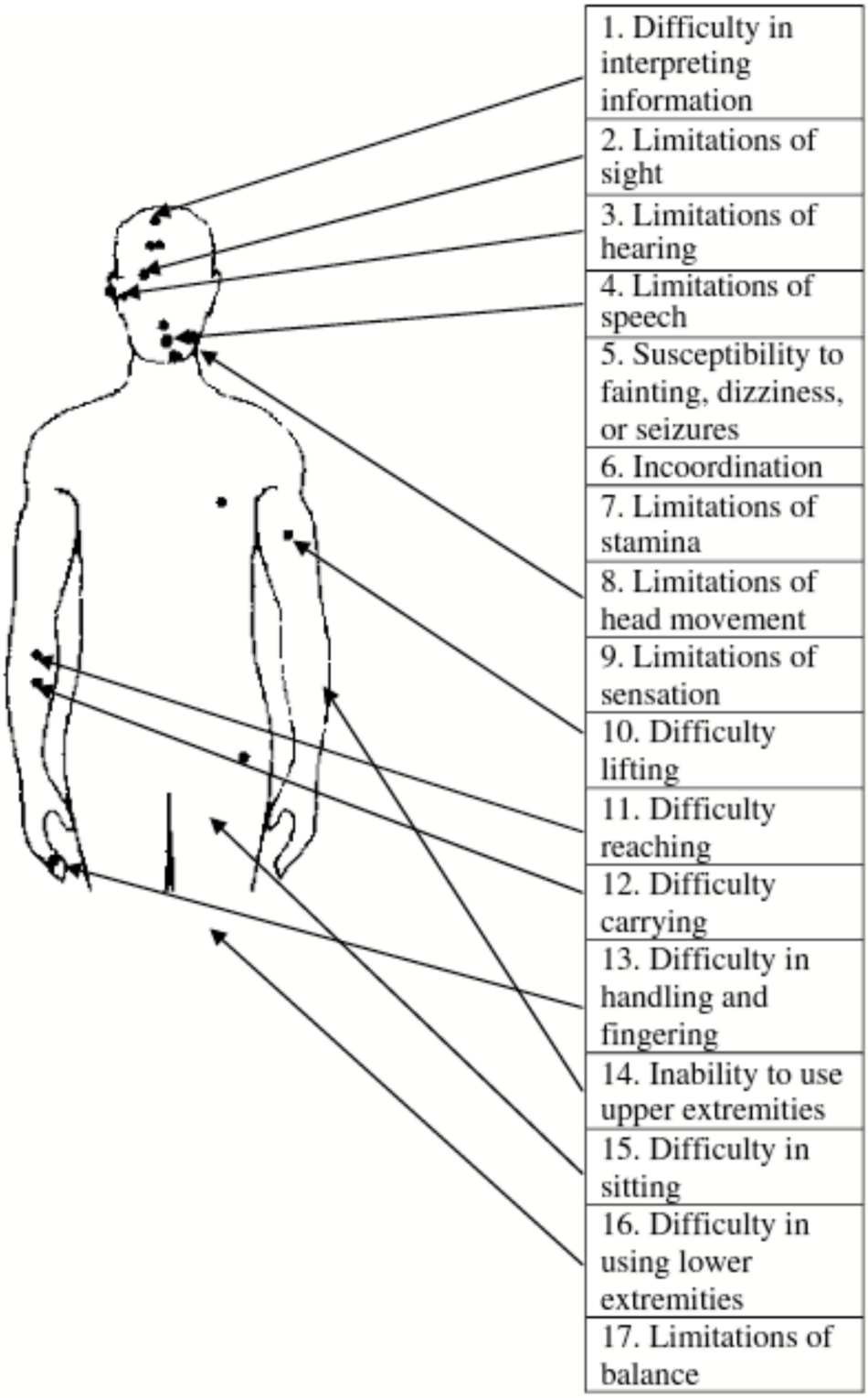


Fig. 3.5 - Clothing Dimensions Used to Evaluate Level of Difficulty. Carroll and Gross © 2010 American Association of Family and Consumer Sciences , reprinted by permission of Wiley Publishing.

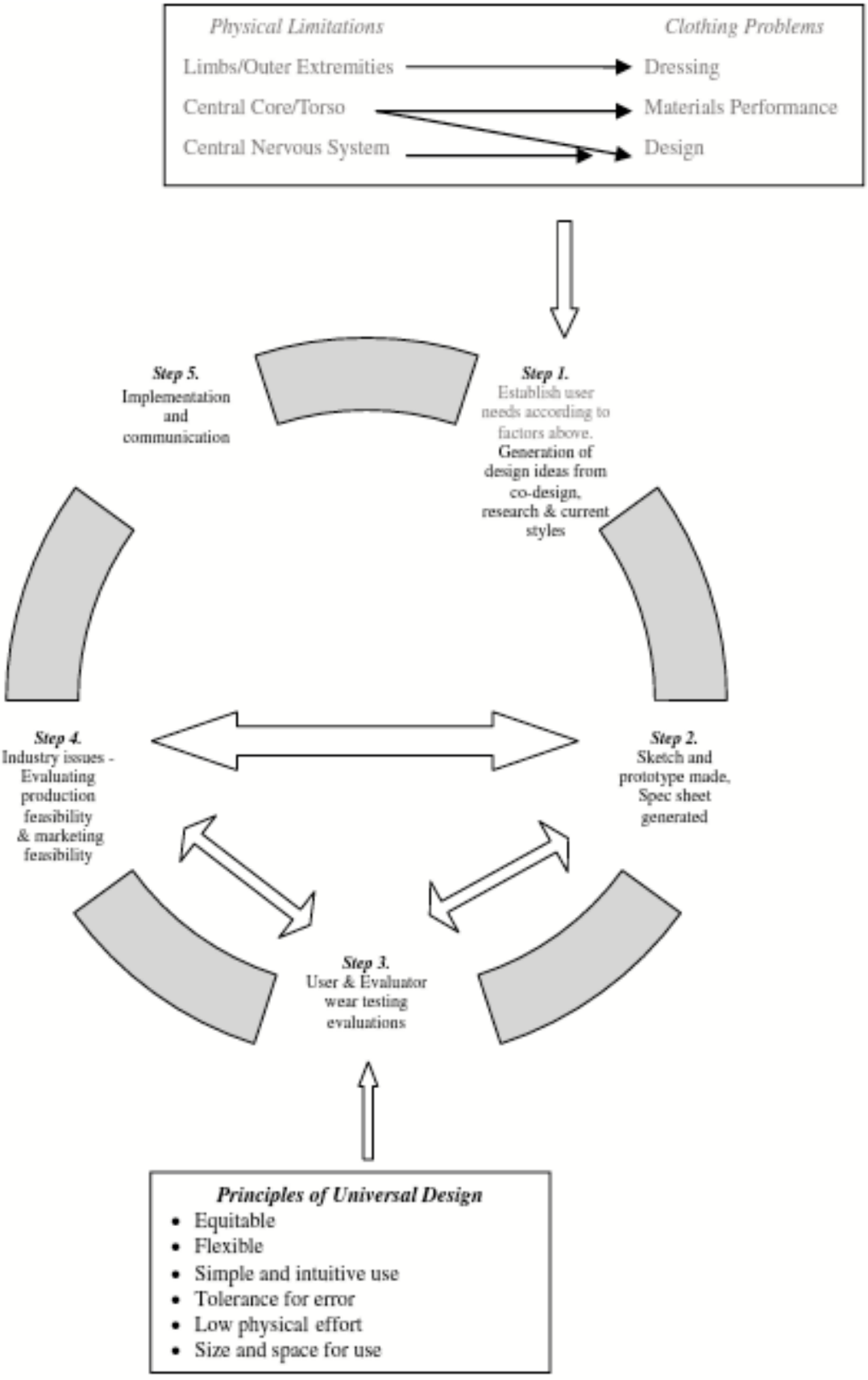
1. Donning and doffing (putting clothing on and taking it off)
2. Managing fastenings (e.g., hooks and eyes, zippers, buttons, due to restricted use of hands and lack of mobility)
3. Freedom of movement of clothing items (for a variety of activities, e.g., crutch walking, sitting in a wheelchair)
4. Fabric comfort (texture and hand of fabric against the body)
5. Fabric comfort (ability of fabric to maintain comfortable body temperature)
6. Coverage of the body (ability of clothing to maintain desired level of modesty, e.g., while walking with crutches)
7. Availability of desired sizes
8. Construction quality relative to needs
9. Extra features (e.g., embroidery, pockets)
10. Aesthetics (attractiveness) of available clothing styles

Carroll and Gross (2010) found the following associations with types of clothing problems:

- Limb/outer extremity -- Dressing: donning and doffing, fastenings
- Central core/torso -- Materials performance: coverage, movement, texture, temperature; Design: construction, sizing, aesthetics
- Central nervous system -- Design: construction, sizing, aesthetics

They also found this information could be used in step 1 of Carroll and Kincade's (2007) model, and a clustering of consumers could enhance steps 4 and 5. This is shown in Carroll and Gross' diagram, *Proposed adaptation to model* (Fig. 3, p. 13), reproduced below in Figure 3.6. The authors suggest "merchandisers would be able to use the groupings for product selection, marketing, selling, and visual merchandising purposes" (p. 12).

Fig. 3.6 - Proposed Adaptation to Model. Carroll and Gross © 2010 American Association of Family and Consumer Sciences, reprinted by permission of Wiley Publishing.



Carroll and Gross (2010) challenge prior industry perceptions that accommodating disabled consumers is not feasible or cost effective. Their results offer insights and practical guidance to the apparel industry that could increase awareness of the range of human distinctions and ways in which industry can effectively address these differences. While the authors do suggest inclusive apparel designs could be used by non-disabled consumers, however, this investigation is outside the scope of their study. The inclusive solutions they propose are targeted specifically to groupings of physical disability categories. More research is needed to determine if their groupings of clothing problems would be adopted by a wider consumer base.

So, in addition to the strategies for adaptive apparel design research previously described, strategies for inclusive apparel design can also be considered. Sportswear, however, has a vastly different end-use purpose and multidisciplinary design and engineering scope than casual or office attire. Needs and values for inclusive sportswear design have their own unique considerations, as will be described later in this thesis. Either with adaptive or inclusive sportswear design, production questions remain on how to present these projects to manufacturers and how to incorporate the needs of a more diverse consumer base.

3.6 Mass Market Apparel Production for Disability Inclusion

As described, Carroll and Kincade (2007) suggest that industry biases around manufacturing apparel for disabled consumers may impede expansion of this market. This section reviews research that has since been done on apparel production inclusive of disabled consumers. As previously indicated, Paganelli (2021) explores embedded ableist biases with the apparel industry by evaluating the application of virtual garment technology for mass customisation in relation to disability inclusion. McBee-Black (2021, 2022) and McBee-Black and Ha-Brookshire (2022) examine design innovation and mass production of mainstream adaptive apparel. They do so through case-studies on Mindy Scheier's (a fashion designer and advocate for adaptive apparel) and Tommy Hilfiger's successful collaboration of adaptive apparel for children.

First, Paganelli (2021) investigates the option of virtual garment design for apparel customisation, specific to disabled consumers. Custom garments, he posits, are only accessible if they are affordable to those who need them. For his research, he writes:

> *3D body scanning, virtual design tools, and computerized 3D knitting [were] assessed on their ability to facilitate the mass production of inclusive apparel for persons with disabilities*. (p. 192)

While an ableist bias was ascertained within these tools, as will be described, Paganelli suggests that updated digital tools could provide new opportunities for representing greater body diversity within the apparel industry.

Paganelli's (2021) design research goal was to produce customised options while still keeping the affordability and efficiency of the mass market. A focus was placed on physical mobility, asymmetry of bodies, and relation to dressing. Four participants identifying as disabled were observed donning and doffing, and they collaborated in designing the apparel (individual suit jackets) and testing the technology. During this process, barriers became apparent to achieving successful apparel designs. These were:

- Most 3D scanning software required the person being scanned to stand with arms either at 45- or 90-degree angles, which excluded all but one participant.
- It was found that "standard" poses – involving full mobility and body symmetry – were required for importing 3D scanned models into the software that creates virtual avatars.
- When converting the digital suit jacket pattern from the virtual software to the 3D knitting software, the atypical silhouette could not be managed.
- Removing a sleeve from the stock pattern, for one participant, ended up compromising the size and shape of the original pattern while also requiring a significant amount of time.

Paganelli (2021), thus, concludes:

> *Research into 3D body scanning, virtual design tools and 3D knitting has exposed numerous biases discovered while seeking to include PWD [people with disabilities] in the digital revolution. As they are currently built and deployed, none of the technologies studied make designing and producing inclusive apparel easier* . (p. 220)

While there were work-arounds to get each technology to meet the participants' needs, it was too time consuming and inefficient for viable retail options. He suggests that with more body diversity built into the range of 3D tools (and greater interoperability between platforms) apparel companies could better include disabled consumers. He does note that since this research was conducted, Clo3D has created new avatars that can have asymmetric bodies (but still with four limbs) and seated poses (Clo3D, 2019b, cited in Paganelli, 2021). Still, with many embedded ableist biases permeating into virtual technology development, expansion of the notion of a "standard" body is essential,

Paganelli asserts. And, he suggests, more diverse voices must be included within the apparel development process, as is evidenced by his participatory approach.

Hobbs and Morris (2020), as noted in section 3.1, indicate use of 3D scanning and virtual garment simulation for a wheelchair user in their development of a Paralympic shooting jacket. Hobbs-Murphy, Morris, and Park (2022) explicate that a handheld 3D body scanner facilitated taking measurements of the athlete while she sat in a backless chair. (Booth scanners, they indicate, are small areas that only allow standing figures with arms and legs extended, Rudolf et al., 2015, as cited in Hobbs-Murphy, Morris, and Park, 2022. They also cannot take measurements perpendicular to the camera, so the tops and bottoms of legs even if seated would not be measured.) The avatar Hobbs-Murphy, Morris, and Park produced from the 3D scan was symmetrical; it is not indicated if an asymmetrical avatar would have been possible. A half-scale dress form was produced for prototype development purposes. Manual measurements were also taken, and the pattern was draped physically onto the dress form. As mentioned in section 3.3, the final jacket prototype was unable to be worn by the athlete while shooting due to problems with the fit. The authors comment, "[n]avigating fit in the virtual environment presented challenges that affected the first fitting prototype" (p. 13).

Hobbs-Murphy, Morris, and Park (2022) state that the avatar and the dress form contributed more information about the athlete's body shape and could remain with the researchers when the athlete could not be present. Also, at one stage, a virtual shooting jacket prototype was generated on the athlete's 3D avatar and sent for feedback. So, while insufficient to manage garment fit, the virtual software was useful for visual communication of the design. The authors conclude, "[a]s apparel technologies advance, research regarding their effectiveness and applicability to underserved populations should be conducted" (p. 15). This sentiment aligns with Paganelli's (2021) conclusion. Also, as Hobbs-Murphy, Morris, and Park's research was focused on a custom garment in a single case, more nuance may be needed in applying virtual garment design technology to address larger adaptive apparel markets.

McBee-Black's (2021) first case study of Scheier and Tommy Hilfiger's collaboration for adaptive apparel for children examines the feasibility of mass manufacturing cut-and-sew adaptive apparel garments. The findings suggest that existing supply chain functions need not be greatly disrupted when entering this market. McBee-Black (2022) also published a case study highlighting Scheier's user-focused approach in creating the adaptive apparel line for children sold by Tommy. It is indicated here that Scheier created apparel design innovations based on common needs she observed within the disability community,

enabling a mainstream corporate partnership. These “adaptive apparel design innovations focused on three categories: (a) magnetic closures; (b) adjustable pant legs, sleeves, and waistband; and (c) the flexibility of donning and doffing using different points of entry” (McBee-Black, 2022, p. 203). The designs also had to be fashionable (McBee-Black and Ha-Brookshire, 2022).

To assess these adaptive apparel needs, Scheier adopted a user-focused approach that involved the disability community at every step of the design process to build trust and allyship, describes McBee-Black (2022). This framework followed a goal of “making life easier” by identifying needs, creating design innovations, and testing solutions. A few semi-structured interviews and an observation were initially done. A survey was sent to disabled consumers, parents of children with disabilities, and medical personnel to find apparel-related challenges. No disability type was excluded, McBee-Black claims, referencing a variety of user-identified physical and cognitive impairments. Focus groups, in-home observations, and wear-testings were later conducted to get feedback on prototypes. Scheier felt the observations were the most beneficial part of the research, McBee-Black states. It led Scheier to think about how to make dressing easier and how the clothing interacted with the body. “Scheier stated multiple times that her adaptive design innovations would have missed their mark without continuous insight from the user” (p. 221).

Brands initially approached by Scheier rejected her ideas due to lack of interest and notions that adaptive apparel was not a profitable market. Scheier’s in-depth and user-focused research with the disability community served to address these questions on scalability, however, assuring her future industry partners that the identified adaptive features would meet a significant portion of the user community needs. She was able to prioritise a balance of user and industry needs to achieve this mainstream adaptive apparel line with Tommy Hilfiger (McBee-Black, 2021, 2022).

According to McBee-Black (2021), Scheier found an ally in sourcing firm Global Brands Group (GBG) who held a licence with Tommy. GBG was first sceptical that the line could be implemented within their apparel manufacturing process. McBee-Black writes:

> *According to Scheier, GBG’s concerns focused on how magnets [used in place of zippers and buttons] would interact with the apparel production machinery, leading to increased production time, ultimately leading to increased costs*. (p. 8)

Scheier eventually overcame these obstacles by:

- Doing further research with disabled consumers;
- Developing how to encase the magnets so they would not stick to the production machines;
- Negotiating down the cost of the magnets with suppliers;
- Testing and refining prototypes with GBG so the adaptive apparel innovations would be production-ready to integrate within the existing supply chain.

McBee-Black concludes:

> *Scheier demonstrated that incorporating underserved markets, like PWD, into a company's product offering does not require a complete reconfiguration of the supply chain. This suggests that brands who once thought that incorporating underserved markets, like PWD, would require significant modifications to their supply chain function may not need to make such significant changes*. (p. 13)

McBee-Black and Ha-Brookshire (2022) propose that Scheier, her research, and her design innovations were viewed as key competitive resources by Tommy Hilfiger to address the adaptive apparel market gap. After failing to find on-trend mainstream apparel for her son with muscular dystrophy, Scheier found that her network of parents of children with disabilities also faced similar barriers. This prompted her shift into an advocate role, leading to the deep user-focused research, design innovations, and eventual industry collaboration described above. She experienced frustration, upon first contact with mainstream apparel brands, that they did not seem to recognise a need for adaptive apparel or understand the scope of this potential market. To inform the industry, "[Scheier] believed that the arsenal of knowledge and data she developed would be of great value to the apparel industry" (p. 185). McBee-Black and Ha-Brookshire suggest that it was this advocacy-related knowledge, data, and design innovations that facilitated the collaboration with GBG and Tommy Hilfiger and the success of the adaptive apparel collection for children. Men's and women's adaptive collections were subsequently launched with Tommy Adaptive.

So, options and examples of industry production of adaptive and inclusive apparel are emerging. Both McBee-Black (2021) and Paganelli (2021), however, note ableist biases in technology available and in attitudes (or lack of awareness) towards catering to this underserved consumer group. McBee-Black and Ha-Brookshire (2022) suggest collaboration with an advocacy ally and in-depth user-focused research can: act as key competitive resources; and help to inform and mitigate potential industry hesitancy towards

incorporating adaptive apparel lines. As previously stated, sportswear has its own set of functional requirements and value-laden needs, which must be considered (McCann, 2005; Gupta, 2011b; Basant *et al*., 2013; Bielefeldt Bruun and Langkjær, 2016). Strategies for adaptive and inclusive mainstream sportswear design and production, in line with findings from this study, will be discussed later in sections 6.1.4 and 7.3.

3.7 Conclusion

As indicated above and in chapter two, methods and practices exist for adaptive apparel, inclusive apparel, and sportswear design. This often involves a needs and values assessment, identification of apparel or industry-related barriers, and exchange of knowledge between disabled consumers and apparel designers or researchers. But in the literature review, overall, there was a lack of focus on sportswear design for people with an upper limb impairment or difference within a mainstream industry context. The articles reviewed in this chapter, however, did provide direction on how to meaningfully and empathetically engage with this consumer group for research purposes. Thus, the most relevant studies on design research for marginalised consumers have been put into Table 3.1 below. Charting the key aims, methods, and gaps helped to guide the primary research planning of this study.

Kidd (2006), Carroll and Kincade (2007), McCann (2016), and Bragança *et al*. (2018) all used interviews or focus groups to understand consumer needs before moving to co-design, sketching, or prototyping. Kidd (2006) and McCann (2016) place a large focus on user empowerment and comfort as they partner with participants in participatory design approaches. Their research takes design direction from real-life users by not relying too heavily on past industry training or adaptive apparel literature. As such, their results consist of experiential knowledge in addition to physical design outputs. Bragança *et al*. (2018) emphasise user needs in the form of functional sportswear recommendations, to be refined later with apparel designer expertise. Carroll and Kincade (2007) present a universal design perspective to group and widen consumer bases. They address potential industry-related barriers to mainstream disability inclusion, such as cost and preconceived notions around an underserved market. The remaining research gap – mass market sportswear design practice for consumers with an upper limb impairment – is the focus of the remaining chapters of this dissertation.

Table 3.1 - Literature Review Key Findings

Author	Methods	Aim/Focus	Relevance	Gap
Kidd (2006)	- interviews - design collaboration - prototype and wear-testing	- combining fashion and function - special occasion wear - bespoke adaptive apparel	- ethics and empathy for participants - led by design research, not previous literature or training - learning through practice	- not sportswear - not upper limb-focused - not mass market
Carroll and Kincade (2007)	- interviews - co-design - wear-testing - stakeholder feedback	- filling a market gap - inclusive/ universal design - office attire	- grouping consumers by effects on body, rather than disability type - industry feedback and barriers considered	- not sportswear
McCann (2016)	- interviews, focus groups, questionnaires - co-design	- filling a market gap - breaking down multidisciplinary barriers - empowering users to voice needs - sportswear	- user empowerment - removing barriers through design practice - exploring needs/context of a neglected consumer group	- not disability-focused - not upper limb-focused
Bragança *et al*. (2018)	- focus group - questionnaire - sketched prototypes	- engineering and human factors - filling a market gap and promoting disability awareness - sport-specific adapt-ive sportswear	- user needs/context assessment - adaptive sportswear - qual research exploration with user focus	- no designers or apparel design methods - not mass market - not upper limb-focused

Another gap revealed in the practice and literature review is virtual design research methods for adaptive and inclusive apparel. Data collection for this study was done primarily through virtual methods. This was necessary due to COVID, the researcher's own accessibility needs, and engagement of non-local participants. The development of these virtual design research techniques, along with subsequent implications, will be discussed in following chapters.

Chapter 4: Methodology, Methods, and Research Design

This chapter details the methodology, research path, and methods used to guide the direction, data collection, and data analysis of this study. Articulated in chapter one, this project is framed by the social model of disability, as well as practice-informed and user-led design research approaches. This framework provided a focus for interpreting the subjectivity and meaning-making that is inherent to qualitative inquiry, which guided this research (Gaudet and Robert, 2018). Primary research methods, as will be detailed, were based on relevant contemporary adaptive and inclusive apparel design research practice from the previous chapter.

The qualitative methodology for this design research generated knowledge through an iterative process. An iterative research model (Figures 4.1 and 4.3 in section 4.1) served to help understand the complexity of the social model of disability in relation to the apparel industry. Barriers to and solutions within sportswear design are experienced by the stakeholders; knowledge comes from these lived experiences. Explanations were, thus, developed from insights gleaned throughout the research, which were co-created by the researcher and participants. This meant there was no set hypothesis to start and an inductive approach took place. Discovering meaning as it was conducted, the research was exploratory. It was cross-sectional as it addressed a particular problem at a particular time (Saunders, Lewis, and Thornhill, 2012; Gaudet and Robert, 2018).

The knowledge acquired through this study is localised, contextual to the time, place, and situation in which the research was conducted (Gaudet and Robert, 2018). This matches the pragmatic research philosophy that was followed. Saunders, Lewis, and Thornhill (2012) write that "[p]ragmatists recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture" (p. 130). Pragmatism is concerned with research findings that have significance for their practical consequences -- as within this type of practice-informed design research (Stappers, 2007; Saunders, Lewis, and Thornhill, 2012; Chynoweth, 2013; Koskinen and Krogh, 2015). Epistemologically, a focus was placed on practical research results, as well as multiple stakeholder perspectives to interpret data (Saunders, Lewis, and Thornhill, 2012). The tools developed as an output to meet the research aim have a context-specific purpose and use. They relate to a real-world, timely need within design practice yet are also underpinned by the above noted tenets of qualitative inquiry.

As this research developed and iterated between primary research and the disability studies framework, elements of constructivism also became relevant. Within this ontological

posture, Gaudet and Robert (2018) state that "reality is constructed through our perception and experience of it and we will be interested in the lived experience" (Choosing Qualitative Inquiry chapter). The authors go on to explain:

> *We create social realities by naming, describing and interpreting them. Creating new understandings of social realities can sometimes help to deconst ruct taboos and empower people*. (Choosing Qualitative Inquiry chapter)

As postulated in the proceeding chapters, social attitudes towards disability, media narratives, and mis/representation of disability can impact how our world includes or excludes certain people. To create the pragmatic design toolkit for this study, it was necessary to understand how disability, ideas of "mainstream" consumers, and sportswear were perceived and experienced from different stakeholder perspectives. Then, constructed social, industry, and apparel-related barriers to disability inclusion could be more intricately understood and more nuanced guidance generated.

A participatory design approach was chosen to understand 'knowledge by doing' and to rely on stakeholder community knowledge for direction and solutions (Spinuzzi, 2005). Spinuzzi notes that participatory design places equal focus on design and on research. Applied as a methodology, a partnership is created between the designer-researcher and the user participants through which they can understand the nature of the activity being explored. This is done through iteratively engaging stakeholders in the ideation, or idea generation, process to access valuable experiential knowledge, wh ich leads to more effective results, writes Spinuzzi. While he discusses participatory design within a context of technical communication, he points out that it can be applied to other industries. For instance, ideating and prototyping with users can aid in the creation of product design for marginalised consumers (Demirbilek and Demirkan, 2004; Moffatt *et al*., 2004). And, as concluded in chapter three (section 3.7), active engagement with users can be effective in adaptive and inclusive apparel research (Kidd, 2006; Carroll and Kincade, 2007; McCann, 2016). This approach can help to mitigate unintentional designer or researcher bias when framing a design problem and addressing areas of inclusion (Agid, 2018; Holmes, 2018).

In line with the above parameters, Table 4.1 summarises the multimethods applied to meet the overall research objectives from section 1.7.

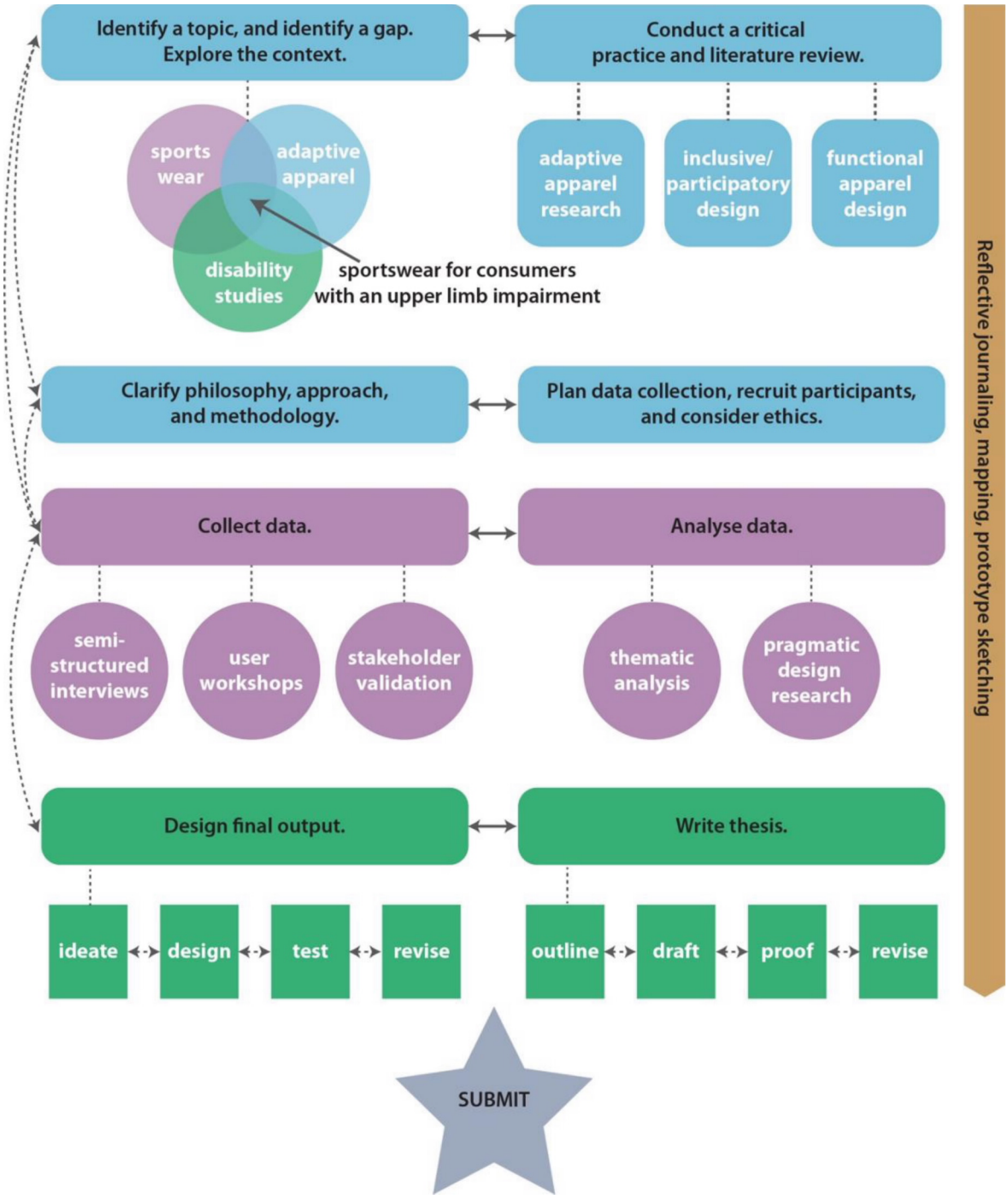
Table 4.1 - Methods Applied to Meet Research Objectives

Research Objective 1: To establish a relevant multidisciplinary research framework within the context of disability studies, the adaptive apparel market, and participatory design.
Methods: literature review, online market survey, online and in-person visits to disability sports and innovation websites and events
Research Objective 2: To conduct a critical literature and practice review of functional apparel design, inclusive design, and adaptive apparel design research.
Methods: literature and practice review, conferences and webinars
Research Objective 3: To identify potential gaps in awareness between sportswear industry practice and the user community and plan the primary research direction.
Methods: mapping, reflective journaling, online and in-person visits to disability sports and innovation websites and events, community engagement through email and social media
Research Objective 4: To iteratively engage stakeholders in an exploration of the perceptions of, barriers to, and solutions for sportswear design for people with an upper limb impairment or difference.
Methods: stakeholder semi-structured interviews, user design ideation workshops, sketching, mapping, reflective journaling, community engagement through events, e mail, and social media
Research Objective 5: To distil findings into pragmatic guidance for sportswear design inclusion, evaluate with stakeholders, and refine results based on feedback.
Methods: user feedback questionnaire, stakeholder feedback interviews, sketching, mapping

4.1 Research Path

Figure 4.1 represents the holistic research path taken for this project to meet the aims outlined in section 1.7. These were: developing sportswear design tools inclusive of consumers with an upper limb impairment or difference; and discussing the implications for sportswear industry design, adaptive and inclusive apparel, and disability inclusion. The research path shows iterations made to refine and adapt the framework, data collection and analysis, and output as the study progressed. As indicated by the orange arrow on the right, reflective journaling, visual mapping, and sketching played an influential role throughout the research journey.

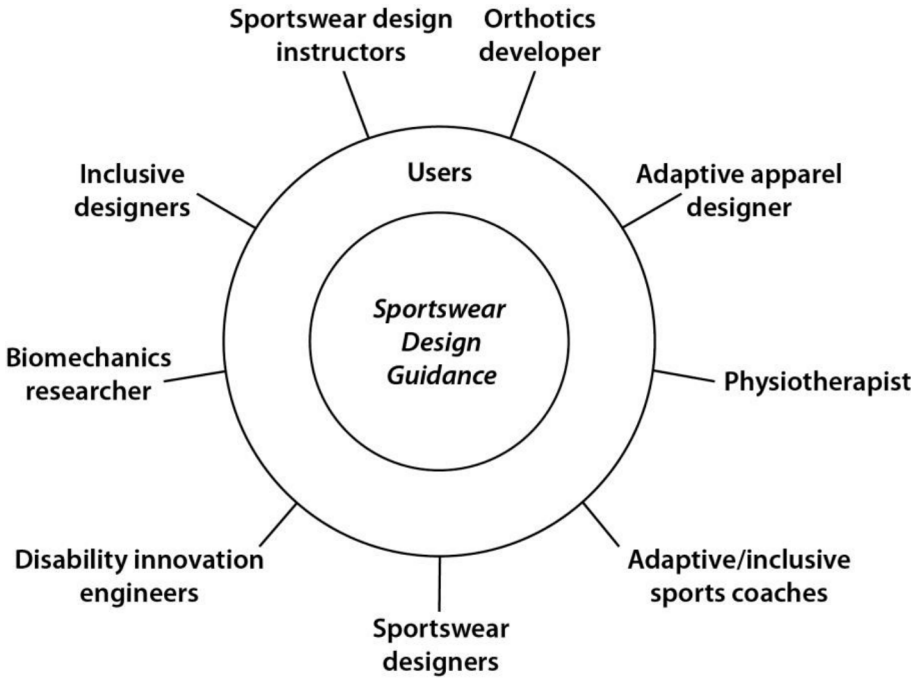
Fig. 4.1 - Research Path



These creative thinking methods helped to make sense of emerging findings in relation to the research questions from section 1.6 – identifying barriers and guidance to mainstream sportswear inclusion and the role of a participatory approach. Visual mapping and diagramming served as reflection on how to present the final results in a way that is useful to industry but also holds true to the input from users. On-going research notes served "to record... ideas and... reflections, and to act as an aide-memoire about [the] intentions for the direction of [the] research." (Saunders, Lewis, and Thornhill, 2012, p. 555).

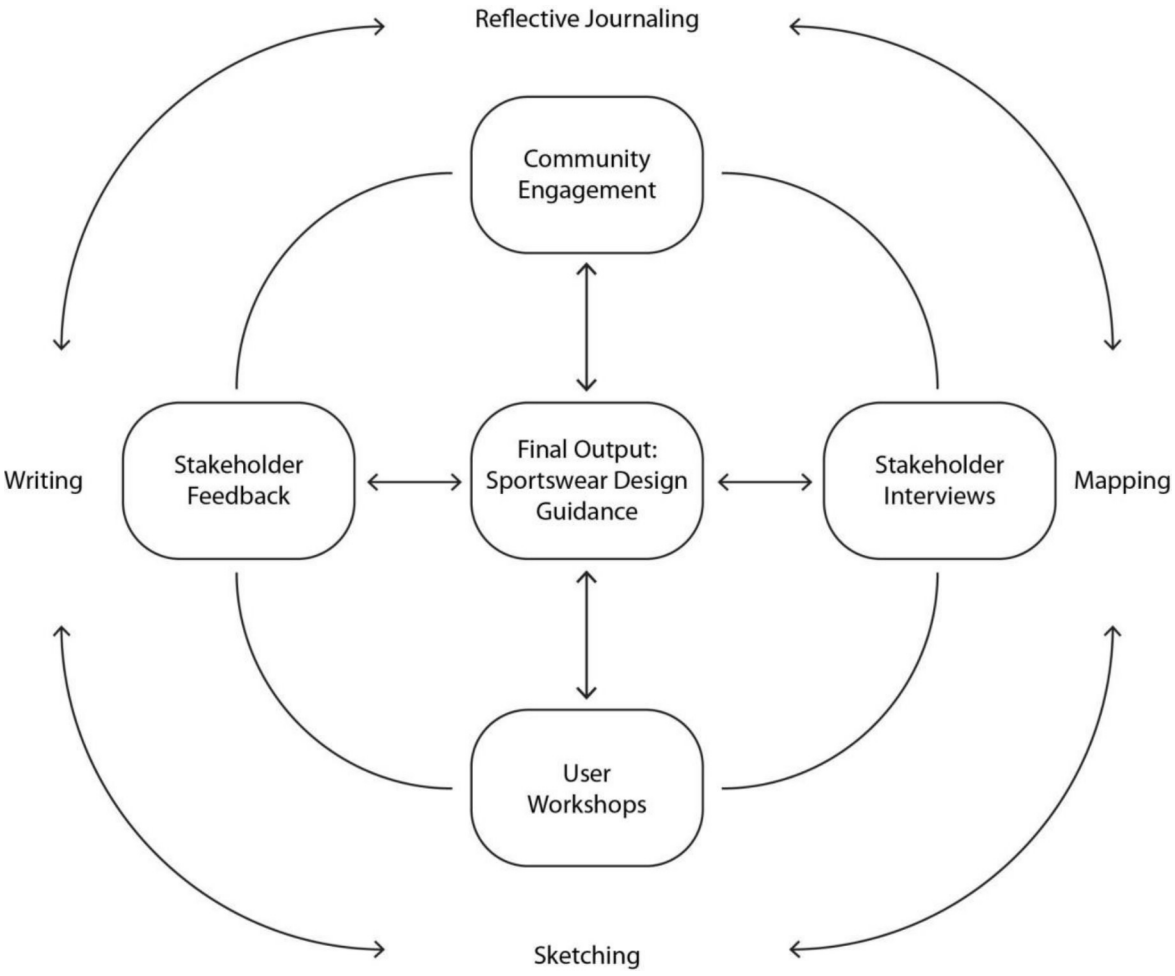
Stakeholder participation and feedback was instrumental in progressing and forming the final outputs for this research. The first-hand, experiential insights that were gained spanned disciplines from sportswear design to biomechanics to engineering to adap tive apparel (Figure 4.2). And, user-led contributions from the disability community were central in shaping the final results.

Fig. 4.2 - Research Participant Stakeholders



The primary research methods took place in stages with all findings building upon one another to generate a final output (Figure 4.3). Each round of stakeholder-focused data collection and analysis was carefully planned and executed with separate aims and objectives. The following sections will detail the primary research stages – interviews, workshops, community engagement, and feedback.

Fig. 4.3 - Research Methods Map



4.2 Stakeholder Interviews

The first phase of primary research for this study was semi-structured interviews conducted with key stakeholders: 1.) individuals with an upper limb impairment or difference who practised sport or fitness (user group); and 2.) sportswear design-related practitioners or researchers (industry group). As previously discussed, Bragança *et al*. (2018) began their primary research on adaptive sportswear with a focus group to investigate current user barriers and areas for improvement. Their findings provided a general understanding of the issues to address and helped to shape the next phase of their study. A similar agenda was adopted here, although individual interviews were ultimately used rather than a focus group. As will be delineated further, decision-making during methods planning was based on pragmatic and participant-led needs.

4.2.1 Interviews Aim and Objectives

The aim of the interviews was to explore the current space for adaptive sportswear design in terms of goals, values, and language amongst various users, designers, and other relevant multidisciplinary experts. The objectives were to:

1. Identify the participant (stakeholder) groups;
2. Explore each group's values of sportswear, perspectives on disability and disability sport, and ideas or concerns for collaboration;
3. Determine initial barriers and solutions that may exist for sportswear design inclusion and collaboration;
4. Synthesise findings into a rough practical framework for the final output;
5. Provide direction for planning the next phase of data collection.

4.2.2 Participant Sampling and Recruiting

Interview objective one was defining the stakeholder groups, which was initiated through the literature review and refined through the recruiting and interviewing process. To begin, three distinct stakeholder groups were identified with a goal of recruiting 6-8 participants from each to conduct in-person focus groups. But after many months of recruiting, purposive sampling local to London proved too challenging to meet this target. Refer to Table 4.2 for the original three targeted groups and attempts at sourcing.

Table 4.2 – *Initial Participant Recruiting Plan for Interviews*

<u>*Group 1:*</u> Sportswear Designers	*Reason:* As in the "Design for Ageing Well" sportswear co-design project described by McCann (2016), the *Clothing* team looked at "technical and aesthetic considerations to be addressed in clothing development." (p. 241). Sportswear design requires knowledge of materials, creativity, and construction (McCann, 2005).
	Sourced: Previous professional contacts from the US sportswear industry were emailed directly. Some agreed, and one reached out to another designer. Four participants were recruited (only three were used).
<u>*Group 2:*</u> Sports Biomechanics or Disability Sport Experts	*Reason:* McCann (2016) highlights the necessity of a cross-disciplinary team to meet the complexities of designs that span several fields. Similarly, Bragança *et al*. (2018) state that functional apparel should employ expertise from several scientific and technical domains.

	Sourced: Several university contacts were emailed, but participation stalled through this route. Eventually, one biomechanics researcher agreed. A wearable orthotics pattern maker was sourced through contact made at Naidex.
Group 3: Users	*Reason:* Kidd (2006), McCann (2016), and Bragança *et al*. (2018) rely on user input to define the apparel needs that were essential to their research outputs. The "target user" is also located at the centre of the FEA Model (Lamb and Kallal, 1992).
	Sourced: A contact who volunteered with the "Wounded Warrior" (US) project forwarded the project description to the Adaptive Sports Foundation (US). They were able to reach two participants who agreed. Three more were recruited through contact with veterans and disability sports groups and an appeal on Facebook.

Eventually, data collection was adapted to virtual one-on-one interviews with individuals from two stakeholder groups – a user group and an industry group. This reflected the availability and location of participants, and it kept in line with the nature of the exploratory, user-led research. Researcher revelations on the reality of the niche recruiting avenues, purposive sampling needs, and real-life context of the participants began to provide a much more accurate research direction than the literature review. Thus, the recruitment process itself was a pivotal learning moment, which expanded the researcher's practice-informed awareness and contributed to the final output. As discussed in section 3.4, Kidd (2006) also notes a distinction between findings from the literature review and the lived experiences that provided original knowledge in her case study.

The full recruitment process took about six months with other attempts made by emailing various London university course leaders, contacting the GDIHub, emailing disability sport organisations and disability charities, and posting on social media (Twitter, LinkedIn, and Facebook). The sportswear designers were quick to recruit. As the researcher had spent several years working in the sportswear design industry in the US, former colleagues who had senior or director levels of experience were contacted and open to participating. Sports biomechanics or disability sports researchers were extremely difficult to recruit. Many contacted were unavailable or felt their expertise would not fit this research scope. After many dead ends, a London-based biomechanics doctoral researcher agreed. A pattern maker/developer from a UK wearable orthotics company was also recruited through a contact formed at the disability innovation trade show, Naidex.

Responses (or lack thereof) from disability and sports organisations also revealed that the initial recruiting parameters for the user group had been too limiting. As noted, originally

only London-based, amateur-sports playing participants were sought. Changing to a virtual format allowed for enough purposive participants from around the US and UK. A key participant became available who had prior Paralympics experience and had been involved with some of Tommy Hilfiger's adaptive clothing line, so previous parameters of non-professional athletes were removed. The recruitment language was broadened to include an open range of individuals who self-identified with the research project. Thus, the "definition" of the user community, for the purposes of this study, became user-led. All participants were over 18 years of age. Demographics information was only recorded as deemed necessary, with more focus on the user group as the consumer of the sportswear designs. The final ten participants (five from each group) who were interviewed are represented in Table 4.3.

Table 4.3 - Final Participants for Interviews. Updated from Poage, Kapsali, and Bardey, 2020, Table 1, *Interview Participants.*

	Gender Identity	**Location**	**Self-description**
User group:	Male	US	Partial paralysis of hand through injury
	Male	US	Paralysis and muscle loss in arm through injury
	Male	UK	Paralysis of arm through injury
	Female	US	Born without a forearm
	Female	US	Multiple shoulder surgeries from congenital condition
Industry group:		US	Senior sportswear designer
		US	Senior designer for apparel and innovation (sportswear)
		US	Head of apparel (sportswear)/creative director
		UK	Doctoral candidate in bioengineering, biomechanics of rowing
		UK	Pattern designer/developer, wearable orthotics

4.2.3 Questioning Route

The questioning route was designed to meet interview objective two (explore each group's values of sportswear, perspectives on disability and disability sport, and ideas or concerns for collaboration). In discussing user involvement, Kidd (2006) described initial consultations that had open-ended questions to "break the ice" and establish an open and positive working dynamic. Similarly, easy and casual open-ended questions began the interviews in an effort to create a positive and relaxed atmosphere. This was considered particularly crucial in the interviews with the users, as, unlike the industry group, they might not be accustomed to this type of research dynamic or probing discussion. Also, as they were asked to discuss their own experiences with disability, sport, and apparel, a supportive and encouraging environment was a priority. As indicated above, participants were organised into two stakeholder groups for data management purposes, but all were interviewed individually. While some of the wording in the questions varied between the two groups, the semi-structured topic guides were similar (Appendix B). According to Barbour (2008):

> *The semi-structured nature of topic guides allows the researcher to focus on issues salient to those being studied, rather than emphasizing the researcher's preconceptions or agenda.* (p. 42)

The questions concerned:

- Challenges with sportswear design for this consumer;
- Solutions to improve sportswear design for this consumer;
- Methods to ideate the problems and solutions;
- Potential barriers for user involvement and a collaborative design process.

Follow-up, probing questions were applied when either: 1.) the answers were brief, 2.) the language used was vague, or 3.) an interview introduced a novel concept or experience (Smith, Flowers, and Larkin, 2009; Krueger and Casey, 2015). Categories of garment type and sport were left open to let the participants discuss what was relevant and known to them, but the conversation was mostly targeted to non-professional level, commercially available sportswear. Garments were not termed adaptive or inclusive to the participants; the topic was posed as sportswear for people with an upper limb impairment. Prior to interviewing, the questions were reviewed by the dissertation supervisors, and pilots were done with non-participants.

As the interviews took place on staggered days over two months, some adjustments were made while the process was on-going. The answers amongst the users were both similar and different at times, depending on their specific experiences. So, this questioning route remained the same for all five users with probing questions used to explore unique perspectives or experiences. Responses from the first two sportswear designers were very similar, however, and matched elements of functional design practice from Watkins and Dunne (2015). As such, questions were altered slightly for the third sportswear designer to generate opinions more specific to this topic. Since the final two "industry" participants were not sportswear designers, but other multidisciplinary contributors, the question wording was adjusted to be more specific to their areas of expertise.

4.2.4 Data Collection

Interview objective three (determine initial barriers and solutions that may exist for sportswear design inclusion and collaboration) was met through the data collection and analysis. Due to the varied locations of the participants, interviews were conducted over Skype using a research-specific account. Skype was not an option for two interviews, so these were conducted over the phone. Lo Iacono, Symonds, and Brown (2016) discuss Skype for qualitative interviewing as beneficial for removing geographical and physical barriers, which can enable a more diverse array of participants. In this instance, virtual interviews aided in purposive sampling, convenient scheduling between global time zones, and allowing more comfort for the researcher who has her own mobility restrictions. The COVID-19 lockdowns occurred after the interviews were complete, but due to the familiarity gained in virtual data collection during this phase, an easy adjustment was made to make subsequent data collection phases virtual. Thus, the research was able to continue unaffected during the pandemic.

Prior to the interviews, email exchanges took place between the researcher and each participant to introduce the research, distribute participant information sheets, collect signed consent forms, and schedule times for the interviews (Appendix C). Interview sessions were no more than 30 minutes, including time for introductions and debriefing. The interviews were audio recorded with notes taken throughout on topics to revisit or to reflect on for analysis. Smith, Flowers, and Larkin (2009) note that more interesting questions sometimes need more reflection from the participant, so the interviewer should restrain from cutting in to allow for a richer answer to develop from the interviewee. Indeed, in the interviews, when a pause was left after participants' responses, in some cases, they resumed talking on the subject to add something new and more in-depth to their first thought.

A chart was kept on:

- Participants details
- Recruitment path
- Skype or phone interview
- Research notes
- Reflective/reflexive notes

Reflective notes were made to reassess significance of emerging themes, as well as the strategic stakeholder groupings. A third-party transcription service was used due to the researcher's physical limitations, and all transcripts were checked by the resea rcher against the audio recordings. All interviewees were offered the opportunity to read their transcripts (Appendix D) prior to data analysis. In keeping with a participatory mindset, participants were also emailed a summary of themes found from their st akeholder group after analysis was complete with an option to review and comment. £30 Amazon vouchers (one per stakeholder group) were raffled to those who responded to the validation email.

4.2.5 Data Analysis

Before interviewing began, interpretative phenomenological analysis (IPA) was chosen as the method to code the data, but this was later revised to thematic analysis as a more appropriate match. Smith, Flowers, and Larkin (2009) indicate that IPA examines "how people make sense of their major life experiences" (p. 1) and can be used to "explore in detail the similarities and differences in each case." (p. 3). This seemed to well suit the interviewing aim of assessing lived experiences with sportswear and collaboration from the various stakeholder perspectives. But, as interviews progressed and more in -depth reading was done on IPA, it became clear this was no longer appropriate. IPA is, in fact, presented as a methodological framework and research approach set within hermeneutics and phenomenological inquiry (Smith, Flowers, and Larkin, 2009; Pietkiewicz and Smith, 2012). This was not consistent with the specific pragmatic design research goals of this project.

Thematic analysis was ultimately chosen for its flexible approach and independence from any specific theory or epistemology, while still providing a complex and meaningful analysis of the data (Braun and Clarke, 2006). Braun and Clarke state:

> *Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data. It minimally organizes and describes your data set in (rich) detail.* (p. 79)

Before starting the analysis, it is crucial to decide what types of claims to make about the data, note Braun and Clarke. They describe inductive analysis as being data-driven, not governed by the researcher's topic or area of interest; it does not try to fit within a pre-existing coding frame. Theoretical thematic analysis is, on the other hand, driven by the researcher's analytic interest or theoretical focus. It is analyst-driven. The choice was made to lean towards a theoretical analysis as only specific areas of interest were of concern relating to the pragmatic research output (e.g. sportswear values and barriers to inclusion). An inductive element, however, was incorporated in the data analysis as specific codes were not predetermined. Accepting unexpected findings from the data allowed participants more influence over results.

The user group (n = 5) transcripts were analysed as one data set and the industry (n = 5) group as another to find themes within each stakeholder group. The themes were then compared and contrasted across the entire data corpus (N = 10). With the use of QDA software Nvivo, Braun and Clarke's (2006) thematic analysis was followed for each data set. Their six steps were applied:

1. Familiarise with the data.
2. Generate initial codes.
3. Search for themes.
4. Review themes.
5. Define and name themes.
6. Produce the report.

All transcripts were reread prior to coding, and research notes were kept throughout the process to:

- Track the creation of codes and think through how they fit into themes;
- Make sense of which themes worked and which did not;
- Log new and surprising findings.

Initial thematic maps were made at step three, and candidate maps were refined at step four (Appendix E). Final thematic maps are presented in the next chapter along with the results of the interviews, meeting interview objective four (synthesise findings into a rough practical framework for the final output). Three participants (two users and one designer) responded to the email of final themes sent for review, and all three agreed with the findings.

A pivotal insight from the interviews was that inclusive apparel, along with adaptive apparel and other options like customisation, seemed feasible to address needs of this consumer group (Appendix F). The industry group was knowledgeable and well-trained to assess specific needs for a given consumer group. Awareness was needed, however, about the context of disability, upper limb impairment, and the scope of sportswear for this consumer. Therefore, the interviews and reflection revealed gaps involving:

1. What design considerations, like trim and construction detailing, are needed to remove apparel-related barriers;
2. How established sportswear brands can include this consumer in a variety of design strategies beyond just adaptive apparel, balancing industry practice and user needs;
3. How to increase awareness of disability and upper limb impairment in terms of terminology, context, and relationship with sportswear in a way that is meaningful to the user community.

These points served to narrow the scope of the final output and dictate the development of the subsequent data collection phase – the user workshops. Thus, interview objective five (provide direction for planning the next phase of data collection) was met.

4.3 User Workshops

This workshop phase engaged a new set of users in virtual ideation exercises. As mentioned above, the interviews and practice review revealed that industry experts already possess the tools and expertise necessary to investigate and design sportswear apparel for a specific consumer group -- if that consumer is well understood. So, greater awareness and influence from marginalised consumer groups, certainly pertaining to disability, is recommended for sportswear to be designed more inclusively. From the interviews, gaps emerged concerning:

1. What kind of trim and construction details are needed, based on lived experiences;
2. How to balance sportswear industry practices (or design strategies) and user needs for meaningful and achievable sportswear inclusion;
3. Deeper contextual awareness of this consumer group.

4.3.1 Workshops Aim and Objectives

Thus, the aim of the workshops was to explore apparel-related needs and the larger context of sportswear design for people with an upper limb impairment from users' perspectives.

The workshop objectives were to:

1. Decide who should be involved in the workshops and source participants;
2. Choose and adapt ideation tools to generate the data needed to meet the aim;
3. Run the workshops;
4. Analyse the data and get feedback from the users;
5. Write up and map findings and incorporate them into the final output.

4.3.2 Participant Sampling and Recruiting

Workshop objective one was deciding who should be involved in the workshops and sourcing participants. It was met through an intensive recruitment process that involved making contact with a variety of disability charities, adaptive sport organisations, and related social media channels. Reflective and reflexive notes were maintained throughout the recruitment process to document contextual and practice-informed learnings. Reflective notes were written recordings of what happened and what was learned as a result; reflexivity examined the researcher's own interactions with the participants and reactions to results for greater insight on interpretations (Saunders, Lewis, and Thornhill, 2012). As with the interviews, interactions with the user community throughout this process provided valuable insights that helped direct the remainder of the research. The initial recruitment parameters followed those applied for the previous interview user group. A target sample of *n* = 6-9 users was refined to those who:

- Have an upper limb impairment or difference;
- Participate in any sport or fitness activities;
- Feel sportswear could be improved to better suit their needs;
- Are age 18 or older and able to give informed consent;
- Live in the US or UK.

Recruitment channels were similar to those from the interview phase:

- Direct emails to disability charities and adaptive sport organisations
- Postings on social media channels -- Twitter, Facebook, and LinkedIn
- Snowball through personal, professional, and research contacts

In the first four weeks, over 100 recruitment notices were posted on social media and sent directly through email. From this set, about six people initially responded, and two ended up participating in the workshops. While feedback from the recruitment notices was very

positive from adaptive sports organisers and other gatekeepers, follow-up from the actual user community stagnated. At this point, the recruitment notice was revised to include past sportswear industry credentials and explicitly asked for the notice and contact email to be distributed further (which was previously missing). This resulted in a flurry of responses from adaptive sports groups, which resulted in more participants volunteering than could be scheduled into the remaining workshop slots. The extra volunteers were included in the stakeholder feedback phase, at their discretion. Spreadsheets were maintained detailing who was contacted, who chose to respond, and how the recruitment snowballed. In the end, the recruitment notice was posted or emailed over 140 times.

As the recruitment notice referred to "people with an upper limb impairment or difference of the shoulder, arm, or hand", this scope was left open for user-led self-identification. Unlike the interview sample, some participants in the workshops were wheelchair users who were quadriplegic. This expanded the researcher's awareness of the complexity of upper limb impairment and is reflected in the final research result. Table 4.4 delineates the final participant set.

Table 4.4 - Final Participants for Workshops

Age	Gender Identity	Location	Self-description
26-35	Male	US	Right below elbow amputee
18-25	Female	US	Missing left hand and forearm
26-35	Female	UK	*Not filled out by participant - missing hand and forearm*
26-35	Female	US	Quadriplegic, limited finger function, limited arm strength
46-55	Male	US	Quadriplegic, C5-7
26-35	Male	UK	Quadriplegic, C5, paralysis of hands, triceps and forearm

4.3.3 Workshop Development

The workshops were designed to guide the participants through a series of creative brainstorming exercises to explore sportswear experiences, barriers, and solutions from their perspectives. This met workshop objective two (choose and adapt ideation tools to

generate the data needed to meet the aim). Originally, in-person co-design workshops had been envisioned but were removed as an option due to previously mentioned factors. These were:

- Difficulties encountered in purposive sampling local participants
- Timing of the workshops during COVID-19 social distancing requirements
- The researcher's own mobility restrictions

After switching to a virtual ideation format, group sessions were first intended. This plan was revised to one-on-one engagement due to challenges scheduling between various time zones and lags in participant correspondence. So, rather than a group dialogue of apparel-related needs and solutions, in-depth explorations were done with individuals. A thematic analysis, detailed below, was then applied to determine commonalities, overlap, or individual key contributions from the workshops. As with the interviews, the virtual format allowed the research to continue during the pandemic and with purposive sampling of participants from around the UK and the US. Digital collaboration software Miro, with its multitude of pre-made templates for brainstorming, ideation, and needs analysis, was chosen as a tool for virtual facilitation, data collection, and data analysis. Miro and similar platforms, such as Mural, have begun to appear as tools within areas of design research (Wuertz, Eshbaugh, and Nelson, 2020).

Within Miro, virtual brainstorming templates were adapted to facilitate ideation of needs, values, and solutions around sportswear from the participants' experiences and perspectives. Guidance from Watkins and Dunne (2015) on ideation -- creative idea generation -- was followed. While their techniques are primarily employed by designers within the functional design process, this guidance was followed for a user-led exploration in the workshops. Watkins and Dunne write:

> *Since early ideas can tend to be more obvious and commonplace, it is vitally important that designers continue to pursue additional ideas beyond those that come easily to mind. This is where ideation tools and techniques are most useful; even experienced designers can come up with more ideas and better ideas using ideation tools than those relying only on what comes to mind.* (User-Centered Design chapter)

On ideation techniques and brainstorming, they recommend not rejecting any ideas; there can never be enough at this phase. Generating creative ideas come from a combination of past experiences and how one processes and applies information. Thus, the users were

guided through a brainstorming process with multiple tools and prompts, looking at past experiences as well as idealised future solutions. Through this creative thinking process, apparel-related needs were identified, and a deeper reflection on the context and meaning of sportswear inclusion was achieved.

The brainstorming, or ideation, templates were based on various established design tools. The Design Council (2015a) in the UK offers a four-part online guide that presents design tools for discovering, defining, developing, and delivering products, services, and environments that focus on user needs. Brainstorming, they write, is meant to enable collaborative working and allow for fast generation of ideas. Approaching the problem from multiple viewpoints is encouraged, as is building on ideas while refraining from judgement.

To visually organise and rank large quantities of information, ideas can be written on individual sticky notes, the Design Council (2015b) suggests. Indeed, post-it notes are a common tool in design:

> *Post-it notes, which are also known as sticky notes, are very flexible tools and are widely applied in design thinking. They are used to verbalize or visualize ideas or insights, which helps to communicate insights or ideas and, therefore, fosters retention. Sticky notes also support the recombination of ideas, since they allow for the easy combining of separate notes and the building of clusters. Finally, they also help to select ideas, because they can be arranged and grouped according to specific requirements and priorities.* (Thoring and Müller, 2011, p. 143)

Virtual post-it notes were used throughout the workshops for this study to record user ideas in view of both the researcher and the participant. These notes were then easily rearranged and clustered for data analysis, as will be detailed below.

A customer journey map is a tool highlighted by the Design Council (2015b) for tracking a user's journey through a service. It can be used to determine areas that work well for a user and points that need improvement. Similarly, experience maps serve to visualise the journey of individuals or teams through planning or problem-solving processes (Connor, 2015; MacLusky and Hastrich, 2015). As tools, these experience maps help identify challenges and opportunities, as well as objectives and motivations at each stage.

The final tools used in the workshops (Figures 4.4 – 4.6) were:

1. User Experience Map
2. Post-It Solution Brainstorming
3. Market Priority Chart

The versions used are a combination of the following:

- The established design methods and tools discussed above
- Pre-made templates from Miro
- Original modifications made to meet the aim of the workshops

First, Figure 4.4 shows a user journey map that focuses on key touchpoints of user interaction with sportswear. It was designed to help participants think about preferences and barriers, not just in wearing the garments for a workout, but throughout the whole sportswear experience. Donning and doffing repeatedly arise as aspects to consider in designing adaptive clothing (Lamb and Kallal, 1992; Watkins and Dunne, 2015), as well as emerge as a key theme from the interviews. So two touchpoints in the tool were “put it on” and “remove it”. “Choose a garment” was meant to address experiences in searching for appropriate garments to buy or wear for sport or activity. And, it was crucial to explore how sportswear interacts with the body during a “workout.”

At each touchpoint, participants were encouraged to discuss their experiences with sportswear in terms of what had worked well for them (opportunities), and what had not worked well for them (challenges). The purposes of this tool were: 1.) to identify specific apparel-related needs or barriers in sportswear for people with an upper limb impairment or difference, 2.) to highlight design considerations that may suit this consumer group, and 3.) to warm-up participants’ thinking around multiple touchpoints with sportswear in preparation for the next tool -- solution generation. The template was modified from Miro’s (2022) *Customer Touchpoint Map*.

Fig. 4.4 - User Experience Map

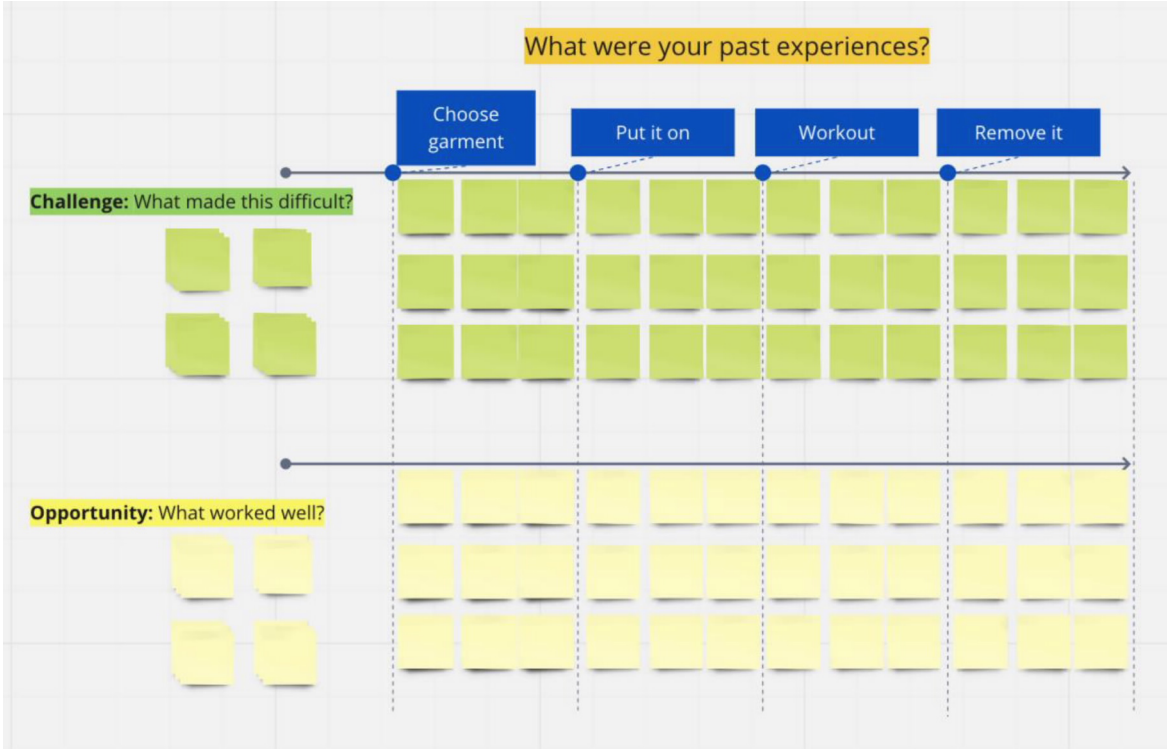
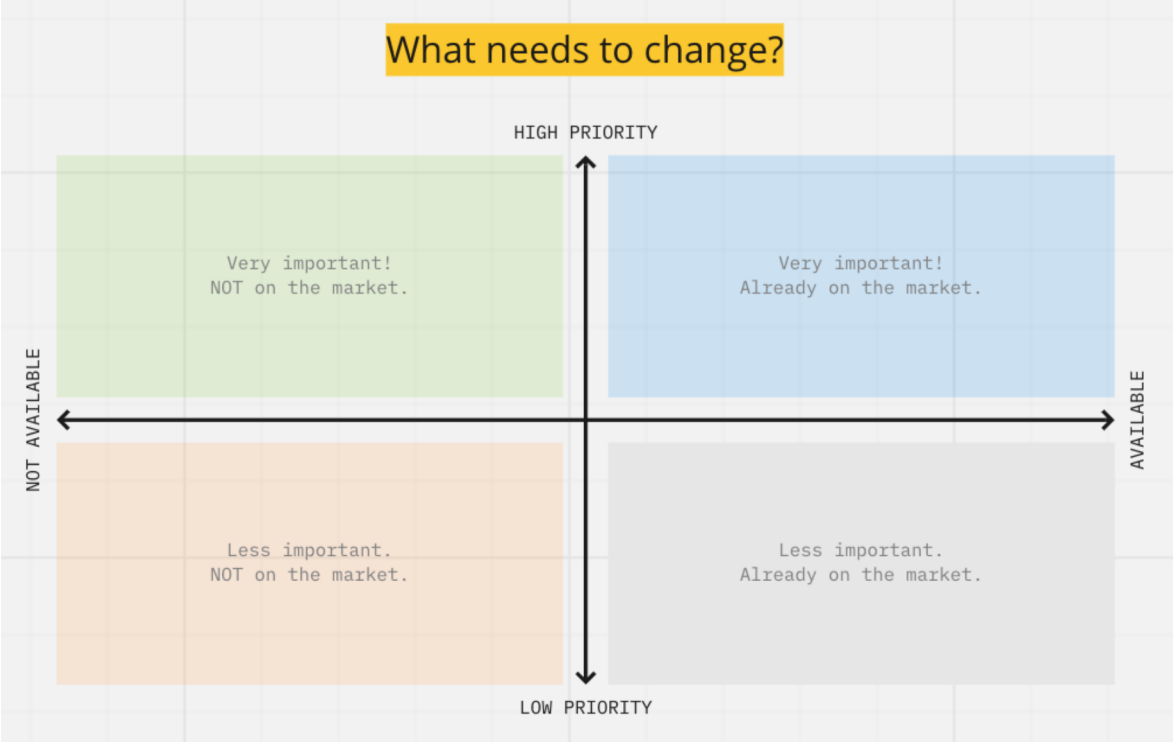


Fig. 4.5 - Post-It Solution Brainstorming

Whereas the user journey map focused on past experiences and context, the post-it notes brainstorming (Figure 4.5) focused on positive solution generation. During this activity, participants were asked to shift focus onto what would be ideal sportswear for them. They were advised that this could include what worked well in the past (or thoughts from the last activity) and what they envisioned would work well in the future. The purpose of this activity was to spark user-led design innovation based on lived experience. It was left open-ended to allow for participant-led direction. Miro's (2022) *Brainwriting* template was used for this activity.

Finally, Figure 4.6 shows a chart that focuses on user priorities and market gaps in sportswear for this consumer group. The four quadrants are meant to distinguish design ideas in terms of: 1.) high or low priority of need, and 2.) already found on the market or not yet observed on the market. Participants were asked to allocate each post-it note from the previous activity into one of the quadrants. The purpose was to highlight and rank market gaps in current sportswear industry offerings for this consumer group. The template was modified from Miro's (2022) *2x2 Prioritization Method*.

Fig. 4.6 - Market Priority Chart



4.3.4 Data Collection

To meet workshop objective three (run the workshops), the virtual sessions were conducted individually with each of the six user participants over Zoom, screen sharing the above tools through Miro. All participants received a participant information sheet and provided consent prior to the workshop (Appendix C). A pilot was conducted with fellow doctoral students to test the technology being used and the tone and understandability of the facilitation and activities. While the Miro activities received positive feedback, there were problems with connection and audio in MS Teams so this was removed as a platform option. Zoom was preferred by many of the participants and found to be the easiest and best fit-for-purpose online platform by the researcher, so this was used for all workshops. Guidance on using Zoom efficiently and securely was implemented (Gray *et al*., 2020). Miro was operated by the researcher and screen shared within Zoom so the researcher and participants could view the activities simultaneously. This way, participants were not asked to purchase, download, or learn any new software. The workshops were recorded for later analysis, and the completed brainstorming templates were saved in Miro.

Techniques for facilitation were applied from readings on how to conduct interviews and focus groups (Barbour, 2008; Smith, Flowers, and Larkin, 2009; Portigal, 2013; Krueger and Casey, 2015). Guidance included:

- Leave a pause after answers to allow for further thinking and more in-depth contributions.
- Refrain from leading.
- Adopt active listening.
- Try to gently encourage quiet participants.
- Be aware of signs of discomfort and redirect the discussion, if needed.

The Definitive Guide to Facilitating Remote Workshops (Tippin, Kalbach, and Chin, 2018) offered by Mural was also consulted. Some pertinent guidance was to test and become familiar with the technology being used beforehand to be able to troubleshoot problems, which was done. The Mural guide recommends breaking down activities into shorter steps of 5-10 minutes to avoid steering off track. The individual brainstorming tools loosely followed this timing as each took about 10-15 minutes. The activities progressed from one to the next either as participants exhausted ideas at each step or as they naturally began to talk about what was planned in the following activity. IBM design facilitator Eric Morrow suggests that online sessions do not have the breaks and social activities that come with live sessions, so the full virtual work format can become tiresome (Tippen et al., 2018). The

Miro screen sharing, thus, was turned off during the introduction and the debrief discussion so the participant and researcher could have a more casual chat instead of sustaining the formality of working through the brainstorming templates. Hand-written notes were taken during these informal conversations.

To begin the workshops, the researcher read a prepared introduction that reiterated the project aim, ethics, and an overview of the agenda. Participants were encouraged to share as much or as little as they wished and given the opportunity to ask any questions before beginning. Each activity was subsequently introduced with a description on what information was being collected and why. (Refer to Appendix G for the workshops topic guide). Participants were then left to offer ideas while the researcher recorded key points onto the virtual post-it notes. Recording contributions in real time on the shared Miro screen allowed participants to view their brainstorming ideas develop and to check that these were being transcribed accurately by the researcher. As with the interviews, no specific sports, garments, or garment properties (such as trims or materials) were suggested by the researcher to start. Participants were asked about "sportswear" in general. Thus, the identification of barriers and preferences on this topic was participant-led. The researcher did, however, offer examples of specific garments or fabric properties when a participant fell silent or seemed unsure of what was expected of them. These suggestions were based on the interview findings or previous workshop participant responses. Once these prompts were given, however, the participant was then left again to brainstorm their own ideas. Follow-up questions were also used to capture greater detail or to clarify ambiguous contributions.

As noted, time was included at the end for a general chat about the research topic. Participants were asked if anything was missed during the workshop or if they wanted to add anything further. This gave participants a chance to voice any concerns or ideas outside of what was covered during the brainstorming session. A few offered some construction feedback on the workshop preparation and questioning route itself. The final minutes were left for a debriefing on what was to happen next in the research, and participants were able to ask questions. A debriefing statement was emailed to participants after each session. Participants also received a £20 (or USD equivalent) Amazon voucher after their session as a thank you for their involvement.

After each workshop, reflective notes were taken to observe how the research was evolving based on each participants' interactions and responses. Reflexive notes were included to think deeper about how the researcher's mode of questioning and the Miro tools may have

influenced participant responses. These cumulative notes were used to continuously refine the workshop tools, the questioning route, and the strategy for data analysis.

4.3.5 Data Analysis

Objective four was to analyse the data and get feedback from the users. Findings were generated from both: 1.) practice-informed insights that came from the user community interactions, and 2.) a data analysis of the user-led workshops contributions. Analysis was designed to address the gaps indicated above that focus on:

1. What trim and construction details to recommend for this user group;
2. What design strategies can be applied to balance industry practice and user needs;
3. What contextual background of this consumer group is pertinent to increase sportswear designer awareness.

Mapping was done to make sense of emerging insights resulting from the recruitment process and the interaction with the participants. This included: 1.) visualising the people and places surrounding the participants, and 2.) listing variables arising within the realm of upper limb impairment and sportswear (see Appendix H). Upon discussion with the research supervisors, deeper reflection was given to why and how this information could be maximised for sportswear designers. Inclusive design toolkits were surveyed for descriptions and visuals of stakeholder ecosystems (Microsoft, 2016a, 2016b), user personas (Engineering Design Centre, 2017), and persona spectrums (Microsoft, 2016a, 2016b; Holmes, 2018). Multiple iterations of original user ecosystems and persona infographics, within the scope of this study, were then generated based on the contextual primary research findings.

To analyse the participant-generated workshop data for apparel-related needs and solutions, a thematic analysis was again applied. This analysis was done directly in Miro by coding and clustering ideas generated on the virtual post-it notes from all workshops, following relevant methods from Thoring and Müller (2010) and the Design Council (2015b). A step-by-step process was adapted from Braun and Clark (2006) for systematic clustering of codes and generating themes (Appendix I). Final themes were checked for participant distribution and for market urgency, cross-checked against the workshops' market priority charts.

Lastly, a summary of final themes was emailed to all workshop participants for review. A link to a virtual questionnaire created on JotForm (an online form building platform) was

provided for anonymous feedback. No workshop participan ts, however, chose to provide feedback. Subsequent user group comments were provided during the stakeholder feedback phase (described in the next section), in which the final study results (sportswear design tools) were evaluated. Workshop findings and the final output are presented in the following chapters. Results, at this stage, were visualised into infographics for the final research output -- the sportswear design disability inclusion toolkit, which is shown and described in chapter six. Thus, objective five (write up and map findings and incorporate them into the final output) was met.

4.4 Stakeholder Feedback

Evaluation of the research output toolkit comprised the last phase of primary data collection. An online questionnaire was sent to user participants, and virtual interviews were done with industry and research designers. Through these methods, the original sportswear design tools were reviewed and discussed by various stakeholders. The final output was, thus, vetted from user, industry, and research perspectives.

4.4.1 Feedback Aim and Objectives

The aim of this phase was to evaluate the pragmatic sportswear design tools output with stakeholders. This served to:

- Mitigate researcher bias in interpreting and illustrating the participant results ;
- Assess the relevance and usefulness of the practical design guidance within the sportswear industry;
- Assess findings and limitations within an academic research context.

Objectives were to:

1. Determine which stakeholders to approach for feedback ;
2. Plan methods for feedback collection from each stakeholder grou p;
3. Engage the stakeholders for feedback;
4. Chart pragmatic findings and apply pertinent feedback to refine the final design toolkit.

4.4.2 Participant Sampling and Recruitment

As Holmes (2018) asserts, design has a purpose, and only the recipient can confirm if it is successful. Sportswear designers, as the designated audience for these tools, evaluated their usability and potential value. Additional consumers with an upper limb impairment or difference were also asked to give feedback on part of the final output. This aligns with the participatory mindset of valuing users as active contributors and making sure results accurately reflect users' needs and values (McCann, 2016; Holmes, 2018; Dandavate, 2020). A physiotherapist was asked to check the accuracy of the terminology used. Finally, critical feedback was sought from other design researchers in disability innovation and inclusive design. Objective one (determine which stakeholders to approach for feedback) was met through this stakeholder distribution.

Recruitment followed a similar path to the previous data collection phases. As indicated, a few users who volunteered for the workshops were contacted to give feedback. One of the interview user participants also gave feedback. A few others were recruited through Twitter and emails to adaptive sports groups. University sportswear design course leaders, inclusive designers, and disability innovation designers were emailed directly. The physiotherapist was located and contacted on LinkedIn after participating in a webinar about adaptive fashion. Sportswear industry designers contacted and recruited through LinkedIn. The final stakeholder participants are outlined below in Tables 4.5 and 4.6. In the end, seven users, two sportswear design course leaders (who also worked in industry), three sportswear industry designers, two disability innovation designers, three inclusive designers, and one physiotherapist (who also ran an adaptive apparel brand) participated.

Table 4.5 - Feedback Participants: User Group Questionnaire Respondents

Age	Gender Identity	Location	Self-description
27	Female	US	missing arm from 2cm below elbow
39	Female	UK	complex regional pain syndrome affecting left arm
58	Female	US	no fingers on left hand, left arm is shorter
58	Male	US	above elbow (amputee or limb difference)
45	Male	US	left arm, below elbow (amputee or limb difference)

60	Male	US	right hand and arm, right leg (amputee or limb difference)
66	Male	US	left arm paralysis

Table 4.6 - Feedback Participants: Stakeholder Virtual Interviewees

Interview Session	**Participant(s)**	**Participant(s) Location**	**Job description and areas of expertise**
1. Group Interview	Sportswear expert	UK	University sportswear course tutor, also a luxury sportswear brand creative director
	Sportswear expert	UK	University sportswear course leader, also a luxury sportswear brand senior technician
2. Interview	Physiotherapist	Belgium	Physiotherapist, also an adaptive apparel brand managing director
3. Group Interview	Disability innovation researcher	UK	Wheelchair wearable tech engineer with focus on user experience research
	Inclusive designer	UK	Industrial designer with focus on healthcare innovation
4. Interview	Disability innovation researcher	India	Product designer (disability innovation) and exoskeleton researcher
5. Group Interview	Inclusive designer	UK	Innovation research fellow with focus on inclusive design for business impact
	Inclusive designer	UK	Professor of accessible design with focus on design anthropology
6. Interview	Sportswear designer	UK	Senior design director at US sportswear company with focus on lifestyle apparel
7. Interview	Sportswear designer	UK	Teamwear designer at UK sportswear company with focus on training and travel apparel

8. Interview	Sportswear designer	UK	Teamwear senior design manager at US sportswear company with focus on football, baseball, hockey, and sideline apparel

4.4.3 Feedback Planning

A chart was created in Miro to map out the: 1.) goals in engaging each stakeholder group, 2.) design tools requiring feedback from each group, and 3.) methods and recruitment to obtain the feedback. This fulfilled feedback objective two (plan methods for feedback collection from each stakeholder group). As with the previous primary research phases, the realities of the recruitment process and running the feedback sessions meant modifications to the data collection plan were made in-action.

The user group was only asked to review one tool (which pertained to apparel design outputs) to determine if the options shown reflected real end-user needs and values. As these design options were generated based on user contributions from the interviews and workshops, this feedback served as a final round of user validation. To include as many user participants as possible, online questionnaires were created in JotForm and open to respondents from the US and UK for a couple months.

The remaining stakeholders were engaged in virtual feedback sessions over Zoom. In this instance, key stakeholders were involved from the UK, India, and Belgium. Focus groups had first been considered for feedback, but the purposive sampling needs of high-level industry-related stakeholders was better matched to scheduling individual or small group (two participants) in-depth interviews (Saunders, Lewis, and Thornhill, 2012). This gave the researcher a platform to first explain the research methodology and intent of the tools before collecting critical feedback on the design tools shown.

4.4.4 Data Collection

Eight interview sessions were conducted to obtain in-depth, expert critical feedback from the design-based participants. Participant information sheets, a confidentiality and consent agreement, and topic guides were prepared for these interviews (Appendix C). Stakeholders were presented with a project overview, relevant design tools, and questions to evaluate the newness and applicability of the tools. Language and specific feedback were adjusted for each stakeholder group. For instance, the physiotherapist was asked to verify the clinical aspects. The inclusive designers and disability innovation designers were asked

about tools relevant to areas of design research and disability inclusion. And the sportswear instructors and designers were asked about relevance and application within an industry setting. Throughout the interviews, hand-written notes were taken on key feedback themes. All interviews were recorded, and reflective notes were generated after each session.

Seven user participants gave feedback through a JotForm questionnaire. Participant information, a confidentiality notice, and an informed consent agreement were embedded in the form. Open-ended questions were included, along with the tool for review, to gather critical feedback on which (if any) design options seemed most relevant and where improvements could be made. Responses to the questionnaire were monitored regularly. After two participants indicated some flaws with the design sketches (which will be recapped in the following chapter on findings), revisions were made and uploaded into JotForm for the remainder of the user feedback. Thus, feedback objective three was met (engage the stakeholders for feedback).

4.4.5 Data Analysis

The aggregate feedback was collected over a few months and analysed to refine: 1.) the final design tools and their use, and 2.) practice-informed reflections on various stakeholder engagement, value in collaboration, and perspectives. As introduced in section 1.8, the type of design research applied for this study indicates that design outcomes should be understandable to design professionals (Koskinen and Krogh, 2015). So, the feedback analysis was focused on identifying key suggestions for improvements in the relevance, visual layout, and intent of the design tools for use in the sportswear industry. As pragmatic research, the findings were filtered for relevance in meeting the research aim (Saunders, Lewis, and Thornhill, 2012). Results were segmented by stakeholder group to recognise various points-of-view on the research outputs. This also helped to ensure that user perspectives were not unintentionally marginalised and remained in balance with industry needs.

Comments about and suggestions to improve each tool were charted after each session, and observations were noted about the perspectives and quality of feedback for each particular group. Suggestions for the tools, and overall comments, were consolidated into key feedback, which consisted of recurring or critical insights. Pertinent suggestions were applied to the toolkit for final development, while other feedback was set aside, depending on alignment with the disability studies framework and the research questions. Similar to the pragmatic final output feedback collected by Baharom (2020) in his automated zipper design research, comments also indicated broader applications of the tools as well as

recommendations for future research opportunities. These results are explained in the following chapters. Thus, feedback objective four (chart pragmatic findings and apply pertinent feedback to refine the final design toolkit) was met.

4.5 Community Engagement

The above described interviews, workshops, and feedback sessions formed an iterative stakeholder primary research exploration. Additionally, throughout the entire study, engagement with various disability, inclusive design research, and adaptive apparel communities helped to locate understanding and implications of this complex topic. As mentioned, pragmatic design research may include exploring and contextualising idea generation within the world around us (Stappers, 2007). Holmes (2018) advises to consider what familiarity people already have with existing solutions in their lives and how this affects them. Therefore, engagement with various stakeholder groups (particularly the disability community) was maintained throughout this research. Below is a list of community engagements undertaken (Table 4.7). Opportunities were joined as available, and the goals were simply to connect, to network, and to learn.

Table 4.7 - Touchpoints with Stakeholder Communities

Type of Engagement	**Touchpoint**	**Year**	**Format**
Webinars and Online Discussions:	Future of Fashion Inclusion: Trousers Edition	2020	Virtual
	GDIHub Disability Inclusion Series	2020-2021	Virtual
	Strut and Stroll: Fashion Show for All	2021	Virtual
	Design.Different (Helen Hamlyn Centre)	2021	Virtual
Social Media Network-Building:	Adaptive and inclusive fashion designers, Adaptive sports organisations, Disabled consumers	2018-2022	Twitter, LinkedIn, Instagram

News Articles:	Opinion pieces, Adaptive brand launches, Adaptive fashion designer profiles	2017-2022	Online
Professional Disability Sports Events:	World Para Athletics Championships	2017	Attended live in London
	Paralympics broadcast	2016, 2021, 2022	TV coverage
Disability-related Events:	Disability Sports Coach Summer Festival	2019	Attended live in London
	Naidex (disability innovation trade show)	2019, 2021	Attended live in Birmingham, Virtual
	Abilities Expo	2021	Virtual
Conferences and Symposia:	Cambridge Workshop in Universal Access and Assistive Technology	2018	Attended live in Cambridge
	London College of Fashion Fashioning Inclusion Symposium	2018	Attended live in London (presented)
	London College of Fashion Fashioning Inclusivity Symposium	2019	Attended live in London (presented)
	DMI: Design Management Academic Conference	2020	Virtual (presented)
	Design as Common Good Conference	2021	Virtual
Informal Chats:	Disabled athletes and dancers, Family of disabled consumers, Disability bloggers/activists, Inclusive and adaptive fashion designers, Adaptive sports coaches and providers	2018-2022	In-person, phone, virtual

Reflective notes and a contact list were maintained. This assisted in keeping track of up -to-date language, thought leaders in the fields being explored, pertinent stakeholders, and the extent of the potential user community. Additionally, recruitment for each data collection phase required a great deal of time spent engaging with various communities. As noted, this was done by navigating and contacting multiple stakeholders, disability sports groups, and gatekeepers through website contact forms, Twitter, Instagram, direct emailing, and referrals. Workshops on research development and emerging design research within UAL and external institutions were also attended.

4.6 Research Rigour and Triangulation

On-going community engagement, stakeholder feedback, and research supervision provided external checks to the researcher's interpretations. Methods for triangulation were also applied to establish trustworthiness of findings. This was done by engaging multiple: 1.) sources; 2.) methods; and 3.) theories (Law *et al*., 1998). Participants were sourced from a variety of recruiting avenues from both the US and the UK -- adaptive sports organisations, disability charities, social media, university contacts, and industry contacts. A range of user participants self-identified with the research scope (Tables 4.3 - 4.5) and enjoyed various activities (hand cycling, stationary cycling, wheelchair rugby, golf, American football, running, swimming, gym workouts, and dance.) These ranged from Paralympic sport to casual fitness or sport. Sportswear designers worked for seven different companies in total, some as design directors and some as senior designers. Experts in biomechanics came from physiotherapy, university research, and orthotics pattern making.

Multiple methods were employed to collect primary data -- stakeholder semi-structured interviews, user ideation workshops, and stakeholder feedback questionnaires or interviews. Findings were interpreted through lenses of practice-informed design research, functional apparel design, sportswear industry practice, and the social model of disability. Results were developed through participant-led contributions, systematic thematic analysis and mapping, and data visualisation. The dissertation supervisory team reviewed the data collection and analysis planning and progress for all phases of the research. Results were then discussed for alignment with the research questions and research aims. As noted, the first phase interviewees were able to review their transcripts, as well as the thematic analysis findings. The user workshops employed screen sharing of the ideation activities for participants to check the researcher's note-taking in real-time. And the final stakeholder feedback sessions served to review the overall research output.

In addition to the supervisory team, critical feedback was obtained from other researchers. While in progress, this research was presented at two inclusive fashion events at London College of Fashion (Table 4.7). Q & A sessions followed each for interactive feedback. A paper following the interview phase results was presented at the 2020 Academic Design Management Conference, run by the Design Management Institute (DMI) (Appendix J). The aim of this paper was "to present an inclusive strategy for sportswear design for people with upper limb impairments" (Poage, Kapsali, and Bardey, 2020, p. 2). Peer-review feedback was received, which helped to refine the subsequent research direction. Finally, during the writing up phase, the researcher was approached by a global sportswear company for a potential collaboration on a design initiative for the 2024 Paralympics. Preliminary discussions revealed industry interest in this research, particularly learning about social awareness and the context of disability in relation to adaptive sportswear. The proposed collaboration, however, was unable to fit within the research timeframe and parameters. But the company did indicate that experts are, indeed, needed in this area.

4.7 Researcher Role and Perspective

Within the practice-informed and human-centred scope of this study, the researcher's background, points-of-view, and relationship with the research and the participants are outlined in this section. Law *et al*. (1998) write:

> *Qualitative research involves the 'researcher as instrument', wherein the researcher's use of self is a primary tool for data collection. Documentation of the researcher's credentials and previous experience in observation, interviewing and communicating should be provided to increase the confidence of the reader in the process. The researcher's role(s), level of participation and relationship with participants also needs to be described, as they can influence the findings.* (p. 7)

They also state, "the researcher's bias and influence of their own point of view should be stated and discussed within the context of the study" (p. 7).

As previously mentioned, the researcher comes from a sportswear industry background with practical experience in technical design for sports apparel. A master's degree in Fashion Design Management was undertaken at London College of Fashion, which resulted in the practice-based thesis, *Drawing Upon Biomechanics Professionals to Create A Specialised Tool for Design Innovation in Athletic Wear* (Poage, 2016). Additionally, the researcher co-authored a design management book (Poage and Poage, 2016). Both the

MA thesis and book relied on semi-structured interviews with stakeholders and interpretation of findings based on pragmatic industry experience.

Disability studies was new to the researcher prior to this study. Originally, this research was planned in conjunction with London College of Fashion and the GDIHub. Unfortunately, involvement with the GDIHub became unavailable after the research began. Prior to th is study, the above-mentioned MA thesis had been adapted into a paper with a disability focus, which was presented at the 2017 Disability Innovation Summit at the GDIHub. Also, the researcher had volunteered as a facilitator for Central St. Martins' Design Against Crime co-design program at HMP Thameside prison guiding inmates through the creation of a nti-theft bags. The virtual short course from Central St. Martins, *Participatory Design and Facilitation*, was also completed at this time. Additionally, she completed a short-course at St. Mary's University, Twickenham in Anatomy, Physiology, and Pathology prior to doctoral study.

As introduced, the researcher identifies as disabled. Her experience is her own (and not related to the upper limb,) so it was not relevant to the findings. Interpretations of research results and the practice-informed output, however, are unavoidably filtered through a researcher lens of being disabled and having a background in the sportswear industry. She found this useful to adapt language to specific stakeholders during data collection based on experience in industry, interactions with medical and physiotherapy practitioners, and time spent in both the US and UK.

An essential aspect of user-led research is recognising power differentials (Faulkner and Thomas, 2002). This is also examined within design projects from a social design perspective (Goodwill, 2020). It must be acknowledged that the researcher was the gatekeeper of access to participation and the point of consolidating stakeholder results. To counter this power dynamic, as much as feasible, open-ended methods were chosen to elicit free flowing participant feedback, and recruitment parameters were flexible to include those who self-identified with the project. For the interviews and workshops, participants were told prior to the sessions what line of questioning would take place in an effort to mitigate any unanticipated discomfort that might arise from being asked to discuss challenges with sportswear. This resulted in some users preparing responses and props ahead of time, which had not been anticipated but were very welcome. One user came prepared with thoughts to share that did not follow the questioning route, so he was given space to communicate what he wanted to express. This interview was rerouted mid-way through, and the original anecdotes he came prepared with were inductively analysed and contributed to the results.

Reflexivity was also practised:

> *Your reactions, your interactions with those taking part and your attitudes and beliefs may each impact on your interpretation of the data that are shared with you.* (Saunders, Lewis, and Thornhill, 2012, p. 556)

Reflexive practice was done through journaling and charting stakeholder interactions to "acknowledg[e] the ways in which the researcher actively contributes to the data she or he is generating" (Barbour, 2008). Reflection and reflexion happened, in part, after points of interaction with the community, which were:

- Recruiting with individual stakeholders and organisations
- Attending disability sports events and trade shows
- Each phase of data collection - interviews, workshops, and feedback

The researcher learned how her language and clarity (or lack thereof) during recruitment resulted in unexpected responses or queries for more information from the contacts. Interaction with users required much forethought and space as an effort was constantly maintained to learn and reflect terminology used by the participants in describing themselves.

4.8 Ethics

A mix of sources were consulted for building the ethical framework of this people-centred, qualitative research. UAL's ethics policies (University of the Arts London, no date) were followed (Table 4.8). The research project was approved by UAL's ethics committee.

Table 4.8 - *Ethical Considerations Followed, per University of the Arts London's Guidelines*

Guiding Principles	Respect for Persons - Participants were briefed on what involvement and the research entailed in order to ensure their autonomy and freewill in taking part. A DBS check was cleared and safeguarding procedures consulted with regard to working with disabled people, as requested by the ethics panel. Justice - Methods were employed to minimise potential risks of asking people to discuss their personal experiences (outlined below).

	Beneficence - Since this research takes a social model perspective, a guiding principle is to remove barriers put up by society that limit disabled people from participation in certain activities. The methodology seeks to involve disabled people at key stages to make sure they have influence over their involvement and the results.
Academic Integrity	Contributions from all participants, supervisors, and previous studies are acknowledged.
Privacy and Confidentiality	All participants were advised that they had a right to refuse to answer (or leave) at any point during the data collection. No individuals are mentioned by name or identifying features in the research.
Data Protection	The research was GDPR-compliant. All primary data was stored on UAL's secure servers or an encrypted device. It will be deleted once no longer needed and not used for any other purpose than disclosed. The online transcription service and coding software used were checked for confidentiality policies. Online platforms for data collection were as secure as possible, and participants were made aware prior of the platform to be used.
Intellectual Property	Participants were advised prior to data collection that intellectual property will remain with the researcher.
Informed Consent	All participants were able to give informed consent. All participants were given a participant information sheet and asked to sign a consent form before data was collected. Prior to starting the sessions, participants were briefed again, asked if they had any questions, and were offered a chance to withdraw their contributions from the study.

The UK Department for Work & Pensions (2014) offers a research guide for involving disabled people, which provided further guidance. The section, "Helping people take part in research" states "[d]esign your research so that everyone can take part" and recommends working with organisations and disabled people to identify what might be a hindrance to taking part. Some potential accessibility issues were mitigated by running the data collection sessions online, but adequate internet and computer access were required for involvement. A benefit was that a virtual format allowed for purposive participants to join from the comfort of their own homes or offices, without geographical or other environmental factors becoming barriers (Lo Iacono, Symonds, and Brown, 2016). All stakeholder participants were asked up-front if any accommodations could be provided during their sessions.

As stated, focus groups were originally planned for the first data collection phase before switching to interviews, so ethical guidance for discussions was sought. Much of this ethics planning was implemented in the interviewing, workshops, and feedback sessions. In

conducting focus groups, the Department for Work & Pensions (2014) states not to be intrusive, meaning:

- Do not ask personal questions if the information is not necessary. (Participants were not asked medical questions, but they were left room to discuss personal or clinical experiences if initiated themselves.)
- Be clear about the outcomes of the research. Do not suggest it will change anything if it will not. (Participants were advised that no actual garments were being produced.)
- Try not to upset or worry people. (Topics were open-ended for participants to share as little or as much as they chose.)

Barbour (2008) states that it can be difficult to predict any distress that may arise during a discussion as that depends on the context and the individuals, but there are ways to minimise potential negative effects. For one, it is important to have enough time to debrief and give out follow-up contact information; this was done for the interviews, workshops, and feedback sessions. As feedback from the user group was obtained through an online questionnaire, the researcher's contact information was embedded in the form for participants if needed. While the discussions around disability were moderated in a sensitive manner, it is not possible to predict all participants' reactions, as Barbour notes. As noted, participants were briefed on the topic, line of questioning, and purpose of the study beforehand and advised they could leave at any time.

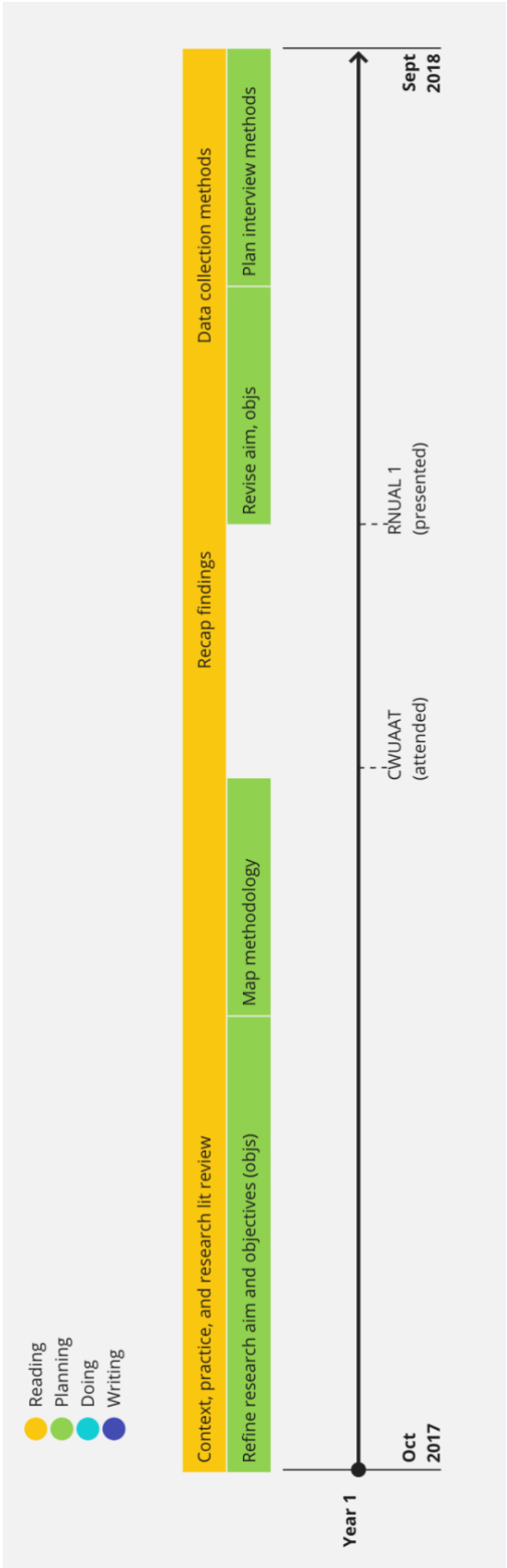
4.9 Conclusion

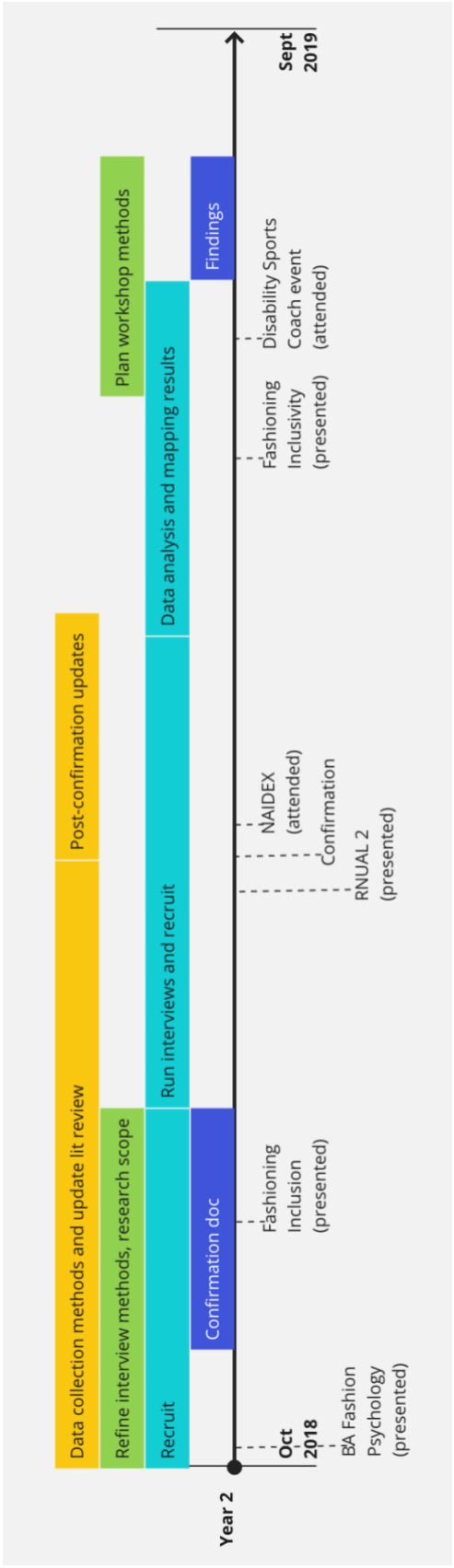
In the end, this research project spanned five years. As mentioned, research was able to proceed during COVID lockdowns through the use of virtual methods (in conjunction with some in-person community engagement, as recapped in Table 4.7). As mentioned throughout this chapter, rolling modifications were made to the data collection and analysis to reflect pragmatic and user-led needs. The application and implications of virtual methods in this type of design research on disability inclusion will be revisited in the discussion chapter.

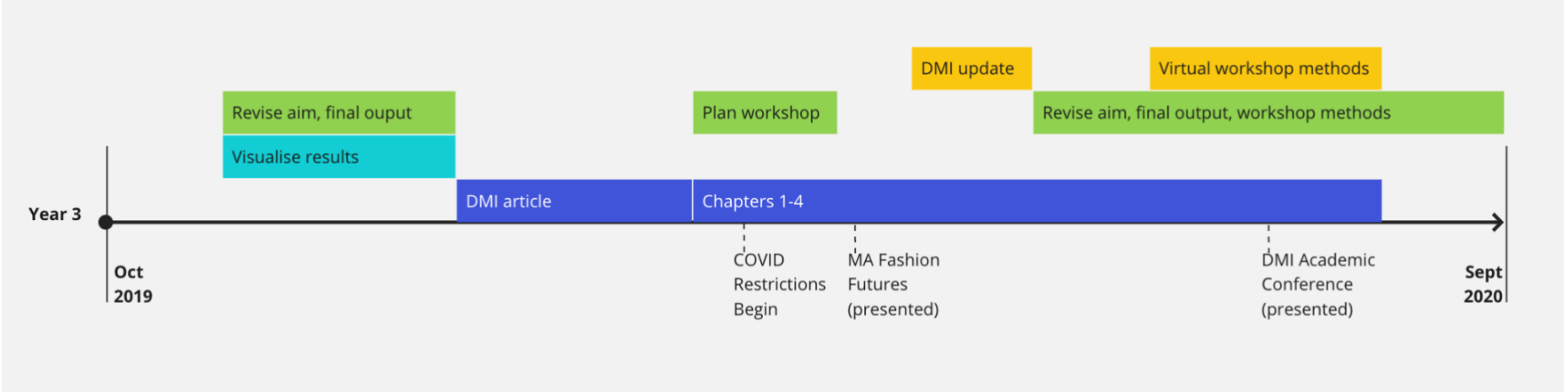
Figures 4.7 - 4.11 show a timeline of the research progression, year-by-year. Reflective of the exploratory nature of the research, the timeline shows that the literature review was revisited many times as the research progressed to further understand topics of import. Also, the writing up phase saw a surge in published articles on adaptive apparel, reflective of the growing focus on this area of research. Another notable aspect of the timeline below

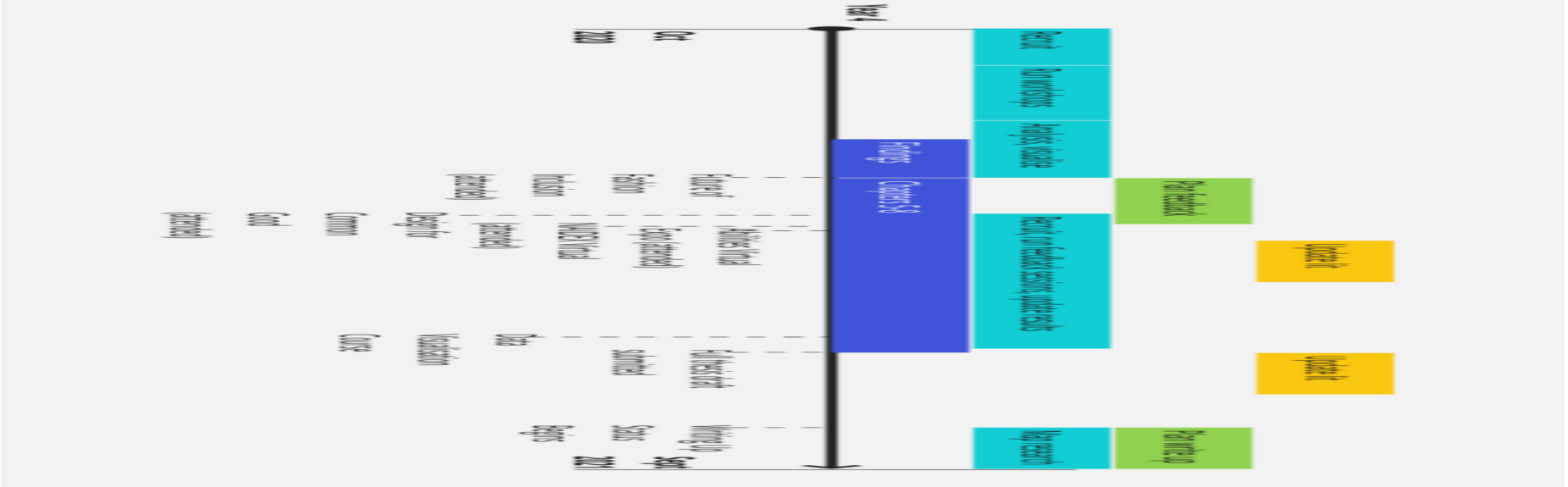
is the length of time (about half a year) spent recruiting and interviewing participants for the first data collection phase. After navigating an array of disability organisations and adaptive sports providers, an extensive network was established that streamlined the recruitment process for the subsequent phases. The process of building up this complex network, in turn, influenced the practice-informed results of this study. These results, in addition to the primary research findings, are presented in the following chapters.

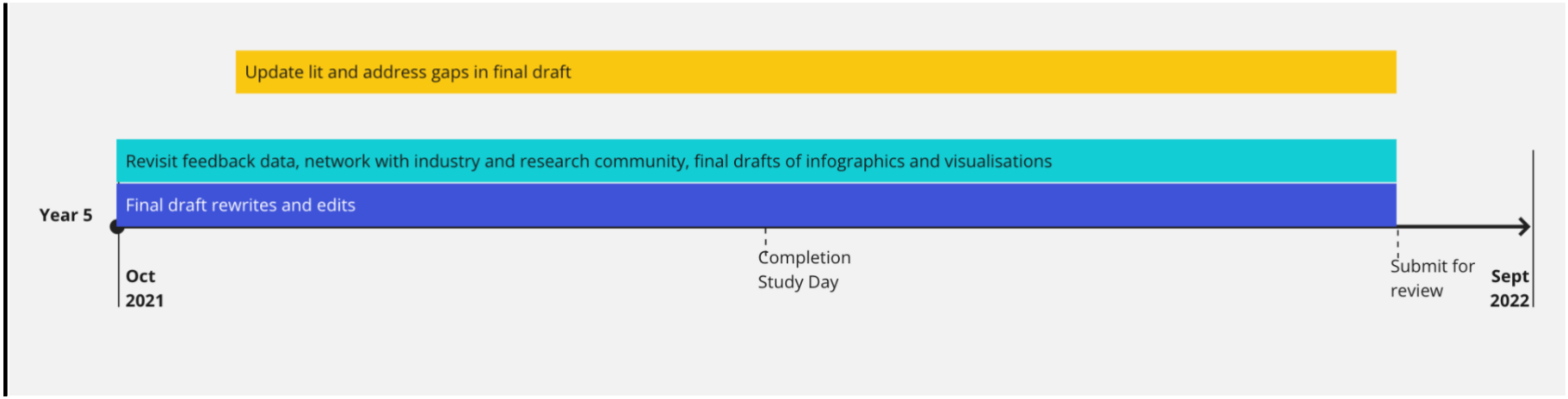
Figs. 4.7 - 4.11 - Research Journey Timeline: Years 1-5






DMI update
Virtual workshop methods
Revise aim, final ouput
Plan workshop
Revise aim, final output, workshop methods
Visualise results
Year 3
DMI article
Chapters 1-4
Oct
2019
COVID
Restrictions
Begin
MA Fashion
Futures
(presented)
DMI Academic
Conference
(presented)
Sept
2020




Update lit and address gaps in final draft
Revisit feedback data, network with industry and research community, final drafts of infographics and visualisations
Final draft rewrites and edits
Year 5
Oct
2021
Completion
Study Day
Submit for
review
Sept
2022

Chapter 5: Findings

This chapter presents the findings from the primary data collection and analysis in three parts:

1. Interview results
2. Workshops results
3. Community engagement

Each data collection phase was modelled on findings from the phase that had proceeded; community engagement was iterative. (The findings from the stakeholder feedback phase are placed in the following chapter along with the final toolkit output.) Iterative reflection and mapping were done throughout the research process, so all results tie back to the holistic development of the research questions, research aims, and final outputs (sections 1.6 and 1.7). All findings were pragmatically scoped for:

- Identifying barriers to sportswear design inclusion;
- Indicating what guidance is needed for sportswear industry designers;
- Facilitating a participatory exploration that is relevant and meaningful to the disability inclusion/sportswear industry context.

5.1 Interview Results

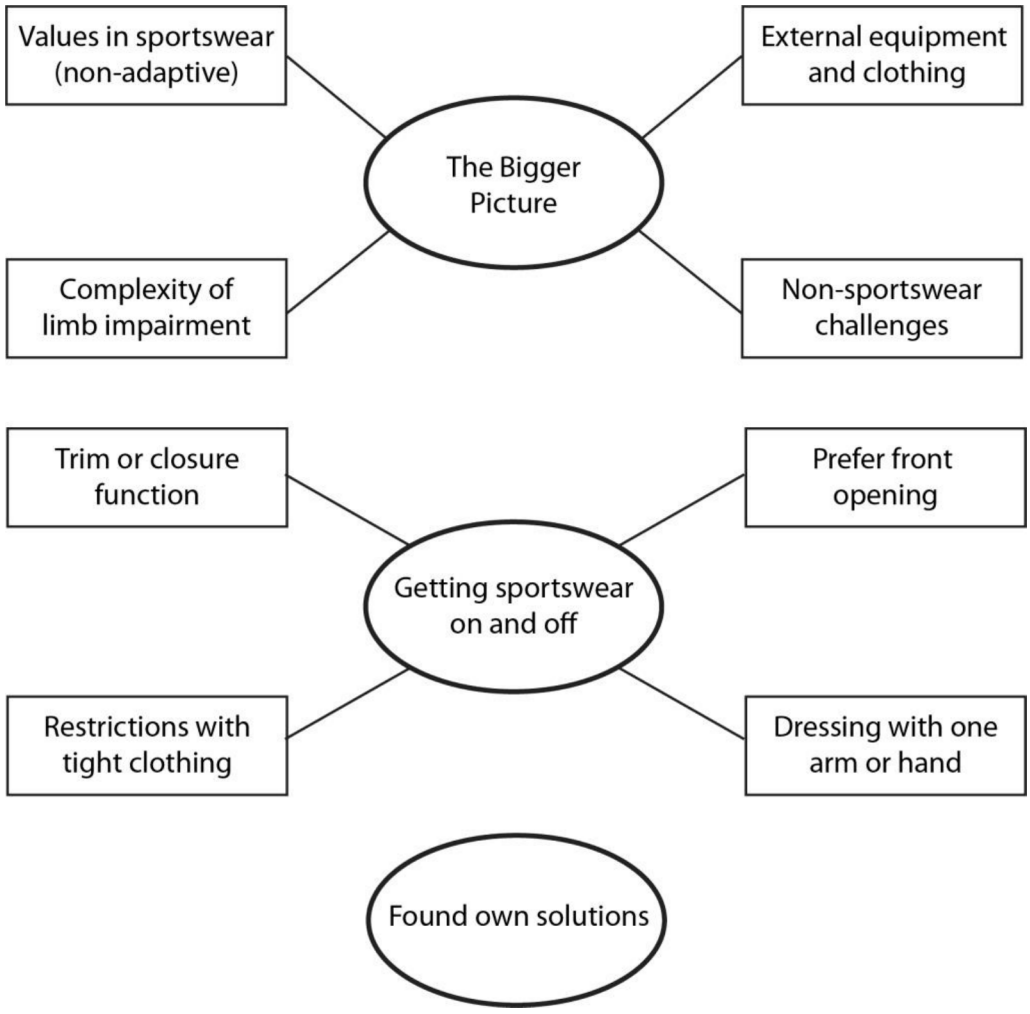
The interview findings are summarised here in three parts: 1.) user group themes, 2.) industry group themes, and 3.) overall findings. As indicated in section 4.2.5, the transcripts were grouped and analysed as two data sets: individuals with an upper limb impairment or difference who practise sport or fitness (users); and sportswear industry designers, biomechanics researcher, or similar (industry). Themes from each data set were then compared and contrasted to find gaps and shared insights between the groups. A condensed initial write up of these interview findings appeared in the Poage, Kapsali, and Bardey (2020) DMI conference paper in Appendix J.

5.1.1 User Group - Final Themes

All participants in this interview group identified as having an upper limb impairment or difference and engaged in sports or fitness activities. The experiences and perspectives shared are, of course, unique to the individuals. Still, taking a pragmatic view of what

sportswear is available and how it fits with participant needs, common themes were revealed. This vast consumer group might be better served, in part, with simple adaptations to existing designs and with more inclusion in the design process to maximise existing knowledge through lived experiences. Figure 5.1 shows the final themes and sub-themes found from the data analysis of the user group, following Braun and Clarke's (2006) thematic mapping for thematic analysis.

Fig. 5.1 - Final Thematic Map: User Group. Updated from Poage, Kapsali, and Bardey, 2020, Fig. 1, *Final Thematic Map – User Group.*



5.1.1.1 The Bigger Picture

Understanding contextual values, narratives, and other design-related barriers present a broader understanding of the user group and potential sportswear needs. This theme and the sub-themes arose inductively, led by what the data revealed rather than the pre-set

aims of conducting these interviews. Much of this data came from the participant-led conversational direction and unprompted personal anecdotes.
This theme was broken down into sub-themes as follows:

- Complexity of limb impairment
- Challenges outside of sportswear
- External equipment and clothing relationship
- Values in sportswear

Participants recounted first-hand experiences and insights into limb impairment from their own perspectives. It shows the vast array of complexity within the label of "upper limb impairment" that was assigned for research purposes. Focusing solely on clinical terminology or the disability "category" misses much of the context and individuality of people's experiences. As Participant 1 put it:

> *Because, for me, I wear a brace, but somebody whose arm is amputated, you may not have to worry about the same things I have to worry about.*

And Participant 2 stated:

> *The more people I meet within the disabled world, the variations of… even just arm amputations within one arm is completely different.*

The array of anatomical and physiological variation is vast, and everyone's experience is unique. While this point is echoed by scholars of disability studies (Shakespeare, 2018), hearing it first-hand from these participants created a more concrete picture of this complexity. Also, if there is an injury or a progressive condition, the degree of "disability" will vary. It is in flux (Shakespeare, 2018). Apparel-related barriers and preferences may shift as a result. For instance, following a traumatic injury, Participant 3 said:

> *Then, tying shoes was almost impossible while I was in the hospital. I do have enough pinch control with my right thumb and index finger now that I can tie my shoes now, but that was, you know, it was probably two years after the injury before I was able to do that.*

And discussing surgery recovery, Participant 5 stated:

Yeah, I mean, for me the biggest thing has been everything front closing because with shoulder surgery going around the back is months away.

There can also be side effects or complex conditions, in which factors apart from the upper limb impairment may affect clothing choices. Medications, for example, may cause weight gain. Or, nerve damage can result in loss of sensory feel, (also discussed by Kabel, 2016). Participant 3 discussed consequences of his loss of sensory feel:

I'd lost sensory feel, so a lot of times, even when I put on gloves now, a lot of times I won't feel that my fingers aren't necessarily going in the finger holes of the gloves. They'll get bent down and just, sort of, stuck in the palm area, or I'll get two fingers into one finger hole on gloves.

As did Participant 4:

So, the other problem is, my skin is numb, so, I have no feeling. So, I could injure that without knowing, causing a pressure sore or friction sore.

Participants discussed design-related barriers outside of sportswear. Barriers were associated with medical equipment, casual ready-to-wear apparel, or certain daily tasks. Understanding these challenges can provide a better picture of the scope of imposed barriers and how design can impact comfort-levels or abilities to accomplish tasks. Participants were not directly asked about challenges outside of sportswear. These contributions were user-led and address disability inclusion on a broader level. This was well-illustrated through Participant 3's frustrations trying to open a water bottle:

So, for a long time I, you know, bad enough I was injured, now I had to have people help me get dressed every day. Sort of, the same, you know, the most embarrassing thing in the hospital was probably when I'd go to buy a bottle of water at ... or something like that, if I'd gone for a walk somewhere in the hospital. They'd hand me a bottle of water and then I'd sit there staring at it because I had no way of taking the cap off the bottle. So, I'm standing there and waving people down in the hallway, 'Hey, can you open this bottle for me?' They look at you like you're, kind of, weird. Like, 'You can't open a bottle?' 'Yeah, right now I can't. Sorry, man.'

Or Participant 4's interactions with his arm cuff:

So, with all the cuffs, even the bigger fabric one, that goes on the outside, when it was newer, there was so much elasticity in the strap, you had to go through th e D ring and pull it back on itself, you know? I tried it a couple of times, and you're trying to hold the material with your teeth, and then pull it, and if you didn't get it right, this flew out, and your teeth snapped together. So, you're risking breaking teeth.

As indicated by the participants, braces, prosthetics, rehabilitation equipment, and other worn medical devices will affect clothing and vice versa. Apparel could be designed to work around it, equipment could be designed to work around the apparel, they could be designed to work as a system together, or they could be designed as one combined unit. This was not considered when preparing the questioning route (or discussed with the industry group), so this is a significant sub-theme from the user group. It supports the addition of the body/garment/external environment ring to the modified FEA Model by Stokes and Black (2012). Participant 1 talked about barriers in changing clothes while wearing an arm brace:

Having to change anything is difficult because I wear a brace. So, if I already have the brace on my arm, if I have to take something off- if I decided to put the brace on top of it, then I'd have to take the whole brace off to get it off. Most things can't fit over the brace, so if I'm changing in general, the whole brace doesn't have to come off, but I at least have to take it from around my neck and then kind of struggle to get it off of my arm.

Participant 4's discussion about the layering of clothing and braces gave a picture of how they work one on top of the other:

So, actually, I found that on all these base layers, a cycling top fits tight enough. So, I get the skin top on, yeah? The [brace] with the white strap, so, I get this on first, because that's skin-to-skin contact. The stretchy material of the base layer is enough to go over that, and then I fit this [other brace] on. Over the top, I'll then pull on a cycling jersey, a long sleeved cycling jersey, or even some of the short sleeved ones.

Everyone talked about the qualities they look for in sportswear. A frequent consideration was material properties, but otherwise priorities were varied, depending on individual preferences. It is critical to keep on-trend for adaptive sportswear so the design is not all focused on disability – a point echoed by Pullin (2009) that designs need not be overly-clinical to function well. An approach could be taking existing mainstream sportswear and simply making it more accessible or more inclusive.

As Participant 4 stated about material needs in sportswear:

> *I think it's the functionality of the material. So, the material would have to be breathable, it would have to be easily washable, and relatively quick drying.*

5.1.1.2 Getting Dressed, or Donning and Doffing Sportswear

Most of the apparel-related barriers of sportswear for these participants involved extra hassle in getting the garments on and off. Some common sub-themes arose around the fit, construction, and fastenings used in the garments. In some instances, participants identified their specific needs or preferences in ideal design details. For this theme, the interview excerpts help to pinpoint what design aspects need a deeper look for better disability inclusion in mainstream sportswear. Identifying common themes, as shown by Carroll and Kincade (2007) and McBee-Black (2022), may help alleviate brand misgivings about reaching a more diverse scope of consumers.

The most common barriers and suggestions were:

- Restrictions with tighter clothing
- Front opening on tops is preferred
- Making sportswear easy to put on with one hand
- Easy to use trims and fastenings

Many participants indicated that tight tops, while preferable for certain activities, caused a bigger effort in donning and doffing for those with an upper limb impairment or difference. Participant 1 said:

> *I don't mean to say Under Armour but tighter materials that are built for like track and field, and stuff. It's definitely good for efficiency. But it is a little difficult for me to get in and out of because I only have use of one arm. And I'm not an amputee, so I still have the limb. So, it's extremely difficult once it gets sweaty, like trying to pull it off, it just takes a little extra effort.*

And Participant 2 commented:

> *So, just the ease of getting the shirt off a little bit more, and that's why the built -in bra helps a lot because you have on your tank top, and that's hard to get off if it's*

tight, and then you have the sports bra which everyone has a problem with, but e ven more so for those with limb differences.

One suggestion was that a front opening might make it easier to don and doff a tight-fitting sports top. Participant 1 suggested:

In my head, I was thinking I would probably try to get my wife to maybe sew in a zipper. Like just cut the fabric up the middle and then sew a zipper on so that the fabric, if I unzip it, it's not hugging the skin. And it would just be easier to just get the whole thing off.

Preference for a front opening was heard from others and related to multiple styles of sportswear tops. As described by Participant 5:

But I'm sure like one thing that will be so beneficial if I ever found the right thing would be something that just zips up the front. I mean when you've had shoulder surgery the one thing that they say all the time is, 'Find things that zip and button in the front. It will make your life a lot easier.'

Some apparel-related barriers involved clothing that was difficult to don or doff with one hand. At times this was connected to tight fitting clothing or the access point of getting into or out of the garment. Participant 4 mentioned challenges imposed by his cycling top:

So, particularly after cycling, I've only got one arm, and it's basically I've got to grab it, and work it up, to get it out from underneath it. There are a few times I've wanted to call for help, but I've just tried myself.

Participant 5 discussed donning of leggings:

I wore a lot of leggings post-recovery, but it was difficult getting them on, and I also found that because of the way- I can only have one hand to pull all this stuff up. I often was tucking things into them.

Other apparel-related barriers concern trims or fastenings that require high dexterity in both hands, like buttons or a drawstring that ties at the end. Replacing these items with simpler devices could go a long way to less-burdensome donning and doffing.

Participant 3 commented on drawstrings on shorts:

> *There's the shorts, that would have helped too, a lot of times, was tie strings on the shorts, and I couldn't do those, but I was able to - the… gym shorts we have, have one tie string with almost the Never Tie toggle on it, that tightens the strings down. So, I was able to just put one finger through the loop on the shorts, pull it up with my right hand and then slide the toggle down with my left hand.*

And Participant 2 discussed her frustrations with buttons:

> *Like, buttons are super annoying for everyone, but standing there to button a shirt is the worst.*

5.1.1.3 Found Own Solutions

There is a wealth of knowledge in consumers who have made their own adaptations to sportswear, shoes, and/or external support, like arm braces. Learning from the user group's lead also gives more agency to that community (Ehn, Nilsson, and Topgaard, 2014). These participants mentioned brands and organisations who provided well-designed adaptive sports gear as examples to follow. The users also discussed their own self-made adaptations for sportswear (or gear - shoes and braces). A participatory collaboration could, thus, yield results that build upon experiential expertise of the users and the professional industry knowledge of the designers for greater inclusion impact. For instance, Participant 3 brought up "Never Tie" laces, which allow shoes to be put on with one hand:

> *But, I used [Never Tie] on the sneakers. My wife ended up taking all the laces out of my shoes, ordering a bunch of these online, and then using those for the shoelaces. That way I could pull them tight with my left hand, and then I'd maybe stick the loop through my right index finger, and then push the tab down with my left hand again, just to get them tight that way, because tying really wasn't an option for a while there.*

While speaking about adaptations made to clothing, Participant 3 indicated:

> *My right hand, it's sometimes hard to manipulate a smaller zipper. So, we'd end up always putting a piece of string or leather strap inside the zipper to make it longer, something more, maybe a loop there so I could pull it up with one finger.*

And, finally, Participant 1 detailed his process in designing a system to keep his brace more secure during sport:

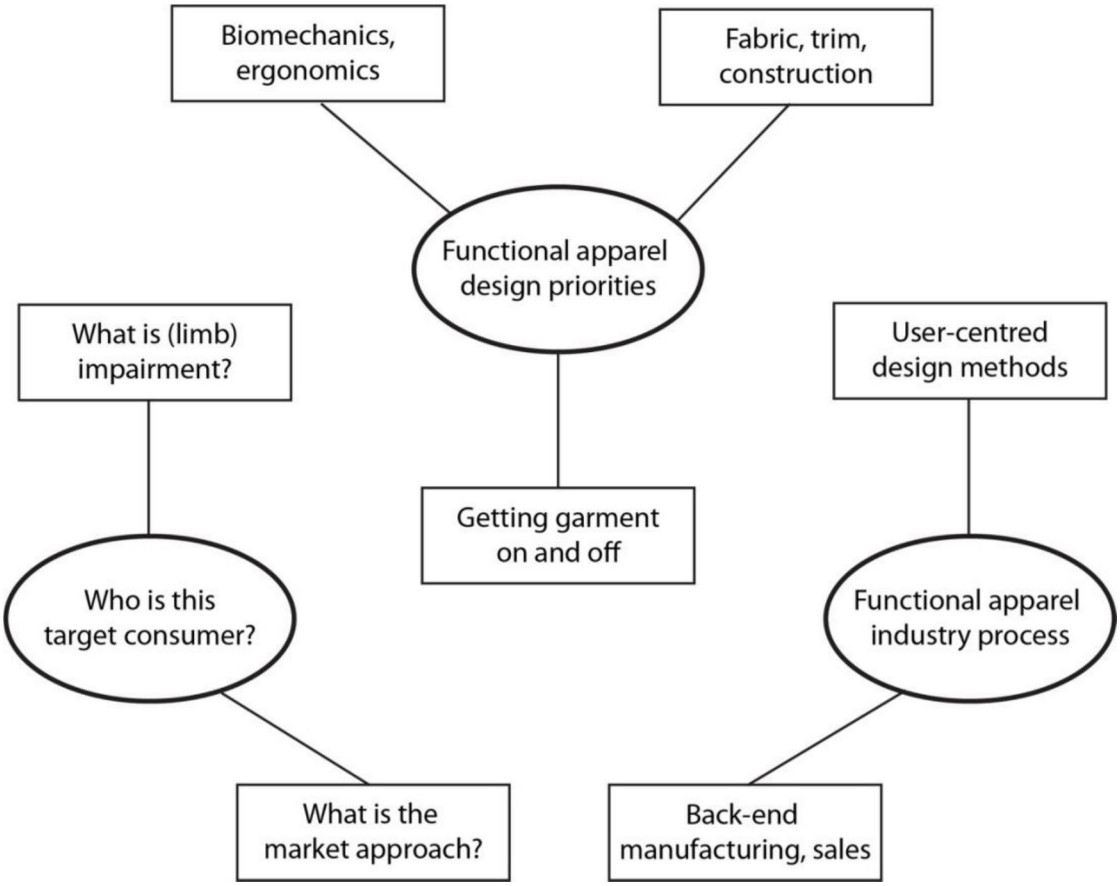
> *So, to minimise movement, I put the brace on which keeps it up. Sometimes I use a bungee cord. I've also sewn like a seatbelt, kind of like the buckle, and I run it through the brace on the part that holds this part of my arm, the forearm. And I just wrap it around me, just to secure it, so it doesn't bounce up and down. So, I have stability here but then I also have the stability from the movement. Just in case I'm running or jumping, or even if I fall, my limb is not just falling all over the place and it's kind of attached to the body. That feels the most secure for me. So, I've used bungee cords and I've also used the seatbelt material because when it gets wet, it doesn't give much. So, you keep that stability. Because I sweat a lot, so sometimes the bungee cord with loosen up. You could just tighten it, and it works well that way for me so far.*

Thus, many apparel-related barriers and ideal solutions were found from the user group thematic analysis. A contextual picture of values and impact of thinking around disability inclusion in sportswear, and other areas of design, also emerge. Next, the themes from the industry group reveal what awareness or guidance may be beneficial for addressing sportswear-related barriers and inclusion.

5.1.2 Industry Group - Final Themes

As indicated in section 4.2.3, the questions posed to both the user and industry group were similar, concerning ideal qualities and needs in sportswear, both in general and for this particular consumer group. Some participants in the industry group were trained in mass market and pro-athlete sportswear design, one in biomechanics research, and one in custom wearable orthotics. None were specifically experienced in mainstream sportswear design for individuals with an upper limb impairment or difference (as the point was to determine what guidance is needed, generally, in industry). The designers were all found to possess strong skills and training for functional apparel design and development, biomechanics considerations, and user research. Gaps emerged around: who exactly this target consumer group would be; and how the designs and market should be approached for disability inclusion. Figure 5.2 shows the final themes and sub-themes found from data analysis of the industry group, following Braun and Clarke's (2006) thematic mapping for thematic analysis.

Fig. 5.2 - Final Thematic Map: Industry Group. Updated from Poage, Kapsali, and Bardey, 2020, Fig. 2, *Final Thematic Map – Expert Group.*



5.1.2.1 Functional Apparel Design Priorities

This participant group had a good understanding of functional design and how it works closely with the body. For this reason, sportswear designers may be well-positioned to design clothing for disabled consumers as they know how to use garment construction, materials, and trims to allow for efficient and comfortable body function. In speculating what should be considered in good sportswear design for consumers with an upper limb impairment, responses were grouped into three sub-themes:

- Biomechanics, ergonomics and anatomy
- Fabric, trim, and construction
- Getting the garment on and off

As mentioned in section 2.1.2, considerations of biomechanics, ergonomics, and anatomy are integral to sportswear design (McCann, 2005; Bairagia and Bhuyan, 2021).

In discussing previous design work for mainstream non-adaptive sportswear, Participant 6 indicated her experience in assessing functional requirements in garments:

> *I was fortunate to interview with the athletes and talk to them about, basically, their range-of-motion and things that they require for the garments.*

Participant 7 talked about considering a balance within the body throughout a workout:

> *So, there's this term that we've thrown around before in the past called, like, proprioception, and it's essentially the balance of your body throughout a workout. When you're not paying attention to it, you could really do a lot of damage to yourself because you're maybe leaning a little bit more to one side, through certain movements where you're pulling muscles where you shouldn't be. This might be relevant in this case too, where if you have one arm swinging freely and another arm that's moving at a different cadence, that could cause some imbalance within the body. Is there something that we could think about with a garment that could help improve that?*

From understanding how the body works, participants were then able to speculate on garment construction and detailing to accommodate functional needs. Participant 6 posited that fabric recovery and construction techniques can help with support and range-of-motion:

> *I would say recovery would be important, the fabric recovery, so that it supports them if they need it. Also, range-of-motion, so maybe you have ventilation or vents, gussets, that type of thing, that can give them range-of-motion that they need, that's probably the most important.*

And Participant 8 talked about adding compression into garments:

> *Okay, so, I think compression is one of the main factors in our products that is most important. I guess the only other experience I've had is the particular panelling. So, the extra fabrics that are added to the product to control certain muscle areas and put compression over those specific areas.*

As mentioned in the readings on functional apparel design, as well as the user group contributions, donning and doffing is an important factor in adaptive apparel (Watkins, 1995; Watkins and Dunne, 2015). Interestingly, the industry group participants accurately

surmised that a front opening on a top could remove some apparel-related barriers for this consumer group. Participant 7 speculated as such:

> *Probably one of the hardest parts for somebody that doesn't have full range-of-motion in their arm is to get their arm actually in an armhole itself. So, I can imagine that the traditional classic T-shirt would be a very difficult piece to throw on for someone like that. Maybe something like a jacket with a front zip would be a lot easier considering that hurdle that they have.*

And Participant 9 also suggested front openings would be best:

> *So, anything, any apparel that is done up in the front, those are positions that are easy to reach for putting on a shirt or a bra, something that has enough give in the material, that even if they can't necessarily bring their arm back, they can fit the object around their arms.*

Generally, the functional design priorities indicated by the industry participants match what the user group mentioned. This had not been anticipated prior to the interviews as not everyone in this data set had worked with disabled consumers. While the industry group talked about these considerations more broadly, however, using terms like range-of-motion, the users were more specific with their examples as they had experienced these situations first-hand.

5.1.2.2 Functional Apparel Industry Process

Participants indicated that designing sportswear for a specific consumer group involves systematic user research, as well as considerations for the tail-end of the industry development process. For the designers interviewed, consumer research seemed to be done in a user-centred, iterative approach. This is similar to what Watkins and Dunne (2015) and Morris and Ashdown (2018) suggest. Also discussed by the designers, garments need to hit certain requirements to be manufactured, distributed, and marketed. So, when talking about making sportswear for consumers with an upper limb impairment that is commercially available in the mainstream market, garment design skills are not a solitary consideration. Other industry factors to be considered are embedded:

- User-centred design (UCD) processes
- Back-end (manufacturing, sales) parameters

Interviews, focus groups, observations, feedback, and iteration -- this is how the designers discussed user research to establish sportswear needs. This kind of needs assessment included talking to consumers with varying levels of athletic engagement and contextual factors around the sportswear and its use. Participant 7 talked about applying direct observations to better understand the life of the athletes:

> *We've done consumer insights where we've gone to people's houses and we've looked in their closets to see what sneakers they're wearing, what apparel pieces they buy. If it's running apparel, for instance, we'll visit extreme runners that are out there running five miles, 10 miles a day, they never miss any part of their routine, to the fair-weather runner that goes out there maybe once or twice a week and it's part of a larger workout plan for them.*

Participant 10 discussed iterative involvement with users to ideate around the product and then review prototypes:

> *There are two stages. There is one stage where there is no design involved, it's really talking about the product itself and the ideology of what the product should look like and what the ultimate product is for them. What that is leaving with is a clear hit-list on things you feel are critical, things you must have. The n there is a nice to have element and, from there, to be able to bring either a design sketch or prototype to be able to review with that person and then get that additional feedback.*

Beyond meeting user requirements, the industry participants discussed other priorities for mainstream sportswear design. Garment appeal, price point, and forecasting for manufacturing and sales were indicated as important factors. Participant 7 mentioned priorities in sportswear from a sales perspective:

> *You know, our experience in sportswear and apparel, you know how important it is for a garment to have hanger appeal, for it to be at a certain price point, to have a certain hand feel, to move with the body.*

Participant 10 talked about the importance of forecasting – locating a demographic and estimating how many garments might be sold – before a style is approved for production:

> *But I think when we talk about volume and running into quantities and forecasting to be able to do a production line, it must be really challeng ing to be able to find a*

tailored product that the brand is going to be comfortable forecasting thousands of units of that one style if they can't quite pin-point where the demographic or where that specific consumer is located and where they can buy the product.

Participant 8 echoed this point:

Or basically, who's going to manufacture the product to make sure that you can bring it in for a reasonable profit. Because there's no point in making a garment if it's going to cost you X amount to make and you're not going to be able to sell any. So I guess you need that kind of information as well when developing a product.

So, in-depth user research seems commonplace for these designers. But questions emerged around: how many consumers would benefit from sportswear for individuals with an upper limb impairment, how would this be forecasted, how can garments be manufactured cost-effectively, and how they will sell. More collaboration with users may challenge some industry-related barriers that exist to including disabled consumers (Carroll and Kincade, 2007). Understanding potential common needs in adaptive sportswear may be influential for mainstream adoption, similar to Scheier's design collaboration with Tommy Hilfiger (McBee-Black, 2022). Greater user participation (as suggested from the user group interviews) may also reveal that adjusting simple design details through an inclusive design approach, like adding a front zip to a compression top, may allow manufacturers to generate enough volume to hit a certain price point.

5.1.2.3 Who is the target consumer?

Despite strong skills with user research, functional apparel components, and industry product development requirements, more awareness around disability and inclusion seems needed. Within the industry group, an area that remained unclear for including people with an upper limb impairment within the scope of mainstream sportswear design was: who exactly is this target consumer? Also, what is the right market and design approach (i.e., inclusive design, customisation, adaptive design) to effectively reach this consumer group? Thus, the sub-themes that appeared were:

- Awareness of upper limb impairment
- What is the target market and design approach?

A broad term was used in the interview questioning route – *upper limb mobility impairment* (later shifted to *upper limb impairment or difference* to better reflect the scope of the

research participants). The industry group talked about this topic in many different ways, referring to: illness, disease, patients, injured athletes, carers involved in dressing, and amputees. As stated, these sportswear designers had not previously worked on adaptive or inclusive sportswear, so they were being asked to speculate on areas outside of their expertise. But as little adaptive or inclusive sportswear is currently available on the market, it is likely mainstream initiatives would involve designers experienced in sportswear but new to disability. This may lead to potential social-related (or unintentional attitudinal) barriers to inclusion (Holmes, 2018; Centers for Disease Control and Prevention, 2020a). If not already widely engaged with this community, what might be the mainstream industry's reference points for limb impairment? Participant 6 recalled family members who have dealt with various conditions:

> *I'm not sure exactly what illnesses, or I don't know the situation exactly, but I know people that have been in my life that had impairment issues through different diseases, that they had people taking care of them, so they had a nurse having to dress them, that type of thing. I had a cousin who had ALS, so I witnessed people having to help him out, his wife or his nurse having to get him dressed, so that's what I was putting into mind when you said, "Impairment".*

Within the industry participant group, the pattern maker for wearable orthotics dealt fully with adaptive gear but not commercial apparel. She and the biomechanics researcher came from more of a clinical rather than mainstream apparel design perspective. Participant 8, for instance, discussed her experience with various patients' adaptive clothing needs:

> *It's the choice of the patient which fastening they have. With things like zips sometimes they're extremely fiddly, especially if a person with, you know, tremors in their hands isn't able to do zips, so they'll choose Velcro or poppers to make that a bit easier.*

Melding this knowledge and the designers' skills and the user groups' experiential expertise would be insightful. More participatory user community involvement may facilitate a user-led focus to widen this area of inquiry and the scope of this consumer group.

In addition to talking about (limb) impairment in a variety of ways, the industry group also categorised this demographic into different segments, such as: Paralympic athletes, injured athletes in rehabilitation, and older consumers.

Participant 10 referred to Paralympics-specific products in relation to sportswear design:

> *I think there is a level of customisation and detail when you look at the Paralympics and what products are being made and supplied for the athletes there. I think a lot of it is what we'd classify as promo because it's really tailored and built for the athlete specifically.*

Participant 9 (who studied biomechanics research) suggested that athletes with an upper limb impairment, retired or otherwise, will inevitably fall into other demographic groups:

> *They're parents, grandparents, working professionals, or retired maybe, that still have those upper limb problems. So, perhaps including older populations as well, older patient populations that we don't necessarily group with the athlete cohort as it were, so including them to get… an age… Do problems vary with age? Do concerns vary with age?*

It would need to be determined if garment designs would include all these consumers or just a segment. For instance, would the sportswear be customised for a specific individual, like a Paralympic athlete, or designed for a group, like athletes rehabilitating from an injury? Or, again, can an inclusive approach benefit the existing target market as well as include a wider range of users with an upper limb impairment or difference? Participant 10 captured this point:

> *I think a lot of these garments that we're talking about… Is it something that you'd be manufacturing in a very high volume or is it something that's going to be more tailored and custom-made for that specific user as well?*

Participant 8 mentioned another approach for functional apparel design (used in wearable orthotics) -- fashioning customised garments from shared base patterns:

> *All the garments work off an original block, so suits, socks, gloves, etc. Then we have specific panelling that goes on top of those base garments, specific to the conditions that they suffer, any requirements that are needed from them particularly, and they're all made-to-measure. Well, the majority of our products are made-to-measure. I would say probably about 90%. But they are all developed from similar base patterns.*

Finally, what is the purpose of the sportswear? Is it simply to make existing sportswear easier to don and doff and more comfortable; or is there a rehabilitative, medical, or performance enhancing goal as well? For instance, Participant 7 suggested the use of material technology to assist with physiotherapy:

> *Like conductive yarns, for instance. I don't know how that could be helpful, but maybe… I mean, the first thing that comes to mind is, like, shock therapy or something. This is something that is helpful to the wearer, maybe that could be seamlessly integrated into an apparel piece so that it offers some sort of regular therapy throughout the day that helps stimulate the muscles to give you that type of physical therapy, if that's helpful.*

For the most part, the users suggested changing sportswear so it is: easier to get on and off, more comfortable once on, or perhaps more supportive for those who wore a brace. The goals and parameters of a new sportswear initiative for individuals with an upper limb impairment or difference would need to be defined before beginning a design project or assessing user needs. Again, a participatory, collaborative approach may contribute here. More learning from the user community before a design project is internally briefed could potentially bridge any gaps in industry knowledge on:

- Complexity of this consumer group;
- What internal pre-existing biases may exist;
- How consumers, themselves, would like to be included in the market.

5.1.3 Combined Interview Results

Comparing themes from the two groups, three key gaps in industry awareness emerged around:

1. What kind of design, trim, and construction details can address specific apparel-related barriers;
2. How to consolidate sportswear industry practices (design strategies) with inclusion needs and values;
3. Deeper contextual awareness of this consumer.

The industry experts had strong biomechanics insights, garment technology knowledge, and skills in deep user research. They were experienced in designing appealing and built-for-purpose sportswear. But the user group had already identified apparel-related barriers

and ideal solutions (not all specifically mentioned by the designers) based on their own lived experiences. Engagement with user communities could help decipher: who would benefit from changes to sportswear designs, why, and in what way? More exploration is needed on exactly what trims and construction details would best match this consumer group for mainstream sportswear options.

The industry group was unsure how to design for seemingly complex (and yet unknown for them) user needs if approaching disability inclusion. More awareness and guidance are needed here on design goals and strategies that are feasible for mainstream sportswear industry practice. From the user group contributions, it became apparent that inclusive design could be one solution -- small adaptations to current garment offerings could include more people. For instance, adding a front opening to a sports bra could benefit both the existing target market and more consumers with an upper limb difference. Also, common apparel-related barriers and needs did emerge from the user group, so adaptive designs may reach a larger number of people than the industry group envisioned. Customisation was also broached by the industry group. These explicit examples of design strategies may be required as industry guidance to move forward with disability inclusion.

A better understanding of the context, complexity, and impact of disability inclusion came from the user group interviews. More collaboration and engagement between designers and the disability community could further this. Some reference points for beginning a participatory exploration, or the user research journey, may be beneficial for designers new to disability inclusion.

5.2 Workshops Results

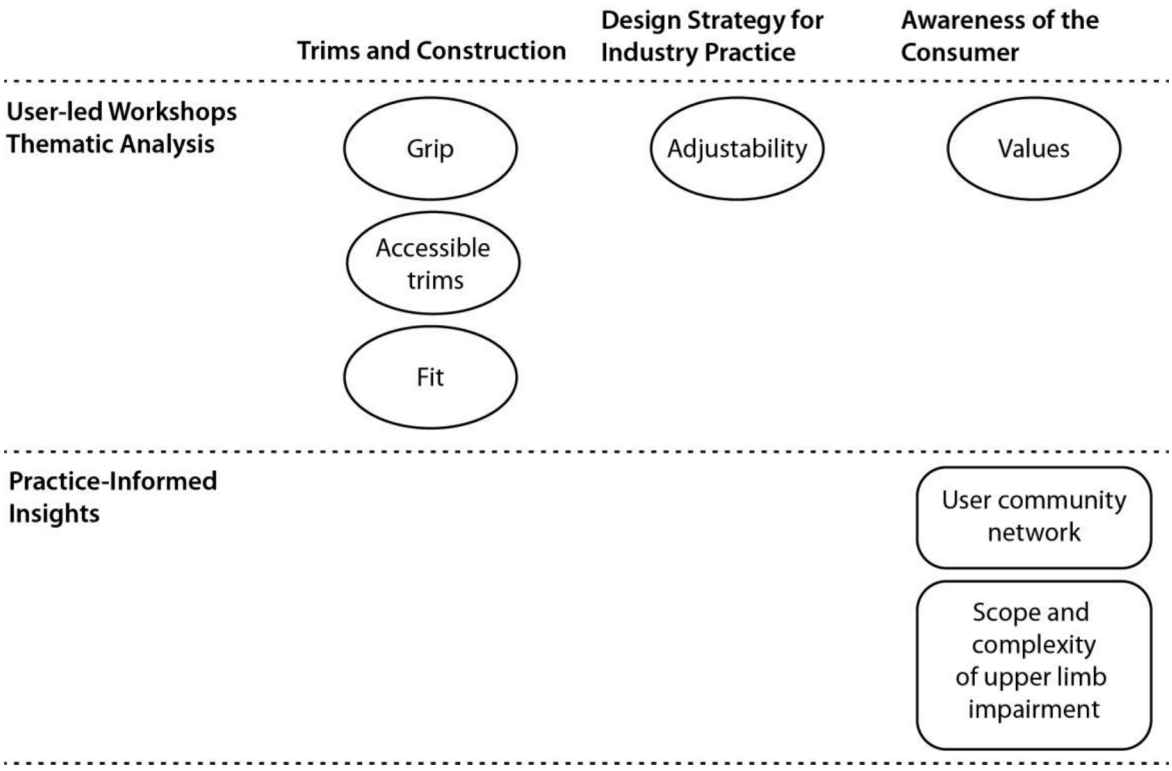
This section outlines the findings of the virtual user workshops, building upon the above interview results. The three identified gaps in industry awareness listed in the previous section – trims and construction, industry practice, and awareness of the consumer – form a reference point. Workshops findings stem from both:

1. The thematic analysis of the collective user-led brainstorming activities;
2. Experiential, practice-informed insights from the recruitment process, interactions with the participants, and the flow of the workshops' activities.

From the thematic analysis of the brainstorming activities, five themes were identified for consideration in sportswear for this consumer: grip, accessible trims, fit, adjustability, and values. These items are viewed in terms of the research questions from section 1.6 about

apparel-related barriers and guidance for industry. From a practice-informed viewpoint, a pragmatic user network emerged, and a complex scope of this consumer group took further shape. This aspect relates to the contributions of a participatory mindset and how to visualise these insights. Full findings are outlined below, reflected in Figure 5.3.

Fig. 5.3 - Workshop Findings



5.2.1 Trims and Construction

Three of the themes resulting from the analysis of the workshops brainstorming activities -- grip, accessible trims, and fit -- focus on trim and construction details desired in sportswear for this user participant group. Very specific apparel-related barriers were identified here along with suggested solutions. First, the theme of grip related to donning a garment or manipulating a zipper. During the first few rounds of thematic analysis, one initial theme was labelled “donning/doffing” with a sub-theme allocated as “grip/pulling.” As this sub-theme, however, contained a significant portion of the data it was made into its own theme. Thus, a deeper look at the intersection of grip and sportswear was possible. In multiple instances, thumbholes or loops were suggested at the waistband or ankles on trousers and at the hem or sleeves of tops so the need to grasp and pull would be eliminated. Zipper pullers were preferred with loops, rings, or a larger surface area to grip. Thumbholes, loops, or rings provide a space to loop in a finger or arm for leverage without the need to grab a section of fabric or a small zipper pull.

Another theme was accessible trims and fastenings, like easy-to-reach pockets or magnetic closures. A crucial point that most participants emphasised was that the accessible items need to work! This sentiment was expressed on a few post-its as “magnets good as idea, but needs to work” and “fastenings need to stay locked during workout.” Responses as such pose the question of whether participants have struggled to find accessible options that are well-designed and function properly. Indeed, one person mentioned wearing golf shirts with a Velcro placket, in lieu of buttons, but indicated that the Velcro did not stay closed during his workout. Also, easy-to-open sportswear pockets were suggested, but these needed to stay securely closed when active. What makes pockets accessible also pertains to the placement on the garment. For instance, a pocket placed on a sleeve will not be usable by someone who has a limb difference or limb loss on the other arm. Certain pockets, as well, need to be big enough for someone whose hands might remain closed.

While all participants had personal preferences on fit, it is clear that overall fit needs to be improved for available sportswear. Fit was discussed in relevance to donning a garment easily and also how it felt on the body during a workout. Generally, workshop participants preferred sportswear that stayed secure and in place, while not being overly tight or too rigid. For instance, a couple post-its read: “snug but not super tight tops (to secure prosthetic)” and “feels secure enough clothes will not move around.” More varied fits to reflect body diversity was indicated as ideal by some. And one participant mentioned the option of being able to specify individual sleeve construction when ordering a garment. He suggested either being able to:

1. Choose from a range of pre-set sleeve lengths to suit various residual limb lengths;
2. Select a desired sleeve fabric separate from the body fabric;
3. Request custom sleeve measurements.

The participant offering the sleeve customisation suggestions worked for an orthotics and prosthetics company and had evident experience of mass production for people with varied physical needs. As such, he came prepared to the workshops with ideas on how to design mass manufactured sportswear that could suit the complex individuality of people with an upper limb impairment. In many instances, his suggestions echoed other participants’ expressions of desiring more varied fits on the market and options for adjustability (a theme detailed below).

5.2.2 Design Strategies for Industry Practice

The workshops discussions also touched on potential uncertainties or opportunities around mass market industry production of garments for diverse needs. One participant pondered just this issue:

> *I'd be curious with adaptive fashion how you can make a product work for a lot of abilities because each "disability" is so different from one another. So then it's like if a brand was to make something adaptive do they take one article of clothing and try to make it different versions for like every type of thing? Do they try to make it more general, would be my assumption. But then for someone like myself would then something that's more general that could fit all these abilities that might have these all different things be worth the investment that if it did cost more? So, yeah, I'm just curious how fashion would make that leap and how they'd go about trying to make it accessible. But then not making it so vastly accessible that then for each category of an ability would it be beneficial?*

Previously stated, identifying common apparel-related barriers or needs could facilitate mainstream adaptive apparel production (McBee-Black, 2022). As described above, trims and garments requiring less grip for donning and doffing could be one option. Or, loops on all zipper pulls could be a part of inclusive sportswear design.

Another option was reflected in a key theme that arose from the workshops data – the concept of adjustability built into garments. This was also expressed as the ability to make self-adjustments to sportswear. Participants indicated preference for garments to be constructed in a way that allows them to make adjustments to suit their own needs. This could be loops to assist in dressing that could then be detached or moved on the garment to another strategic spot.

Adjustability of sleeves was suggested by multiple participants and could be a way to mass produce garments that suit a wide scope of individuals. It was suggested that long sleeves on tops or jackets could have an option to be rolled up and secured in place. Sleeves could also be detachable or come apart at certain lengths, as mentioned by a few participants. As recorded during the brainstorming activity, some ideas were expressed as "option to take off or put on sleeve" or "make sleeve easy to roll to certain length." Rollable or detachable sleeves were noted by participants in other types of clothing but not in sportswear. Modular or adjustable sleeves in sportswear, thus, is an area worthy of further research and development. Adjustable features could make adaptive apparel more producible in bulk

(McBee-Black, 2022). Or an adjustable sleeve could be marketed as inclusive design and benefit an expanded target market, which could facilitate larger quantities to be forecasted and perhaps reduce manufacturing cost. Of course, the fastenings used to attach the sleeve pieces or hold a rolled sleeve in place would need to be accessible.

One participant indicated that she would not purchase adaptive apparel if it was too difficult to find. She also indicated strong brand loyalty so preferred items from a certain well-known global brand. So, perhaps some accessible design features could become standard and incorporated into current non-adaptive sportswear lines to make them more inclusive. For instance, take an example of larger pockets placed at easy-to-reach locations on the body. These pockets could also stay securely closed during a workout but could be opened by magnets or a zipper that has a loop on the puller. If these were standard on, say, a running jacket, this would be an example of inclusive design in that the existing market is widened to encompass people previously excluded. People with reduced dexterity, movement, or strength in the hands and those with one hand might prefer such pockets, and those with full function in both hands might find these pockets more user-friendly as well. Still, adaptive apparel may be the best option for some people, and preferred, in some situations (such as wheelchair rugby, per Bragança, S. et al., 2018). And big brands addressing disability inclusion in apparel offerings could make shopping easier and more inclusive.

As in the above excerpt that opened this section, some participants mentioned that cost could be a barrier. One participant suggested that some disabled people are living on a small income so budgets are tight. This needs to be kept in mind, and more work on costing could be applied. There is no single, simple solution for making sportswear broadly accessible, but a variety of strategies, like adaptive and inclusive design or self-adjustable garments may open up possibilities.

5.2.3 Awareness of the Consumer

In addition to functional preferences, like accessible trims and adjustability, values within sportswear inclusion emerged as a theme from the analysis of the workshops data. While aesthetic details were a matter of personal choice, it was noted as a general concern. A post-it in this theme indicated a desire for “adaptive clothes that are still cute.” Reducing the amount of time and fuss it takes in dressing was also noted here. As one participant explained, his priority in sportswear was practicality; he wanted to know he could get it and put it on quickly. And, adjustability as a concept also fit under the theme of values. One participant extolled the “ability to modify to fit personality,” as recorded on a post-it. Adjustability offers users more choice and independence. During the closing conversation

of one workshop, a participant discussed modifications she had someone do on her bicycle to put the hand brakes together on one side. Instead of having to hire and request someone to do so, however, she would have preferred that these options for modifications simply came standard for users to do on their own. She then elaborated:

> *Yeah, I guess that's like the main thing is to put people in charge of their own… like, that's what I want at least, is like to be able to be in charge of my own stuff and not always have to ask for somebody to help me or... that it's like a special request. Just that it's normal to have options.*

As previously stated, the extensive recruitment process for the workshops necessitated wide-spread engagement with the community. Again, this was done entirely online through Twitter, Instagram, organisational websites, and extensive emailing. Those who responded were often enthusiastic, with one potential participant writing:

> *I would be delighted to work with you, is my dream to work with someone who cares about this subject. I feel like we are the forgotten Consumer. I feel like this is a huge market. I can't find anything to fit my needs, and there's many of us.*

Others expressed similar solidarity for a design research project that considers body diversity. Two adaptive training centres offered to sell the hypothetical garments. While disability organisations and fitness centres were asked to send the recruitment notice directly to their members, some coaches and administrators also responded with their own observations and suggestions on improving sportswear. Their ideas on design solutions were not included in the data analysis as this workshop phase had a precise user-led focus. But, as gatekeepers to the community, these coaches and others close to the users were impactful for directing purposive sampling and learning more about adaptive sport.

As indicated in section 4.3.2, over 100 people and places were contacted, and numerous more were saved for future reference. In navigating this list of contacts and resources, a detailed scope of the character, quality, and mission of these collective organisations began to emerge. Disability charities ranged from: addressing local communities to offering national support; being government-led to being peer-led; and focusing on disability generally to providing awareness about specific conditions. Similarly, adaptive sports organisations offered a variety of disability and fitness focuses, levels of inclusion, and geographic coverages. Other institutions contacted included wounded veteran groups, physiotherapy centres, research centres, and hospitals. Considering this recruitment list holistically, a network of people and places that surround the target consumer emerged.

As more people responded to the recruitment email detailing how the research might be relevant to them or to others, the scope of this potential excluded consumer segment increased in size and complexity. An excel spreadsheet was maintained to track emerging intersections of sportswear, disability, and inclusion. This encompassed, in part:

- Medical terminology of health conditions, like spinal cord injury (SCI) or limb loss
- Effects on the body, like muscle weakness
- Type of engagement with sport, such as Paralympic athletics or casual fitness
- Use of sportswear, such as sport-specific apparel or garments fit for rehabilitation

These variables, at once, highlight the individuality and vast scope of upper limb impairment in itself and in relation to sportswear. It also reveals the expansive market potential of th is neglected consumer area. This complexity and diversity within the attributed label of "upper limb impairment or difference" further suggests that multiple design strategies (adaptive, inclusive, adjustable, customisable) would accommodate more people and give the industry a range of options for broader inclusion. It also highlights the importance of a participatory exploration with the community to understand the individuality and complexity involved.

Reflecting pragmatically, the Miro-based workshops were successful in obtaining the data needed to reach the aim of this data collection phase. As noted in section 4.3.4, the screenshare and visual ideation activities allowed par ticipants to view what contributions were being recorded, how they were worded, and where they were placed. In one instance, a participant spotted a post-it placed in the wrong quadrant of the market priority chart (Figure 4.6), and so it was corrected. And closing the workshop sessions with an open-ended, user-led discussion illuminated further insights, like how adaptive clothing is marketed or how other areas of the sporting industry, such as equipment, can be more inclusive. These discussions captured additional elements of the human-centred context of the values and meaning of inclusion.

As suggested, the virtual format aided in engaging participants dispersed around the UK and US, as well as in adhering to social distancing during the pandemic and ac commodating the researcher's own physical challenges. At times, the language used needed to be distinguished between notices received by a UK audience ("sportswear") and those being distributed in the US ("athletic wear"). Also, as noted in section 1.1.2, Goodley (2017) suggests that the framework of disability can be dependent upon cultural context. Within the contextual research and recruitment network building, the social model of disability was referenced in many UK-based *disability sports* organisations. This did not appear in the US *adaptive sports* websites found. Similarly, *disabled people*, as mentioned, appears more common in the UK, while *people with disabilities*, seems preferred in the US. And, certainly,

not everyone who could be bureaucratically or medically classified as disabled, identifies as disabled (Shakespeare, 2018). So, as much as possible, language was followed from the participants' leads.

5.3 Community Engagement

Between the interview and workshop data collection phases, disability-related events were visited. A trip was made to Birmingham, UK to attend Naidex, which is an inclusive event and trade show showcasing the latest innovations for independent living. Exhibitors who were approached and engaged in informal chats about this study and their own products dealt in:

- Co-created prosthetics
- Media publications for the disability community
- Independent dressing
- Inclusive fashion
- Adaptive sports
- Adaptive apparel

Panel discussions were attended on: 1.) sports and inclusion, and 2.) inclusive fashion. Other attendees at these panel discussions included staff from the UK disability charity Scope and areas of inclusive sports development. In-person networking served to further contacts within the stakeholder community, which led to new recruiting avenues and deeper awareness about sports inclusion. Email follow-up with one contact (an inclusive sports coach) triggered a key turning point in the research results when he introduced an inclusive sports model that helped to make pragmatic sense of the interview findings.

This inclusive sports model is referred to as the Inclusion Spectrum incorporating STEP (Black and Stevenson, 2011, Black and Williamson, 2011, cited in Grenier, Miller, and Black, 2017). Utilising an inclusive design approach, the model shows complementary options for environments that address the needs of each participant. For instance, open activities require little or no adaptations for everyone to be included. In modified activities, however, changes or supports are needed for all participants to take part. Separate or alternate activities can be planned when individuals require an option specifically focused on their needs. This framework inspired the idea of a spectrum of options for sportswear inclusion, which reflected the findings of multiple design strategies emerging from the interviews and workshops findings (i.e. inclusive or adjustable). The resulting design tool output will be shown in the next chapter; Appendix F shows an initial iteration.

Other disability events attended, as previously shown in Table 4.7, included the Disability Sports Coach summer festival (attended in-person in London, UK) and Naidex and Abilities Expo virtual events. These served to expand awareness about adaptive sports, product and service design for the disability community, and networking avenues. As previously discussed, the extensive recruiting process of both the interview and the workshop phases resulted in in-depth interactions with stakeholders and the user community. Insights from these experiences, such as mapping user context and the recruitment path, contributed to the sportwear inclusion toolkit presented in the next chapter.

In some instances, this research's methods and framework expanded after alternate ways of viewing complex design and social issues were considered. Sessions on systems mapping, for one, from the Social Design Institute at UAL highlighted the relevance of looking at systemic causes of complex problems (Bailey, 2020). As will be outlined in the conclusion chapter, sportswear exclusion was mapped in relation to multifaceted barriers – apparel, industry, and social-related.

5.4 Conclusion

What resulted from the cumulation of these cyclical phases of data collection, analysis, reflection, and mapping are the pragmatic sportswear inclusion guidance and tools that address the overall research aim. This final research output reflects a participatory design approach for user-led ideation, as well as practice-informed direction for identifying and removing barriers to sportswear design inclusion. Next, chapter six explicates the development, intent, and context of the final sportswear design inclusion tools based on these primary research findings.

Chapter 6: Sportswear Design Disability Inclusion Toolkit

This chapter presents the final output of this research – the Sportswear Design Disability Inclusion Toolkit. The findings from the interviews, workshops, and community interactions, as indicated in the previous chapter, were mapped into the following tools (detailed below):

- *User Context Wheel and Statistics*
- *User Network*
- *Sportswear Inclusion Map*

Following stakeholder feedback (which will be discussed), two addition al tools were created to address a remaining gap in guidance for mainstream industry sportswear inclusion (detailed below):

- *Sportswear Design Needs Wheel*
- *Sportswear Design Detail Pages*

All the tools are original creations fully built in Adobe Illustrator.

6.1 Overview of the Toolkit

Certain questions arose throughout the research exploration around what guidance to consider for sportswear industry designers. How is one to begin to incorporate participatory and inclusive practices when the industry may not even be aware of who is being excluded and to what extent? How can "invisible" consumers be reached to begin a meaningful collaboration? How can seemingly complex physical diversity fit into an industry built on mass manufacturing? And, what needs (or barriers) should be addressed for better mainstream sportswear inclusion of individuals with an upper limb impairment or difference?

In response, these tools can be used as sportswear industry guidance to address a gap in awareness in how to better understand, explore, and ideate with this marginalised consumer group. The tools are meant to enable a participatory design process and complement established functional apparel design and inclusive design processes (Eikhaug and Gheerawo, 2010; Watkins and Dunne, 2015; Holmes, 2018). Rather than explicitly telling designers what sportswear should precisely be for this consumer group, the tools are a starting point to direct participatory engagement and needs explorations. Thus, designers are encouraged to undertake their own experiential learning with the community to expand

awareness and partnerships. Each tool is detailed below in terms of structure, purpose, and position within existing inclusive design and adaptive apparel guidance.

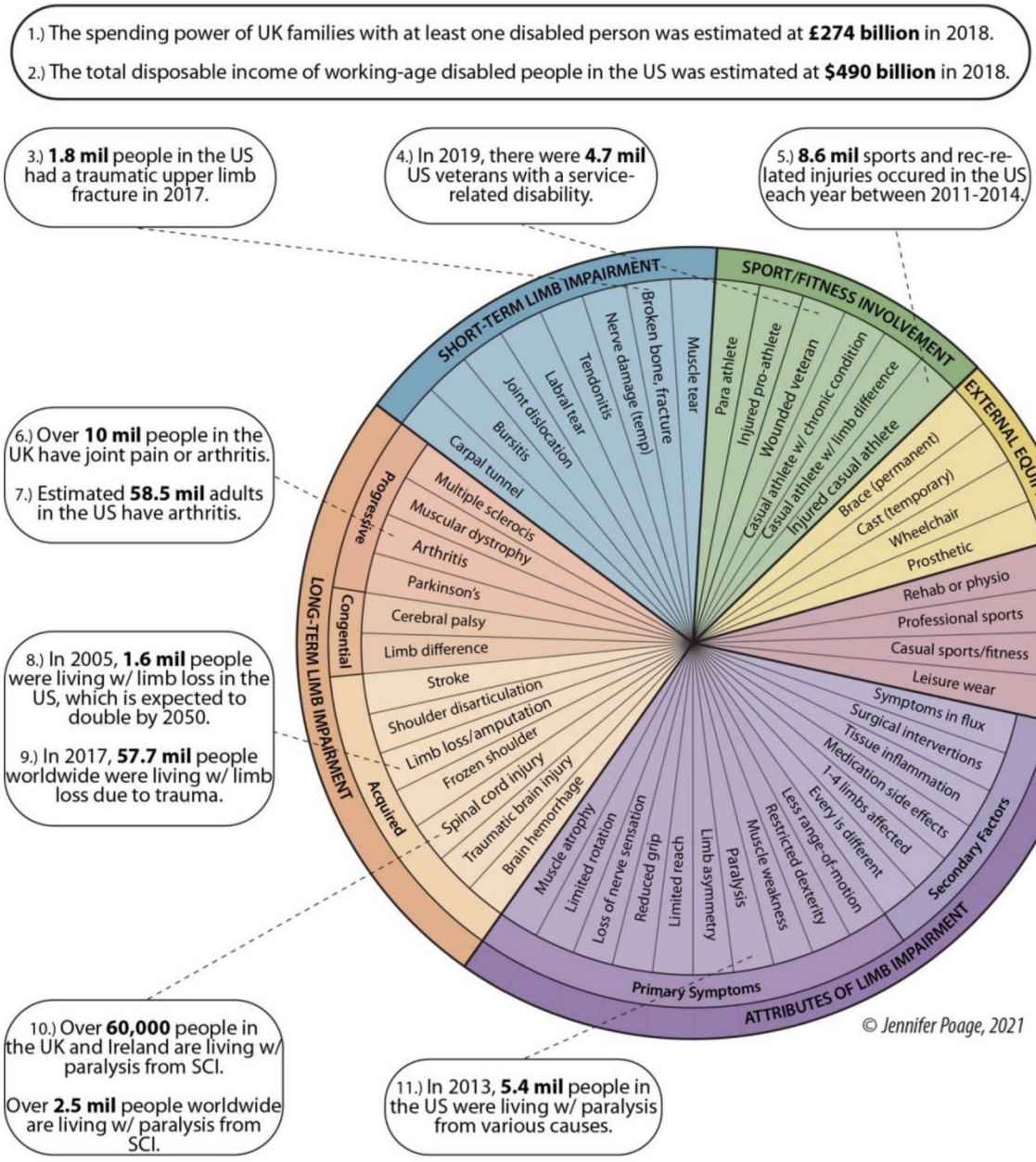
In practice, it is recommended that a disability studies framework supplement the tools. An overview of the social model of disability and culture-specific inclusive language could provide an appropriate underpinning. The toolkit could be made available in a format similar to those of IDEO (2022), Microsoft (2016a), or University of Cambridge Engineering Design Centre (2017) – a website or digital guidebook delineating intent and use of the tools. Or, the toolkit could be delivered through a virtual or in-person training workshop. This may be ideal when designers are new to the topic and can engage in a deeper discussion with a facilitator familiar with inclusive design and disability studies. While intended for an industry designer audience, the toolkit may also apply more broadly (e.g. marketing or fashion design education), as will be explained in the next chapters.

6.1.1 User Context Wheel and Statistics

As described in section 5.1.2.3, a theme that came from the industry group interviews was: Who is this target consumer? Since disability has traditionally been absent from mainstream sportswear, it may be unclear to industry professionals how many people are excluded, how certain impairments affect the body, and how this relates to sportswear design. The Paralympics have cast a light on professional para athletes, but this may still be filtered through the media with potential social biases (Silva and Howe, 2012; Beacom, French, and Kendall, 2016; Martínez-Bello *et al*., 2021). And this coverage does not reflect the huge population of people who may have an upper limb impairment or difference but practice sport or fitness on a casual level. Thus, the below *User Context Wheel and Statistics* (Figure 6.1) has a three-fold impact. It shows the potential scope of this neglected user community in terms of: 1.) the vast number of people who may be excluded from mainstream sportswear; 2.) the complexity and individuality of this consumer group; and 3.) aspects to consider when designing sportswear inclusive of this consumer group.

The statistics provided in this figure support the need and opportunities for mainstream design initiatives around disability inclusion. (References for this image appear at the end of the dissertation reference list.) Scope (no date-a) estimated the spending power of UK families with at least one disabled person to be £274 billion in 2018. For the same year, Yin *et al*. (2018) reported that "the total after-tax disposable income for working-age people with disabilities [in the US] is about $490 billion" (p. 1). If that much spending power is available, then why is this consumer group neglected? Or more pragmatically, how can we now improve inclusion?

Fig. 6.1 - User Context Wheel and Statistics

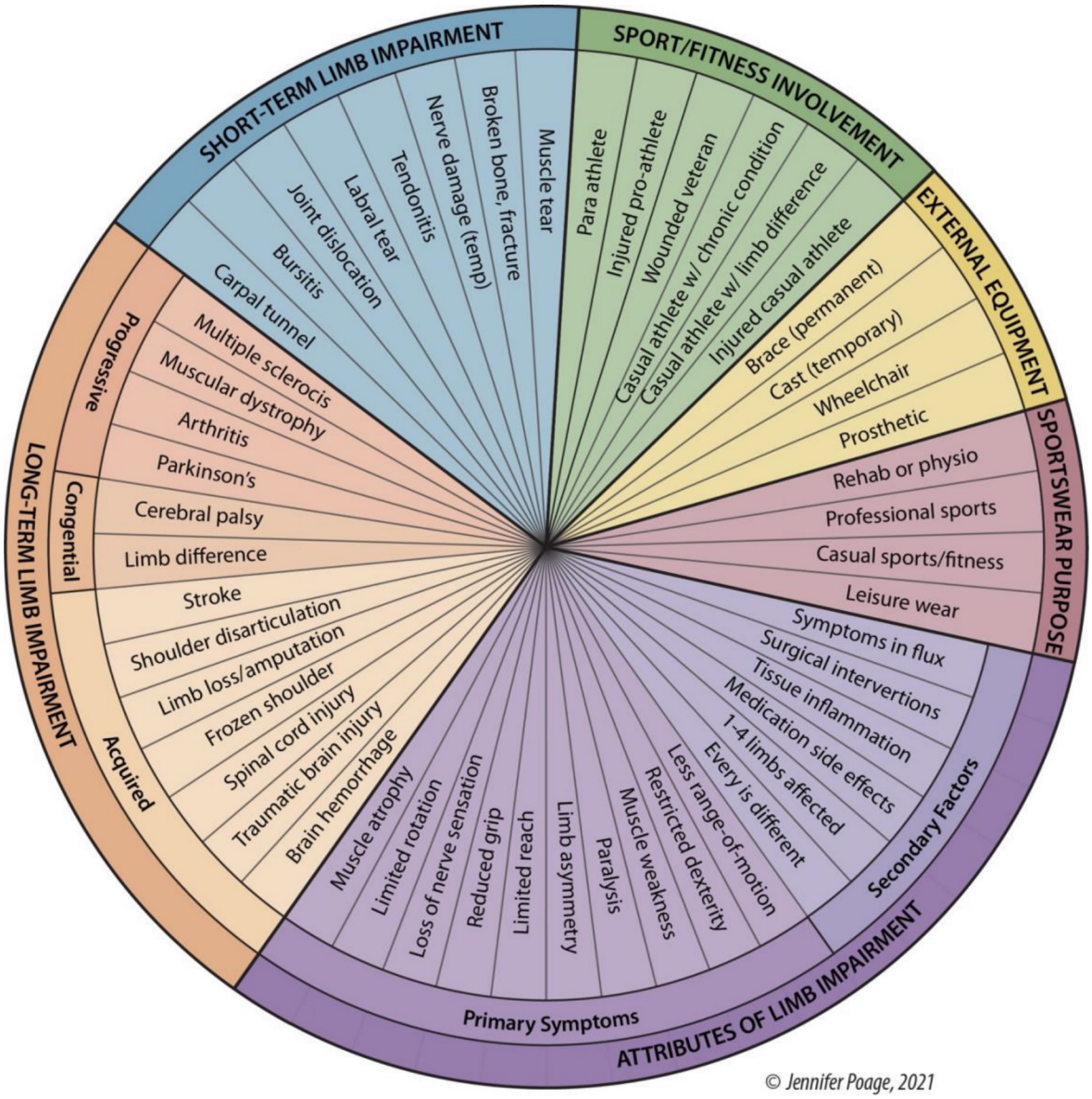


All statistics, except for source #3, include other areas of disability or impairment in addition to upper limb impairment.

Researching some of the individual segments on the wheel reveals millions of people who may benefit from mainstreaming disability inclusion. Approximately 68.5 million people in the US and UK combined have arthritis (National Health Service, 2018; Centers for Disease Control and Prevention, 2022), and around 57.7 million people worldwide have lost a limb due to trauma (McDonald *et al*., 2021). These figures suggest potential focuses for adaptive or inclusive sportswear exploration.

Removing the statistics, the *User Context Wheel* (Figure 6.2) is a tool in its own right. The goal is to reflect that disability is diverse and to highlight some contextual factors. It should not be read as a complete picture or definition of "upper limb impairment," but rather a suggestion of areas for inclusion and collaboration.

Fig. 6.2 - User Context Wheel



These components relate to the research participants, adaptive sports websites, disability community gatekeepers, and other contextual information arising from the primary research and researcher experiences. The decision of the circular, or wheel, design was inspired by the *Being Defensive* chart in McCandless' (2009, pp. 208-209) data visualisation book *Information is Beautiful*. The topic (psychotherapy) of that particular chart is irrelevant here, but the circular layout of the chart is inspiring. The idea behind the *User Context Wheel* is

to show a lateral spectrum of human-centred complexities and variables related to sportswear design. There is no “average” person, nor is there a linear list of common attributes. This wheel represents individuals and communities connected to this research, and it can be expanded as more people are approached in future collaborations.

Taken as a whole, the viewer is meant to expand the scope of what would be considered in sportswear design for these consumers. Under Armour, as mentioned, produced tops using the MapZip – a magnetic zipper that could be done with one hand (Regenold, 2014). This, of course, is inclusive of anyone who would use either one hand or two hands to work a zipper, which is a meaningful concept. But referring to the “Effects of limb impairment” wedge of the wheel, if someone has reduced grip or limited finger dexterity, would this zipper pull be suitable? Perhaps an added loop would be beneficial. And if there are pockets on this jacket, are they located in a convenient place for different angles of reach? If someone wears a prosthetic or arm brace, should the sleeves also be removabl e or rollable? And moving over to “Sportswear purpose,” are adaptive design details being carried over from pro-athlete apparel to yoga tops to athleisure hoodies?

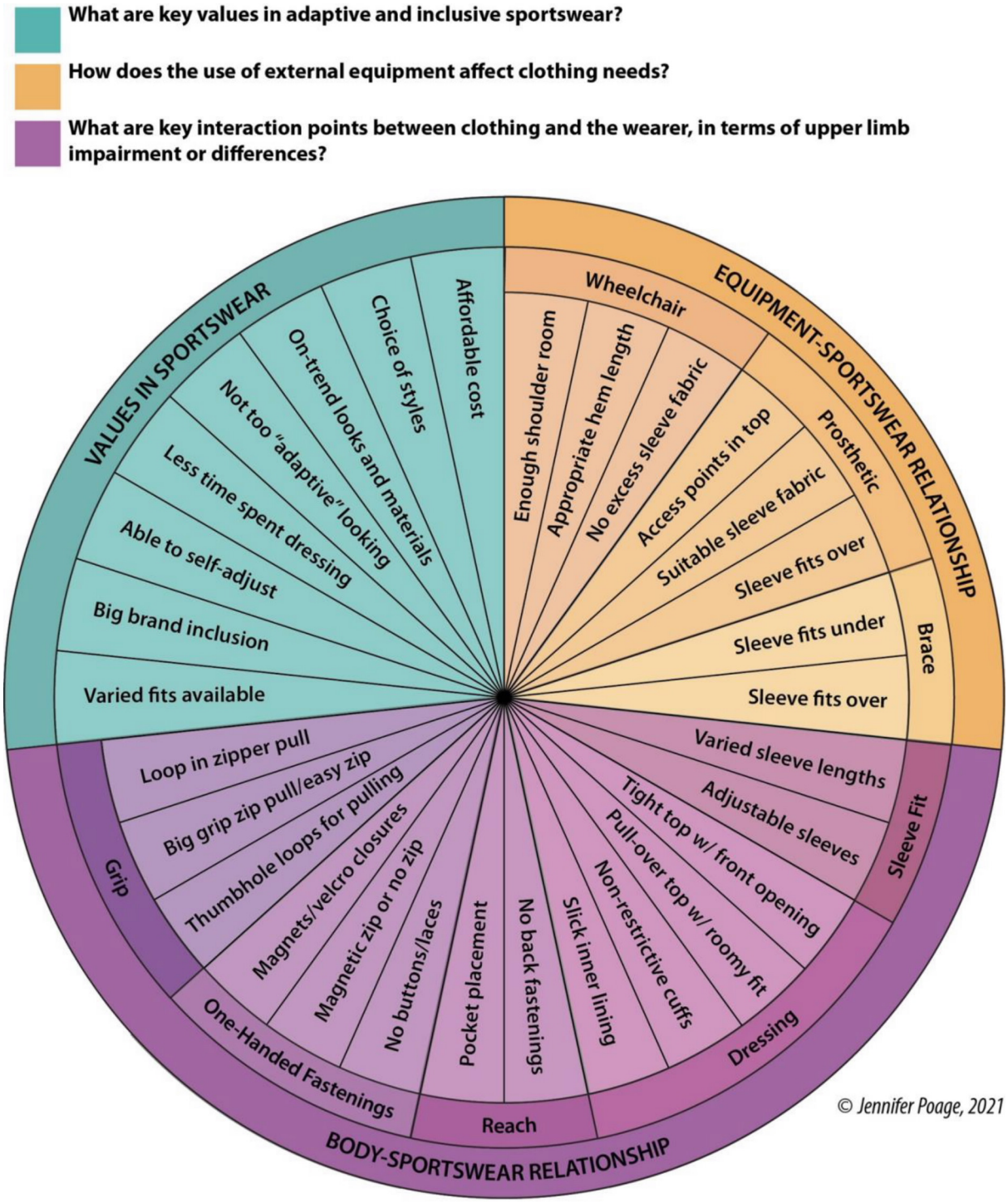
For a more sport-specific adaptive design approach, a designer could consider a few relate d elements from each wedge. For instance, tops could be designed for wheelchair users who have partial upper limb paralysis from a spinal cord injury and do hand -cycling. Or, an inclusive design approach would be to incorporate multiple factors (wedges) in to mainstream sportswear garments. A further look at various design approaches to encompass complex factors and individuality of consumers accompanies the *Sportswear Inclusion Map*, which is shown below. While the potential users should still be directly involved in the exploration, design, and development process, this wheel presents designers with more awareness on the potential consumer base and what aspects to consider.

6.1.2 Sportswear Design Needs Wheel

A second wheel -- the *Sportswear Design Needs Wheel* (Figure 6.3) -- was created in response to stakeholder feedback that more tangible design direction may be applicable in a sportswear design toolkit. A comment was also made that the *User Context Wheel* may appear clinical, in parts. Thus, the below *Sportwear Design Needs Wheel* addresses apparel-related barriers, values, and design suggestions based on primary research findings. It is not meant to replace user-led needs research or a collaborative ideation, but it does give recommendations to designers of key areas to consider and explore. For instance, a look at the “values” segment reminds that a choice of styles and on -trend

aesthetics are important. Functional aspects are also indicated, such as elements to consider for grip. It focuses more on the apparel adaptations needed for inclusion from a social model perspective.

Fig. 6.3 - Sportswear Design Needs Wheel



A parallel can be drawn to Martinez-Bello et al.'s (2021) suggested alternative portrayal of Paralympic and Olympic athletes (from section 2.2), where commonalities amongst

everyone are celebrated. Any consumer may have needs associated with the outer ring on the graphic: Values in Sportswear, Body-Sportswear Relationship, and Equipment-Sportswear Relationship. And might the values shown on this graphic be considered universal? This remains an essential point in dismantling potential stigma or othering of disabled consumers or athletes. Pullin states:

> *particular disabled and nondisabled people may nonetheless have shared needs in particular circumstances, despite their differing abilities at other times. And of course, particular disabled and nondisabled people may have shared tastes and priorities that have nothing at all to do with their abilities*. (p. 92)

Within the inner segments of the *Sportswear Design Needs Wheel*, however, practical design considerations are indicated that were expressed as critical (and not always available) for this consumer group. It is essential that a range of adaptive or inclusive products does fulfil end-user requirements for consumers with an upper limb impairment or difference. So, specific functional or value-laden needs within the overarching categories of required sportswear considerations should be recognised. As Maika and Danylchuk (2016) suggest for Paralympic representation, a balance can be struck between not ignoring disability and also not stigmatising it.

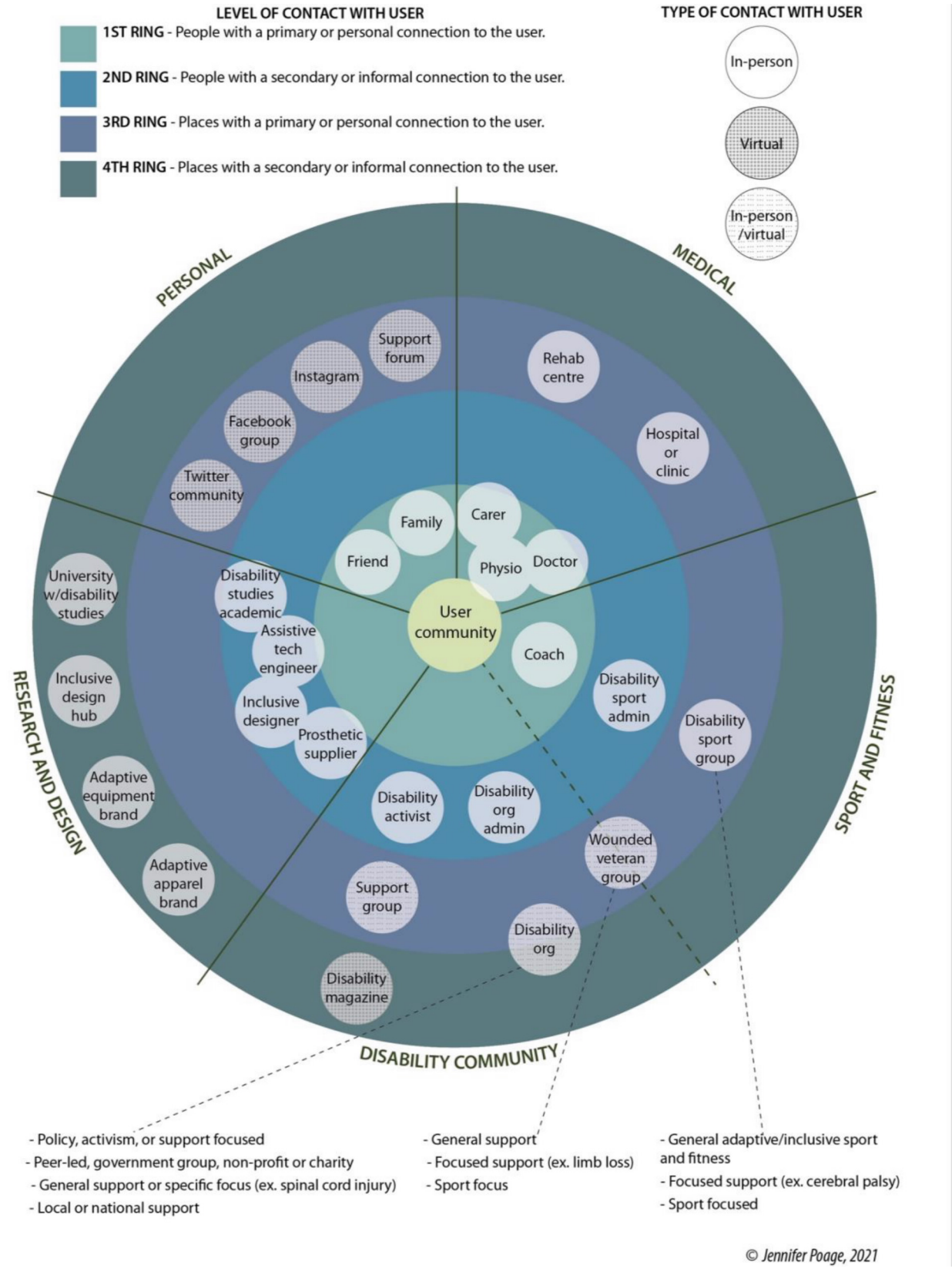
6.1.3 User Network

During one of the industry interviews, a question came up of where can this consumer be reached? Indeed, making sportswear more inclusive or adaptive in a way that is meaningful to marginalised consumers requires in-depth user research and participation with this community. The *User Context Wheel and Statistics* gives a sense of how many people could benefit from this type of sportswear inclusion, as well as different relevant areas of physical diversity and sportswear context. But designers also need to know how and where to connect with this consumer group, as well as understand a broader picture of the community. Of course, disability is a part of regular life and is part of what makes society diverse, in general. So, to answer the question of how to reach this consumer, a call out to the general public should be standard. For this study, some research participants were recruited by general posts on Twitter and Facebook.

In instances, however, a targeted approach was also effective in reaching people within a specific context. Contacting adaptive sports organisations naturally led to connecting with adaptive athletes, for instance. As previously mentioned, a log was maintained of every person and every place contacted for the workshop recruitment. This log, as well as other

connections formed through the research journey, is mapped in the below *User Network* (Figure 6.4). It provides a network of resources to learn more and reach this consumer group for the purpose of sportswear design and development.

Fig. 6.4 - User Network



The *User Network* is segmented and stratified to reflect the extensive and varied quality of the resources. Five main resource categories are depicted: personal, medical, sport and fitness, disability community, and research and design. The level of contact of each resource with the user group (placed at the centre) is also mapped. An adaptive apparel brand, for instance, may be a crucial source for adaptive apparel market research, but an adaptive sports coach will have direct and individual contact with the target user community. Additionally, some of these resources only exist in the virtual world, such as online support groups or social media communities, but physical places, like hospitals or gyms, will have in-person interactions with users. For many of these resources, a gatekeeper (such as a coach or group administrator) may need to be contacted first in order to connect directly with the user community. The clustered and stratified layout was inspired by graphics found in an online search for stakeholder and ecosystem maps. The *Presentation ecosystem* (Duarte, 2008, cited in Bao, 2012, para. 5) and *An example of a high-level service ecosystem for an insurance provider* by Grimes (2022, Fig. 2) were particularly influential for the bullseye layout and categorising elements around a central focus.

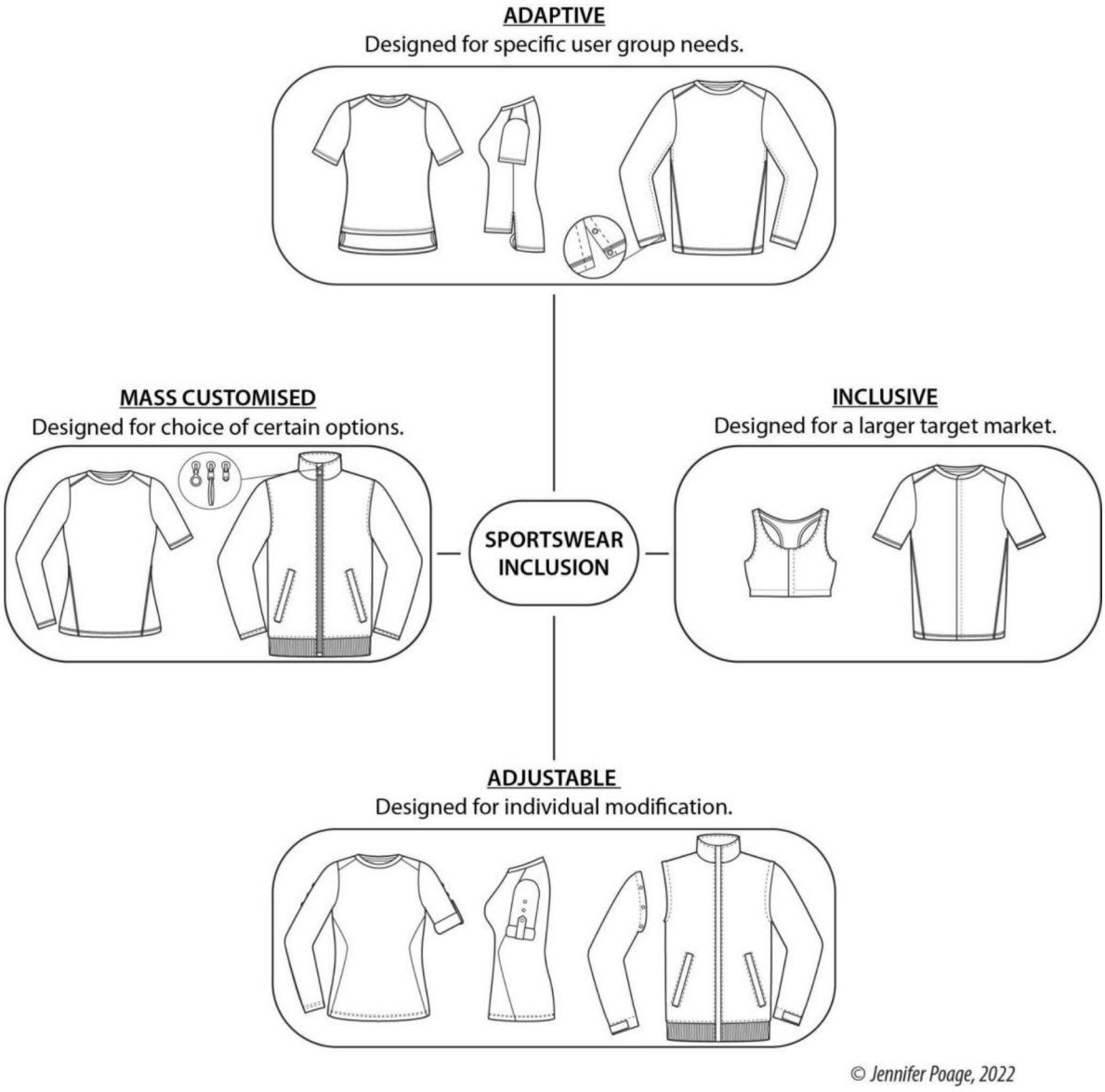
A few resources in the *User Network* have breakout sub-categories. These were key avenues for participant recruitment and provided much awareness for the scope of this study. Disability sport and support organisations exist throughout the US and UK and offer a range of focuses. For instance, the US Adaptive Golf Alliance is sport-specific, making golf a disability-inclusive opportunity. There are also groups that offer a range of sports to include and support specific communities, such as Cerebral Palsy Sport in the UK. Many more organisations operate regionally to provide a range of adaptive and inclusive sports. Some of these adaptive sports providers, particularly in the US, have divisions specifically for wounded veterans. Other groups provide sporting outlets entirely for wounded veterans, such as SUDS in the US and the Invictus Games Foundation in the UK. And Blemsa supports limbless veterans in the UK, not just in sport, but in many areas of civilian life.

Rather than naming all the specific organisations, groups, publications, and centres researched and approached within this study, this *User Network* offers an outline for designers to begin their own community exploration. As was done for this research, searching and networking through the varied types of resources could help designers build their own contact database. Navigating the different types of resources and initiating contact could be a means for emerging into the community and for experiential learning. The *Network* aims to provide direction for reaching, connecting, and including a consumer group previously invisible to the industry.

6.1.4 Sportswear Inclusion Map

As described in section 5.3, the below *Sportswear Inclusion Map* (Figure 6.5) is inspired by Black and Stevenson's (2011, as cited in Neale, no date, p. 7) *The Inclusion Spectrum Framework*. (An update to their inclusion spectrum appears as *The inclusion spectrum is a useful tool for planning and organizing instruction*, Black and Stevenson, 2011, cited in Grenier, Miller, and Black, 2017, Fig. 1, p. 53). The *Sportswear Inclusion Map* presents multiple design strategies for sportswear brands to better include people with an upper limb impairment or difference. Recognising the complexity of individuals, highlighted by the *User Context Wheel*, there is no single solution for inclusion. This diagram, thus, suggests a range of options meant to reach a large number of people within big brands' mass manufacturing operations. The branches are as indicated.

Fig. 6.5 - Sportswear Inclusion Map



6.1.4.1 Adaptive

Adaptive garments are designed to benefit a specific consumer group whose needs are not currently being met by the mainstream market (Watkins and Dunne, 2015; Kabel, 2016). McBee-Black (2022) shows that certain design innovations can be built into apparel to meet shared needs of many disabled consumers. Common themes found from the user group interviews and workshops within this study suggest that certain design features in sportswear might benefit many individuals with an upper limb impairment or difference. For instance, access to a prosthetic or arm brace could be built into a top through Velcro or magnetic openings along a sleeve.

Another adaptive sportswear feature could be thumbholes or loops attached to the hem (on a top) or waistband (on bottoms). These added details would allow the wearer to pull down or pull up a garment without the need for tight grip. Other considerations appear in the *Sportswear Design Needs Wheel*, such as trims to facilitate one-handed dressing and easy-to-reach pockets. An additional comment from multiple users was the assertion that an adaptive style not look "too adaptive." Indeed, aesthetics and material properties for sport were mentioned by some research participants as requirements. As Lamb and Kallal (1992) illustrate, fashionable considerations must be balanced with functional requirements.

6.1.4.2 Inclusive

Within an inclusive design strategy, garments would be designed for ease of use so that a larger range of consumers are included. A zipper with a loop hanging from the puller was suggested by some of the research participants for easier dressing. Thus, loops added to zipper pullers could be a simple design detail to reach more consumers and advance inclusion.

In the interviews, multiple users discussed a preference for tops with front openings rather than pull-over styles. One participant stated:

> *Yeah, I don't know, the few times I've gone to the gym I've just gone in my regular bra because I can't get my sports bra on, so… All the ones I have are like that, where you have to pull them over your head.*

As quoted in the findings, another participant suggested that, while people with limb differences may have a greater struggle with sports bras, it is a garment that is a problem for everyone. Examples of inclusive sportswear, then, could be a sports bra or a tight-fit cycling top with an accessible front opening.

6.1.4.3 Adjustable

Adjustable garments would be designed for consumers to make their own modifications to suit their own preferences. This was a feature applied by Scheier in her collaboration with Tommy Hilfiger (McBee-Black, 2022), and it was a theme found from the user workshops. Complexity of disability, individual personalities, and agency are elements to consider here. The goal is to allow the wearer to self-adjust sportswear for independence and ownership over personal choice and comfort. This category could be considered adaptive or inclusive. Adjustable garments can be a method to add a level of customisation within a mass manufacturing industry (Loker, 2007).

Examples from the interviews and workshops could be long sleeve tops or jackets with sleeves that roll up and secure in place with magnets. Or sleeves could be removable or be separated at certain lengths. Not only could a wearer's functional needs be better met, such as removing a sleeve to make room for an external brace, but personal preferences and tastes could be better accommodated. It allows the consumer more autonomy by not having to bring a long sleeve garment to a tailor, which was mentioned by a workshop participant as a high cost and extra work.

6.1.4.4 Mass Customised

Mass customised sportswear is another way to offer consumers more personalised choice. Here, the mass customised branch represents an approach in which the consumer can select from pre-set options upon purchase. One example would be a choice of zipper pullers: 1.) a standard puller, 2.) a larger, easy grip puller, or 3.) a puller with a fabric loop attached. Another choice could be a selection of varying sleeve lengths or of different fabrics for the arms, as suggested during the workshops.

Mass customised sportswear, as well, could be either inclusive or adaptive. As mentioned in section 2.3.1, mass customisation may need further development for wider mainstream adoption (Loker, 2007; Liu, Chow, and Zhao, 2020; Paganelli, 2021). Digital garment technology could be applied in this branch, but there may still be work to do in removing potential ableist biases here (Paganelli, 2021). This is worthy of further investigation, as personalising fit, construction, and trim details encompasses a larger range of people with diverse needs and preferences.

6.1.5 Sportswear Design Detail Pages

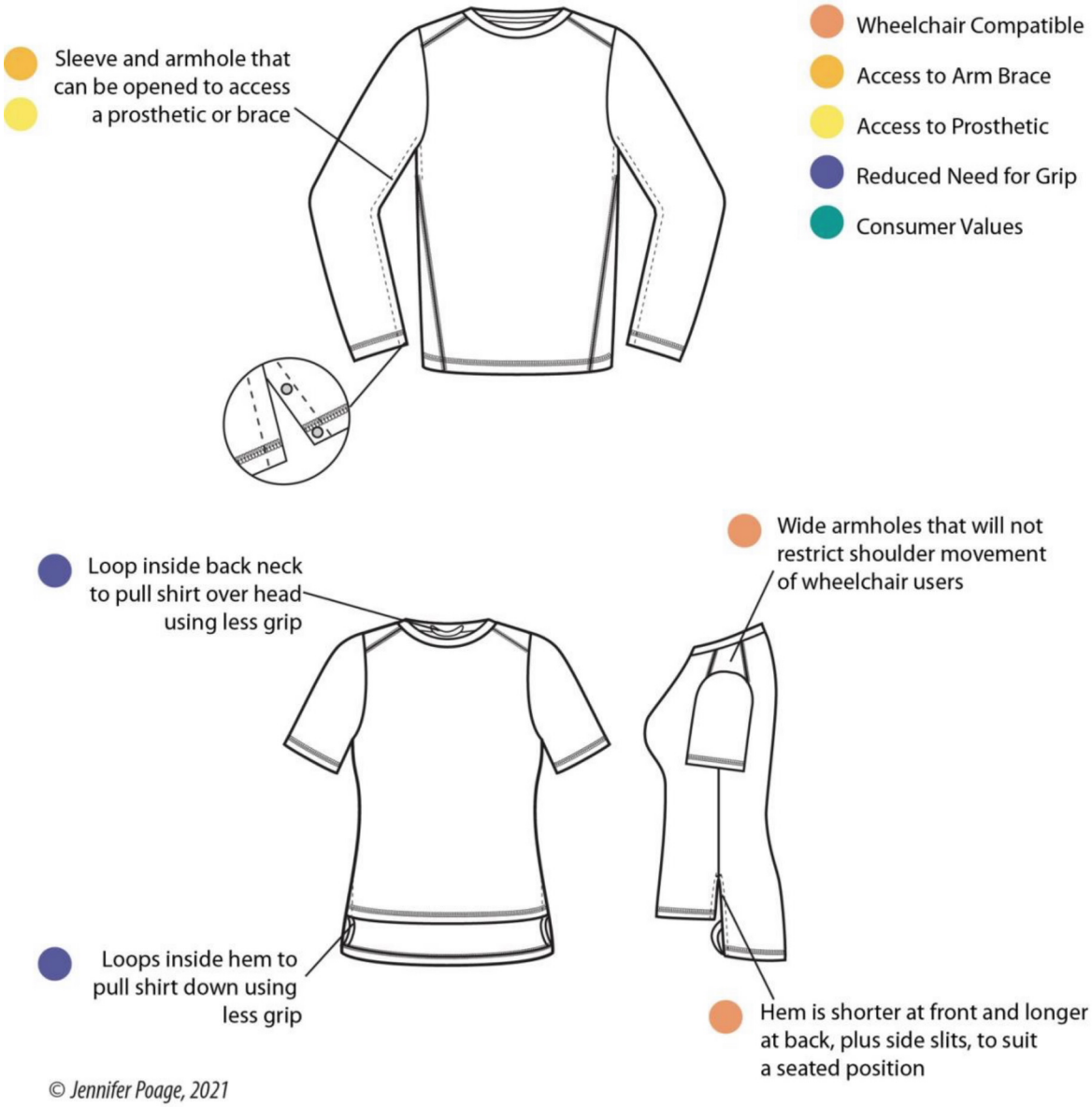
Figures 6.6 – 6.9 show the branches of the *Sportswear Inclusion Map* in greater detail. The sportswear designs depicted are conceptual based on consolidated interview, workshop, and feedback findings of desired design considerations. The garment images with construction callouts are stylised to match apparel industry technical flat sketching used in development and manufacturing. Coding the adaptive or inclusive features within the garments was inspired by a Data Visualisation Online Short Course taken at UAL. The sportswear designs should not be read as finalised and production-ready. Rather, they offer guidance on how to address and build inclusion into sportswear with further insights from the user community.

Along with elements from the *Sportswear Design Needs Wheel*, the content of these pages was a result of the stakeholder feedback. Adding direct quotes from the research participants was suggested during these feedback sessions to generate more empathy. These quotes point to human-centred values and drivers for sportswear inclusion and represent individual voices. As Holmes (2018) writes, it is helpful to understand what really motivates a person to use a solution beyond just functional reasons. The pragmatic design descriptions are meant to further illustrate how specific detailing can address needs for various inclusion strategies.

Many iterations of the data visualisation (some shown in Appendices E, G, I, and J) were done throughout the interviews, workshops and feedback phases before reaching the versions presented here. The following section details the stakeholder feedback on the penultimate versions and discusses how it influenced the resulting toolkit. Various stakeholder points-of-view are also evaluated for reflection on their contributions.

Fig. 6.6 - Sportswear Design Detail Page: Adaptive

ADAPTIVE - Designed for specific user group needs.
Sportswear is designed specifically for certain consumers with an upper limb impairment or difference.



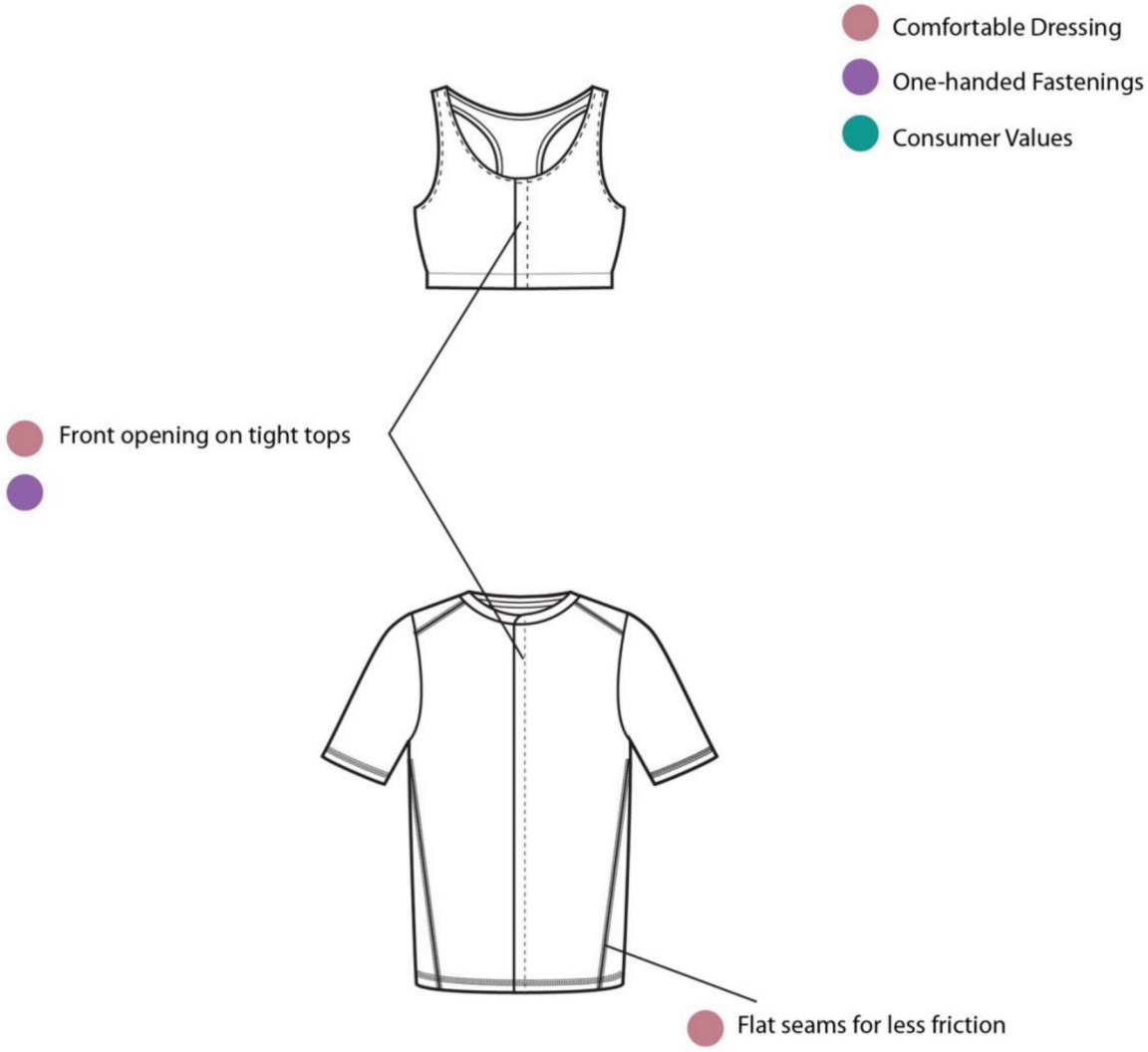
I want clothes that are easier for me but I don't want to necessarily wear things that look different from other participants.

Also affordable. Usually anything labelled adaptive come with a much bigger price tag!

From my perspective, I want to see big sports brands do more in this stuff.

Fig. 6.7 - Sportswear Design Detail Page: Inclusive

INCLUSIVE - Designed for a larger target market.
Sportswear is designed for ease-of-use so a wider scope of consumers are included.



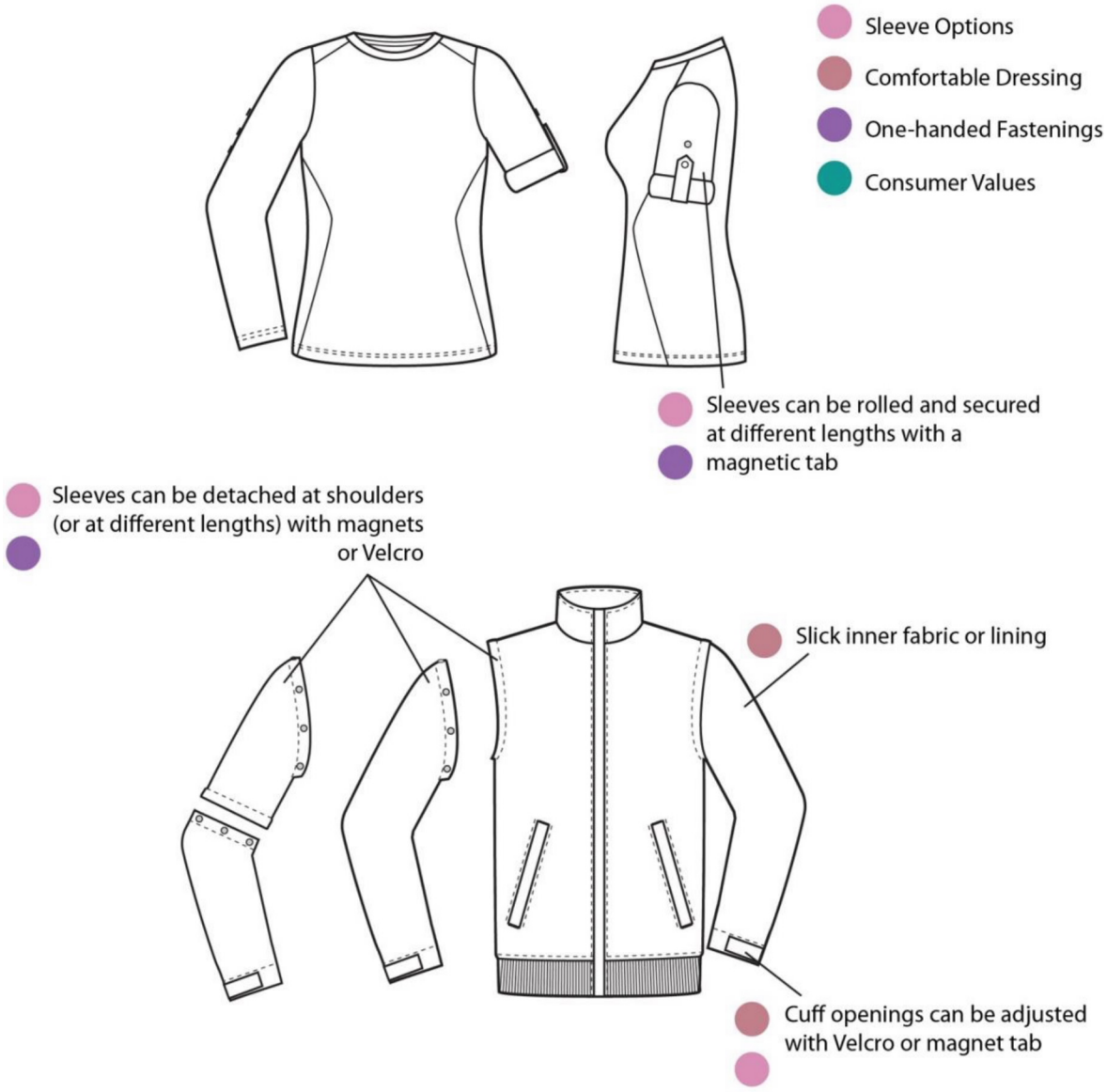
So, the other problem is, my skin is numb, so, I have no feeling. So, I could injure that without knowing, causing a pressure sore or friction sore.

Like just cut the fabric up the middle and then sew a zipper on so that the fabric, if I unzip it, it's not hugging the skin. And it would just be easier to just get the whole thing off.

I think some simple modifications is all that is really needed and I believe it should benefit everyone.

Fig. 6.8 - Sportswear Design Detail Page: Adjustable

ADJUSTABLE - Designed for individual modification.
Consumers can make self-adjustments to the garments to suit their own needs and preferences.



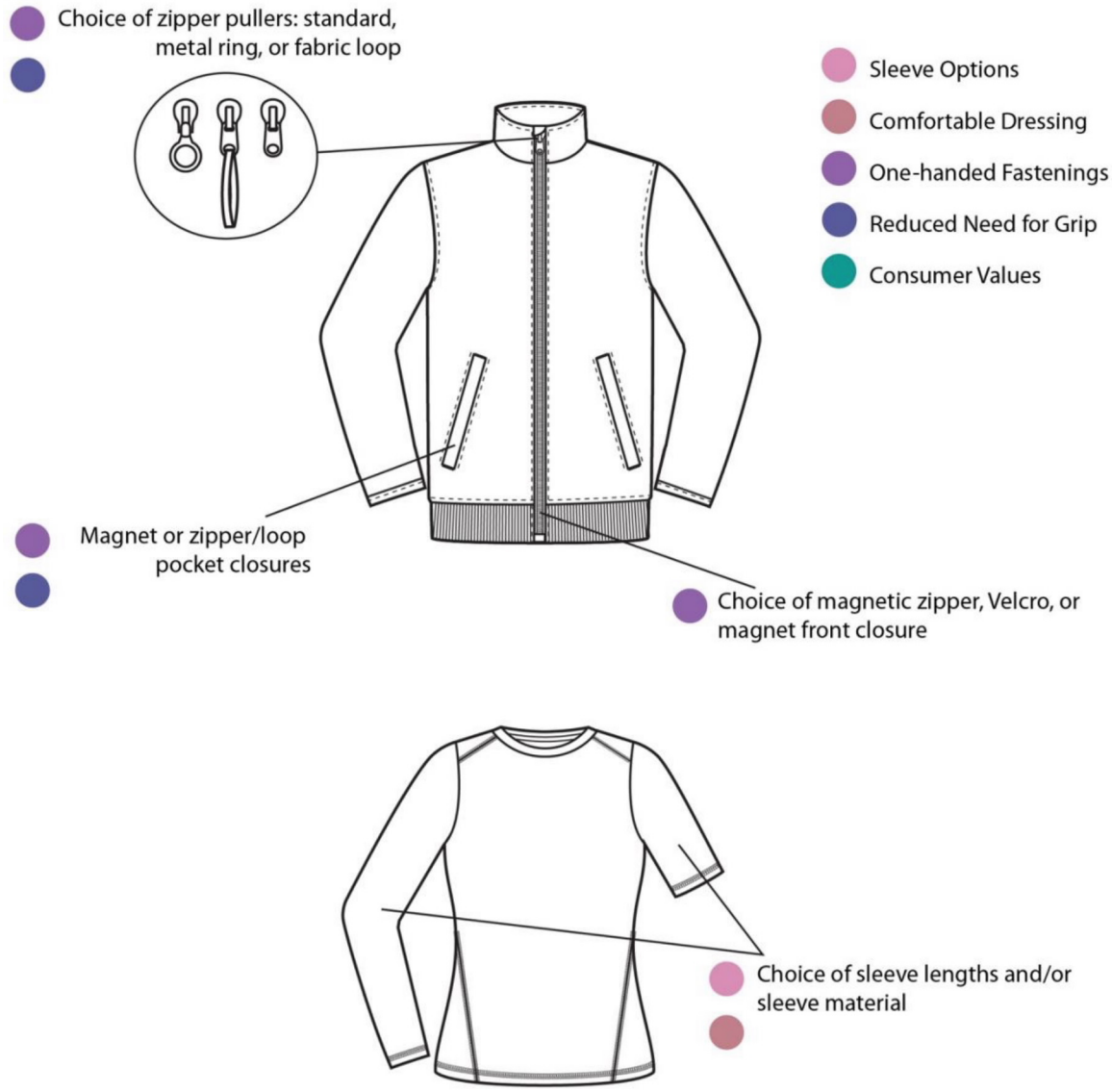
The more people I meet within the disabled world, the variations of… even just arm amputations within one arm is completely different.

Like, buttons are super annoying for everyone, but standing there to button a shirt is the worst.

I guess that's like the main thing is to put people in charge of their own… like, that's what I want at least, is like to be able to be in charge of my own stuff and not always have to ask for somebody to help me or... that it's like a special request. Just that it's normal to have options.

Fig. 6.9 - Sportswear Design Detail Page: Mass Customised

MASS CUSTOMISED - Designed for choice of certain options.
Consumers can select from options to customise based on their needs and preferences.



My right hand, it's sometimes hard to manipulate a smaller zipper. So, we'd end up always putting a piece of string or leather strap inside the zipper to make it longer, something more, maybe a loop there so I could pull it up with one finger.

Mass-Customized is really important to me. It's really hard to zip up or down a jacket or pants. And, it's really hard to find a garment with out zippers. Additionally, it's really hard to find loops for the zippers. I have not found them yet.

That's kind of the, really, the kind of the struggle behind being an amputee. You've gotta really try to customise everything to it.

6.2 Stakeholder Feedback Results

For the feedback phase, stakeholder groups were: 1.) users (individuals with an upper limb impairment who engage in sport or fitness); 2.) a physiotherapist who also launched an adaptive apparel brand; 3.) inclusive and disability innovation designers; and 4.) sportswear course leaders and industry designers. (Refer to Tables 4.5 and 4.6). Feedback varied between stakeholder groups for each tool, but, in some cases, overlapping themes emerged.

As stated in section 4.4.4, the user feedback was obtained through an online questionnaire (Appendix K). The other stakeholders were engaged in virtual interviews. (Refer to Appendix L for a sample topic guide). Select tools were reviewed with each group. Users, for instance, were only asked to comment on the *Sportswear Inclusion Map* to validate if the final design options would be meaningful or accurate for them. The physiotherapist was shown the *Sportswear Inclusion Map* and the *User Context Wheel* to validate the clinical terms, as well as the adaptive design features. All remaining stakeholders were shown the *Sportswear Inclusion Map*, the *User Network*, and the *User Context Wheel*. The *User Context Wheel* was shown without the statistics to lessen the amount of text to read within a time-capped session. A few statistics were mentioned, however, to highlight the millions of people encompassed within this graphic. As noted above, the *Sportswear Design Needs Wheel* and *Sportswear Design Detail Pages* were developed from the feedback results.

The pragmatic results from each stakeholder group -- evaluation of the tools -- are detailed below. Feedback was also summarised holistically, consolidating the full results of all stakeholders together. The final table of results, summarised into key points, can be found in Appendix M. These key suggestions were filtered by the researcher for: relevance to the research aim and framework; and feasibility of incorporation into the tools. (For instance, interactive graphics would be a novel future development but not feasible within the scope and resources of this study.) Finally, this section concludes with insights on what each stakeholder group had to offer and the perspectives they took.

6.2.1 Users and Physiotherapist Feedback

A principal finding of the user group JotForm feedback was the variety of perspectives. One question asked which branch of the *Sportswear Inclusion Map* appealed most: inclusive, adaptive, adjustable, or mass customised. Responses were split amongst all four options. This echoes Dodds and Palakshappa (2022) findings of multiple disability identities within service experiences in a retail context. The integrated self seeks mainstream integration,

for instance, while the authentic unique self-recognises uniqueness of the individual. The expressive self may respond to access to co-creative solutions. Thus, preliminary feedback suggests that industry has several potential strategies to reach better inclusion of this complex consumer group. Every solution will not work for (or appeal to) everyone but having a selection of options is a move towards broader inclusion.

Users also provided specific garment design feedback, such as strongly disliking zippers or preferring slick inner lining fabric on tops. Certain values were also reported, like keeping cost affordable and not designing adaptive garments that look “too adaptive.” These findings are in-line with the workshop findings. Other crucial considerations indicated were: properly marketing to this consumer and knowing the "proper way of measuring a stump. ”

Design sketches in the *Sportswear Inclusion Map* were critiqued by the physiotherapist who relied on both her clinical experience and recent work in adaptive apparel production. She asked very specific questions about the design detailing on each garment sketch and critiqued areas she felt would not work well functionally. She posed questions as to how the sports bra would open or close and also as to how the detachable sleeves would come apart. She supported the idea of front openings and of detachable sleeves (and had not previously seen this). A built-in arm brace, initially shown as an adaptive option, she indicated would not work. Prosthetics and braces are so individual and personal that this was not an option for mass production, she asserted. There was less focus on the *User Context Wheel*, and no changes were made.

Suggestions from both the users and the physiotherapist were made to alter certain garment sketches. Notably, these suggestions included not using so many zippers (from user comments) and having open-access sleeves rather than a built-in arm brace (from physiotherapist feedback). The users and the physiotherapist upheld a critical need for sportswear inclusion.

6.2.2 Inclusive and Disability Innovation Designers Feedback

One inclusive designer questioned whether the *User Context Wheel* was meant to assist designers or to make a business case, as did one of the disability innovation designers. The inclusive designers all mentioned more empathy building could be added to the tools -- storytelling, personas, or sketches and videos, for instance. As mentioned above, the *Sportswear Design Needs Wheel* and the *Sportswear Design Detail Pages* were, thus, developed to: further assist designers pragmatically; and build more empathy from direct quotes and values of inclusion. Since part of the toolkit is specifically meant to reach the

user community for direct interaction and first-hand learning, personas or storytelling were not included.

The participants, generally, found the *User Network* highly useful and easy-to-read. One researcher mentioned that they all go through a difficulty of reaching the right user base and that a map is needed. Another thought the segmentation of resources into categories was insightful to know who to approach for what knowledge. One inclusive designer, however, thought the *User Network* could be overwhelming to designers and suggested adding a clear entry point and direction in which to contact people. One participant suggested indicating the value and quality of knowledge from each resource in the *Network*. These were deemed areas of potential future research.

One disability innovation designer proposed that, within the *Sportswear Inclusion Map*, more radical innovation could be achieved by cross-combining the branches or exploring concepts more deeply within each segment. Others in this group suggested cost could be brought down by bringing in sustainability and that these sportswear inclusion options could be utilised as a win-win for consumers and businesses. Training sportswear designers with a disability studies framework, appropriate terminology, and methods for working with "vulnerable" groups were mentioned as advisable for introducing this guidance to industry.

6.2.3 Sportswear Course Leaders and Industry Designers Feedback

The sportswear university course leaders, who also had industry experience, indicated these data and graphics for understanding this consumer were new to them and insightful. The *User Context Wheel*, they said, broadened the scope of who this consumer might be, and they did not find it "othering." These participants did want more user visualisations, motion, and compelling design within the tools. User visualisations, however, were deemed outside the intent of this toolkit. McCormack (2021) suggests that "pictures are not neutral." She further writes:

> *They help us to form attitudes towards ourselves and others, and sustain our understanding of history, culture, race and sexual identity, among many other things.* (p. 12)

As disability is still widely misrepresented and marginalised, there was a concern that select user visualisations would not translate a comprehensive understanding of the user community scope and complexity. Again, rather, routes for engaging with the community

directly are provided. Suggestions of motion graphics, or perha ps interactive design, may provide direction for future toolkit development.

The *User Context Wheel* was very well received by the sportswear industry designers and succeeded in challenging expectations of who this consumer group might include. As one designer described, “for me [the wheel] just opens your mind to, very quickly, what you think you know isn’t enough.” Another designer commented:

> *Looking at this wheel, I know people who have some of these conditions, and it’s so eye-opening… yet I don’t think about them when I’m designing. It makes you feel a little bit selfish because you do just automatically design for the mass mark et and then seeing all these different conditions and how they’ll be affected and how they’ll struggle day-to-day it’s quite eye-opening. And, I think, a lot of people will probably feel the same, a lot of designers when they’re going through the design pr ocess, I don’t think we do think about this enough. You get so focused on the concept and the aesthetic, and also the price point as well…. To see all these conditions and to think about the thousands of people, or millions, who are affected by this, it’s really eye-opening.*

A few designers had not considered that arthritis might fall within this consumer group; the statistics were described as insightful. One had not thought about short term injuries, and another had only previously envisioned Paralympic athletes.

Additions suggested for this tool were: adding age ranges of consumers; population statistics; a visual spectrum of users; quotes from real users; and specific design considerations or needs. Some of these suggestions were used for the *Sportswear Design Needs Wheel* and *Sportswear Design Detail Pages*. Other areas may be relevant for future research, such as including population age ranges.

The *User Network* received less feedback overall from the sportswear designers. Generally, it was described as clear and helpful. One designer asked if specific brand names or individual organisations would be included as resources within each category. Another designer suggested Tik Tok could be a valuable resource, which is an area to explore further. She made the point that it is prevalent amongst younger users and specified popularity in India. Another designer echoed that each country and market will have their own resources. This tool can, then, act as a guide or format for expansion of location - specific or evolving lists of resources.

The individual branches of the *Sportswear Inclusion Map* were familiar to most. More detailed and finalised designs were requested by some. The *Sportswear Design Detail Pages* may partially fulfil this request. But the ultimate goal of the toolkit is, again, to provide guidance for a user community exploration and collaboration. Finalised sportswear designs would be an end-result.

Several designers indicated that mass customisation was an intriguing option as they had only known of it being used for choice of decorative options, not for selecting from construction or functional options. While a selection of construction or trim options might be possible, some indicated that the cost and manufacturer required minimum units might be prohibitive. As one designer indicated, "unfortunately, it does come down to cost. It's frustrating from a design point-of-view as well."

All expressed a need for more disability inclusion in sportswear design. Attitudes towards the research project were positive, and a few suggested these tools could be used as models for other areas of exclusion. Some desired avenues for research expansion were: marketing strategies for this community, more market research on the community and current use of sportswear, and a longitudinal look at full user stories or journeys.

6.2.4 Considering Stakeholder Perspectives

Not only did the feedback sessions generate a pragmatic critique of the tools, but they also suggest a distinction in perspectives and knowledge from each group. Hearing and reading how designers, users, and others interpreted these tools, and what they found lacking was crucial to the final output. Updates to the tools were made on a rolling basis when: individual comments were relevant (such as the correction by the physiotherapist that a built-in arm brace would not fit multiple users with different needs); or cumulative comments revealed themes (such as the request for more design details and user needs to be illustrated).

User involvement, direction, and critique was valuable and essential at all stages of this design research in shaping the content of the tools. Feedback from the users on the *Sportswear Inclusion Map* sketches was highly valuable in refining the design details and supports a participatory process. While zippers were supported as an option by previous users from the interviews and workshops, the frequency of zippers shown in the *Sportswear Inclusion Map* was negatively received by some on the feedback form. This served as a reminder to the researcher that other closure options needed to be visibly shown. Many user respondents indicated positive support for this research and a real need for it. One

participant wrote in JotForm: “I really enjoy being involved wit h something that’s for a greater cause.”

The physiotherapist’s feedback helped to refine the functionality of the sketches. She offered clinical input from decades of working with many different clients in a rehabilitation setting. In some instances, she supported options that would work for many people, like front openings. Other times she asserted when user needs were too individualised for mass garment production, such as a built-in arm brace. Her insights were valuable as a co-collaborator.

The inclusive designers had much experience with and knowledge about empathy building tools. There was also a large focus on the design goals and making a business case for inclusive design. Some practical critique of the tools, however, aligned less with the disability studies framework of this study and the goal of designers taking lead from the disability community. This included suggestions for the development of user pers onas or considering Paralympians as lead users. Considering the 18 users who participated in this research, however, each person’s own set of experiences and clinical considerations were unique. As Holmes (2018) writes, creating personas in design work is meant to simplify large quantities of people to make it simpler for designing targeted solutions and to remind designers they are designing for someone other than themselves. But personas are fictional and over-simplified people, she states. This may be a problem when dealing with a marginalised, or misunderstood, grou p when more nuance and awareness is critical. So, the above tools point the direction to a wider scope of user participation and ideation rather than providing pre-determined personas. This will be discussed further in the following section.

The disability innovation designers seemed well-placed to analyse the tools from a disability studies perspective. The suggestion of viewing Paralympians as lead users was countered with a comment that professional athletes' body conditioning and functional needs may be different than consumers who do sport or fitness on a casual level. This same design researcher suggested the *User Context Wheel* may be overly clinical from a disability studies perspective and that it was important not to imply the goal was to “fix” people. The other researcher, however, countered that clinical knowledge was essential to designing products that relate to the body and underlying conditions. He indicated that clinical knowledge can be applied without adopting a demeaning attitude. In r esponse, the *User Context Wheel* remained unchanged, while the *Sportswear Design Needs Wheel* was added to highlight that changing design details can remove apparel -related barriers in relation to the social model.

The sportswear course leaders and designers commented greatly on the positive impact of the tools. Not having worked in adaptive or inclusive apparel (apart from one), they did feel the tools offered an applicable and insightful portrayal of this consumer group. Additionally, the sportswear designers thought these tools could go beyond upper limb impairment and support inclusion of other areas of marginalisation from fashion. They were able to comment on the feasibility of the *Sportswear Inclusion Map* - most branches considered achievable for mainstream disability inclusion. Mass customisation, as indicated, still needs further investigation for cost and manufacturing viability. The sportswear designers did indicate the need for more disability inclusion, and all commented that the project revealed a much wider scope than they had realised. So, their feedback validated that the direction of this research targets a real industry need. Testing the tools within an industry design initiative is a next step for future research.

Overall, the stakeholder groups all had unique perspectives on the tools and the topic, while all supporting the same goal of sportswear inclusion and better guidance for designers. This supports the call for further collaborative exploration on sportswear design inclusion in research and in industry. All stakeholders offered knowledge on user research and a people-centred design practice. The user group, however, held the key experiential knowledge to give precise detail on the function, values, and social attitudes needing to be addressed for meaningful sportswear inclusion.

6.3 Comparison to Existing Inclusive Design Toolkits

As discussed in section 2.4, inclusive design guidance and toolkits exist to assist companies and designers in reaching a wider diversity of people (Eikhaug and Gheerawo, 2010, 2021; Microsoft, 2016a, 2016b; Engineering Design Centre, 2017; Holmes, 2018). So why are these new tools needed, and how are they distinct from what has already been published? Some existing toolkits have a perspective that perhaps focuses more on engineering or assistive technology (Engineering Design Centre, 2017). Others reflect on the history and reasons for exclusion in the first instance before proposing strategies for inclusion (Holmes, 2018). Eikhaug and Gheerawo (2010) include a section on people-centred research methods for inclusive design, and Microsoft's (2016a, 2016b) inclusive design toolkit maps techniques for inclusion. All encourage a wider level of inclusion and thoughtfulness when launching new products, services, or technology. But none focus precisely on the apparel industry, sportswear design, or physical disability. When considering the contexts and biases that exist around these specific areas, more nuance and detail is needed to guide sportswear industry designers.

User personas or visualisations were suggested from some stakeholders during the feedback sessions, as mentioned. Indeed, this appears a common design method. In the University of Cambridge's inclusive design toolkit, user personas are listed as an activity for the explore phase. They are meant to highlight a variety of factors and values for designers to consider a wider range of users. Their personas are based on a survey of 338 people in England and Wales and consider "various characteristics that impact one's ability to use digital technology successfully" (para. 9). A table shows clustering variables, such as competency with and frequency of use of technology. Using cluster analysis with five key variables, respondents were grouped into twelve clusters -- each cluster represented by a persona. "Derek," for instance, is a retired widower, very rarely utilises a computer or mobile phone, and tends to avoid technology. He uses reading glasses, a walking stick, and sometimes a mobility scooter, and he takes pride in being independent. More factors, such as influence of life stages and positions of personas within a social network are also mapped (Engineering Design Centre, 2017).

The Design Council (2015c) suggests creating simple sketches or visual representations of character profiles. They advise to identify key characters, based on user research or a brainstorm, that will be the basis of a design project. Composite profiles, they note, can also be created by merging features of real users. It may be that user personas or visualisations, as an established practice, work well with certain design projects geared towards certain users. When the goal is to understand a marginalised user group's scope and designers are new to this area, alternate types of visualisations or community mapping may be helpful.

As mentioned, Holmes (2018) critiques the use of personas in inclusive design work. Quantifying human characteristics and determining averages, she asserts, is not conducive to understanding human diversity. Arguing against the notion of "normal," she states:

> *If there is no normal user, there is also no extreme user. There is no such thing as people on the far reaches of the curve. There is no abnormal scenario. There is no edge case. Rather, we need new tools to represent human diversity and challenge entrenched habits of designing for the average.* (p. 99)

As an alternative to user personas for inclusive design, she presents a persona spectrum -- designing for the one person who experiences the greatest design exclusion and then extending to the many. Illustrating a persona spectrum for touch, for example, she shows a person with one arm (greatest design exclusion), a person with an arm injury, and a new parent whose upper body is occupied carrying a baby. This represents a spectrum of permanent, temporary, and situational mismatches with designs experienced by individuals'

physical situation. Microsoft's (2016a, 2016b) inclusive design toolkit similarly operates on persona spectrums: "Being mindful of the continuum from permanent disabilities to situational impairments helps us rethink how our designs can scale to more people in new ways" (p. 40). As described in section 2.1, Lamb and Kallal (1992) suggest functional apparel designers build a user profile with demographics, characteristics, activities, and preferences. But, they note, designers must be mindful of cultural ramifications in developing profiles or defining users' needs. These needs, they state, should be determined *with* the users so they have more control of the outcomes.

Rather than illustrating individual user personas or a linear persona spectrum, the *User Context Wheel* shows a scope of variables that may indicate market exclusion and contextual considerations for a sportswear inclusion exploration. A range of potential users and situations is indicated based on the primary research community engagement. The wheel does signify a distinction between permanent and temporary situations that would impact design decisions. It goes further, however, to recognise differences within these temporal situations. Someone with a permanent upper limb impairment, for instance, might have an acquired, congenital, or progressive disability. How someone with a congenital limb difference interacts with and values a garment may differ from someone who has acquired partial hand paralysis from a spinal cord injury. This reflects the social model, as well as addressing diversity within disability (Shakespeare, 2018).

Considerations of sportswear purpose and sport/fitness involvement suggest areas that motivate some consumers beyond just functional reasons of easier dressing. Further values, such as reasonable cost and agency in making self-adjustments, have been embedded into the *Sportswear Inclusion Map*. This *User Context Wheel* is meant to expand a designer's awareness of upper limb impairment in relation to sportswear, but there is no "typical" user depicted within this scope. Collaboration with many real people represented within (and externally) to this wheel is recommended for a design exploration. Within the *Sportswear Design Needs Wheel*, apparel-related barriers are clustered into areas for suggested ideation topics. These are representative of areas discussed within this research journey, so room should also be left for additional ideas sparked by new participant discussions.

The University of Cambridge's inclusive design toolkit suggests creating a stakeholder map during the exploration phase (Engineering Design Centre, 2017). In the Microsoft (2016a) inclusive design toolkit, the Frame stage is described as learning from different perspectives to apply to the bigger picture. One activity in this stage of the Microsoft toolkit is a Persona Network, or a personal ecosystem for considering design challenges. This method includes

mapping interactions an individual makes during the day in order to locate mismatches between the person and their environment. It is noted that there is no correct way to map this network; it is a matter of what works for the creative process.

So mapping is an established tool for diagramming a user or stakeholder ecosystem or network. These can have various purposes -- from delineating key stakeholders in new product development to understanding how a user interacts within their personal environment. There seems no previous mention, however, of mapping a resource network of an excluded user group in order to find and reach meaningful collaborators. The *User Network* fills this purpose.

6.4 Comparison to Existing Adaptive Apparel Guidance

Aside from inclusive design toolkits, it is also worth addressing how these new tools fit into the lexicon of existing adaptive apparel guidance. Within the practice and literature reviews, there was a dearth of guidance precisely addressing: 1.) sportswear for people with an upper limb impairment or difference; 2.) mainstream adaptive and inclusive sportswear strategies; and 3.) disability awareness training for sportswear industry designers. These tools are unique in that capacity. The tools adhere to established practices of focusing on apparel or industry-related barriers and a participatory collaborative approach (Kidd, 2006; Carroll and Kincade, 2007; Kabel, McBee-Black, and Dimka, 2016; McCann, 2016; Kabel, Dimka, and McBee-Black, 2017).

Emerging guidance in this area seems geared towards providing descriptions of adaptive features for apparel design. Addressing the gap in adaptive apparel training in fashion design, Kosinski, Orzada, and Kim (2018) propose:

> *to create an adaptive clothing design guide for apparel design instructors, students, designers and manufacturers to reference when designing new garments. This guide will include suggestions for adaptive features on clothing to help facilitate inclusive product results, assisting designers to create fashionable and functional clothing for all.* (p. 2)

It will be intriguing to find out if the above-referenced guide will take a universal design approach with the goal of supporting all diversity within the population (Barnes, 2011). Or if specific apparel-related needs are advised for areas of disability inclusion (McBee-Black, 2022).

The toolkit presented in this chapter supports multiple approaches. As Barnes (2011) asserts, a universal design that encompasses every person is most likely unattainable. But the inclusive branch may reach many more people than are currently being served with mainstream sportswear. A more targeted approach, like adaptive apparel, may be conducive to more sport or consumer-specific sportswear. Crucially, the *Sportswear Inclusion Map* goes beyond the adaptive features that can be included to suggest overall design and manufacturing strategies for mainstream inclusion. As Carroll and Kincade (2007) and McBee-Black (2021) indicate, brands or manufacturers may be unclear how to address disability inclusion within the apparel industry.

Recommended adaptive apparel features and specific apparel-related barriers were previously indicated in sections 2.1.1 and 3.2. Certainly, these considerations are essential knowledge for adaptive and inclusive apparel designers. But adaptive feature recommendations alone may not be enough. In the early 2000s, Lamb (2001) asserted the need for more disabled consumers to be involved throughout the design process. Indeed, more meaningful representation and contextual understanding of marginalised consumer groups may come through user collaboration and exploration (Eikhaug and Gheerawo, 2010; Agid, 2018; Holmes, 2018). The *User Context Wheel* and *User Network* are unique to adaptive apparel guidance in this sense – giving direction to scoping and reaching this consumer group. Gaining user-led knowledge around disability, diversity of the body, and values of inclusion may provide an essential underpinning for adaptive apparel design training.

Finally, as described in section 3.6, McBee-Black (2021, 2022) and McBee-Black and Ha-Brookshire (2022) show the value Scheier, as an advocate, brought to the collaboration with Tommy Hilfiger and the launch of their successful adaptive apparel collection for children. According to the authors, Scheier was able to inform and advance the apparel industry around adaptive apparel through:

- Facing barriers, first-hand, to accessing mainstream fashions for her son;
- Networking with other parents of children with disabilities;
- Previous work in fashion design;
- Conducting in-depth, user-focused research.

Indeed, collaboration with disability and adaptive apparel advocates may help access and promote insider knowledge, particularly when dealing with children. An interesting point, however, relating to the women's Tommy Adaptive collection, was raised by one of the research participants. As a former Paralympic athlete, she had assisted Tommy Hilfiger on

their adaptive apparel line. During her interview from the first phase of data collection, she expressed surprise that no other disabled people were in the room during her input session on their adaptive apparel development. She asserted that more involvement with the disability community for insights based on direct experience was needed, from her perspective.

The toolkit from this study provides sportswear industry designers with guidance to build disability awareness and user collaborations in lieu of, or in addition to, advocate partnerships. By initiating their own participatory exploration with a potential consumer community, might industry designers build their own meaningful user collaborations? Multiple collaborators, as self-advocates, from the user communities could be approached through the *User Context Wheel* or *User Network*.

6.5 Conclusion

Thus, the *User Context Wheel and Statistics*, *User Network*, *Sportswear Inclusion Map*, *Sportswear Design Needs Wheel*, and *Sportswear Design Detail Pages* form the Sportswear Design Disability Inclusion Toolkit – a toolkit for mainstream sportswear industry inclusion of people with an upper limb impairment or difference. The tools are to be applied in conjunction with established functional apparel design practice (Watkins and Dunne, 2015). But they go beyond to provide a disability awareness foundation for those new to this area of design. As will be explored in the next two chapters, these tools may also be applicable to other areas of apparel design exclusion or to the broader field of disability inclusion.

Overall, the interviews, community engagement, workshops, and feedback sessions each contributed to these tools. All methods generated unique findings, as well as some overlapping results. The interviews allowed for lengthier personal narratives of lived experiences, whereas the workshops included creative brainstorming tools to ideate pragmatic solutions around this market gap. The lengthy recruitment process, online exploration of adaptive sports providers, social media communities, and disability events provided a broader, contextual framework. And, finally, the feedback sessions assisted in honing and capturing findings for the intended audience. This guidance provides a scope of consumer considerations for inclusion, a path to a participatory collaboration, and ideation starting points for removing apparel and industry-related barriers.

Through an iterative, participant-led exploration, a vast scope of exclusion and strategies for inclusion were revealed. Reflecting participatory and practice-informed results, the

toolkit provides a roadmap for broader awareness and guidance to begin a collaborative journey to mainstream sportswear inclusion. Chapter seven will discuss potential implications of these findings within research, industry, and broader contexts.

Chapter 7: Discussion

This chapter explicates potential implications of the resulting Sportswear Design Disability Inclusion Toolkit and the research experience. First, elements of functional apparel design are revisited to determine how the tools align or differ from previous practice. The same comparison is done between contemporary adaptive and inclusive apparel design research and the toolkit. Implications of the toolkit are also speculated for sportswear industry inclusion practice, as well as impacts on broader aspects of disability inclusion. Reflections on the participatory design research journey are also included to illuminate experiential learnings. Aspects of navigating doctoral study as a disabled researcher and utilising developing virtual qualitative research methods will be discussed. Finally, research limitations will be outlined, which can provide direction for future research.

7.1 Functional Apparel Design Perspectives

The toolkit developed and presented in the previous chapter melds with the fit-for-purpose and collaborative nature of functional apparel design practice, as described in section 2.1. In-depth user research and engineering collaboration, such as described by Gupta (2011a) and Watkins and Dunne (2015), can still be applied. Rather, the tools offer new ways of viewing what adaptive apparel is, who might use it, and how disability inclusion is much more than meeting the functional needs of the disabled population.

Elements of Watkins and Dunne's (2015) advice for adaptive apparel do appear in the two wheels (such as considerations for braces and easy fastening devices, which were indicated by research participants). And the *User Context Wheel* aligns with Gupta's (2011a) four key requirements for functional clothing -- physiological, biomechanics, ergonomics, and psychological. For instance, the reasons noted for short and long-term impairment on the wheel relate to physiology, and the primary symptoms listed, such as limited rotation, deal with biomechanics. External equipment will affect ergonomics, and sportswear purpose (and indeed the intent of disability inclusion and the toolkit) affect psychology. While Gupta's four requirements were not directly considered when creating the wheel, the results do reflect the complex, multidisciplinary scope of functional apparel design.

The entire toolkit, however, goes beyond Gupta's (2011a, 2011b) and Watkins and Dunne's (2015) delineation of functional apparel design. With these tools, sportswear and adaptive apparel are no longer separate sub-categories as they are within functional apparel design

literature. The description of clothing for people with medical conditions and physical "handicaps" from Watkins and Dunne evokes the medical model of disability. Their writing seems to imply this consumer group inherently falls outside the scope of mainstream apparel. Could there not also be a section on inclusive design within functional apparel literature to discuss along with adaptive apparel? It could be noted that *any* category of clothing can be designed for a wider diversity of people. This is not to replace adaptive apparel practice, but simply to exist as an alternative to the binary mindset that design can either be for disabled or non-disabled consumers (Engineering Design Centre, 2017). Inclusive and adaptive apparel approaches both have impactful roles to fill. The *Sportswear Inclusion Map* and *Sportswear Design Detail Pages* reflect this thinking.

Lamb and Kallal's (1992) FEA Model focuses more on the balance between function and fashion when considering functional apparel design. While the three components – functional, expressive, and aesthetic – are essential in functional apparel design, further considerations may also apply. As described in sections 4.2.3 and 4.3.3, the interviews and user workshops had open-ended questions and activities to encourage more participant-led results. In several instances, this allowed for unexpected contributions and key insights that had not been realised from the literature and practice review. The notion of rolling sleeves, making sleeves detachable, and generally giving wearers more independence in choice and usability emerged from multiple participants' lived experiences. Adjustability is equally a functional, aesthetic, and expressive concern.

This aligns with Stokes and Black's (2012) findings that the FEA categories are not necessarily distinct and may overlap at times. So, the FEA Model (and revised versions) could work in conjunction with the toolkit from this study. As noted, the toolkit offers additional insights, such as the scope of excluded consumers, values of disability inclusion in sportswear, and design strategies to match mainstream industry practice. Perhaps these considerations would align with the culture exploration central to the FEA Model. As Hobbs-Murphy, Morris, and Park (2022) recommend, this deeper understanding is crucial before assessing the particular FEA needs.

The toolkit presented in the previous chapter is meant to bring a range of users into the design process for a participatory approach that may challenge what fit-for-purpose actually means to those involved. Viewing functional apparel design more inclusively, and from a user-led perspective, may alleviate some stigma around the goals or perceptions of adaptive apparel. Adaptive apparel practice can work in tandem with inclusive design practice, and both can incorporate the multidisciplinary practices of functional apparel design.

7.2 Adaptive and Inclusive Apparel Design Research

As concluded in chapter three (section 3.7), there is a gap in design research specifically around mainstream sportswear for people with an upper limb impairment or difference. This research output, as such, expands knowledge specifically for this topic. The resulting tools uniquely pinpoint the precise scope of this consumer group, the many nuances to consider in relation to sportswear industry design, the routes to access collaborative design participants, and the multiple approaches to achieve overall inclusion.

The virtual multimethod approach to data collection and stakeholder participation that fit the pragmatic nature of this study had not appeared in the adaptive and inclusive apparel research literature reviewed. Many of the researchers mentioned in chapter three -- Kidd (2006), Carroll and Kincade (2007), and McCann (2016) -- produced physical prototypes so in-person co-design, fitting, and wear-testing sessions were conducted. As mentioned in section 3.3, Hobbs-Murphy, Morris, and Park (2022) were unable to conduct a final in-person fit session for their custom Paralympic shooting jacket due to COVID-19. A virtual evaluation interview along with photographs sent by the athlete took place instead. The authors also note that limitations with the virtual design software made it insufficient to accurately address fit. These restrictions resulted in a jacket that was unsuitable for its intended use due to fit issues. At the time of this study, it seems virtual technologies and methods may not be able to replicate the effectiveness of in-person testing and fitting a garment.

For the front-end exploration of design barriers and needs within this study, however, the virtual qualitative, participatory methods applied were beneficial. They helped to reach an expansive range of collaborators, and purposive participants contributed from multiple time zones in multiple countries. And eliminating frequent travel accommodated the researcher's own physical needs and streamlined the data collection process. These virtual methods suggest exciting opportunities to expand upon practices for adaptive and inclusive apparel design research in a way that removes certain physical or geographical barriers (Lo Iacono, Symonds, and Brown, 2016).

Also distinct to other adaptive and inclusive apparel design research from the literature review is the presentation of multiple strategies to promote overall sportswear design inclusion. The *Sportswear Inclusion Map* and *Sportswear Design Detail Pages* from the toolkit illustrate this range of options. Previous adaptive or inclusive apparel research publications often focus on one or a few of the branches.

As previously described, Bragança *et al*.'s (2018) design research on sportswear for wheelchair rugby players aimed to promote inclusivity of disabled athletes. This was done by designing sportswear specifically for the requirements of wheelchair rugby players through an adaptive apparel focus. Fit, temperature, and suitability for wheelchair use ranked as high priorities. Manoeuvring the wheelchair and throwing the ball needed to be considered in garment fit and construction so that movement was not restricted. Thus, the preferred sportswear is adaptive -- suitable for the context of wheelchair rugby. Elements of adjustability are also considered, with designs showing sleeves and trouser legs as detachable at various lengths.

The case study McCann (2016) presents on collaborative sportswear design for the active ageing falls under an adaptive apparel approach, aiming to design specifically for this neglected group. She does suggest that new design and production strategies are needed to address this consumer. Perhaps it would be worthwhile to explore other branches of the *Sportswear Inclusion Map* when considering this user group. For instance, do some of the final design details appeal to a wider audience, and what would inclusive solutions look like? Are there any areas, stemming from the findings, that can be made adjustable or mass customisable either specific to the intended audience or for a wider mainstream au dience?

Carroll and Kincade's (2007) study is of particular note in that they tackle inclusive (or universal) design within a traditional apparel industry environment, as well as manufacturing constraints for a mass market. Elements of adjustability and mass customisation are suggested but embedded within the overall universal design exploration. Amongst the principles of universal design applied as indicators for their study is flexibility in use -- clothing can adapt to fit varying body types. Their results were designed with long sleeves that could be turned back to expose the lining to suit people with different arm lengths. Additionally, as neckline preferences varied amongst participants, "add -on" features were conceptualised. Separate collars or scarves, propose Carrol and Kincade, could be purchased and attached by the wearer if desired. The garment was, thus, designed ready with a loop at the inner back neck for such additions.

So, Carroll and Kincade (2007) do consider apparel construction and in dustry production methods to reach a wider array of complex user needs through universal design. But adjustability and mass customisation (not named as such by the authors) could be highlighted as design approaches in their own right to really maximise gar ment flexibility. Such is one application of the *Sportswear Inclusion Map* and the *Sportswear Design Detail Pages*. The Map could be used by researchers of apparel inclusion to either: 1.) narrow research to focus specifically on one of the branches, or 2.) explore all areas of the map for

the most suitable strategies for a particular project. The *User Context Wheel* and *User Network* could assist in conceptualising the scope of apparel inclusion and locating appropriate collaborators.

Kidd (2006), addressing special occasion wear design exclusion of young women with spinal curvature, details a project focused on fully customised garments. As previously described, the young women who participated in the study each had a special occasion dress custom designed and fitted for a bespoke result. Bespoke apparel may be the ideal in this situation. Individually customised garments were also supported by some of the athletes in Bragança *et al*.'s (2018) research, as mentioned.

Offering bespoke garments is not a feasible strategy, however, for much of the mainstream apparel industry at this time (Paganelli, 2021). Thus, while fully customised garments were a branch in the first iteration of the *Sportswear Inclusion Map* (Poage, Kapsali, and Bardey, 2020, Fig. 3, *Inclusive Sportswear Spectrum*), it was removed from the final result. Having apparel design students, though, create bespoke garments for clients that require non-symmetrical pattern making and working with external braces could encourage future apparel industry professionals to think more inclusively. Kidd (2006) notes that the student designer in her case study was forced to break with traditional fashion design learning and expand her skill set through this project.

Barry (2020), in an op-ed for the *Business of Fashion*, states that fashion design education is not set up for inclusivity. Drawings and mannequins used in foundation training, he asserts, reflect white, binary, thin, and non-disabled bodies. So, the tools proposed in this study could hold value with students to expand their training and awareness in designing apparel with more body diversity in mind. Training more inclusively minded and skilled students would ideally result in a more inclusively minded industry.

7.3 Sportswear Industry Practice for Disability Inclusion

With pragmatic guidance rooted in areas of disability studies, inclusive design, and participatory design, the sportswear industry may be well placed to address mainstream disability inclusion. As was apparent in the stakeholder interviews, those sportswear designers were skilled at understanding functional and biomechanical needs in sportswear. With no experience designing for consumers with upper limb impairments or differences, the interviewees speculated very closely what functional needs should be considered. They suggested range-of-motion and donning and doffing as considerations, which were mentioned by the user group interviewees as well as literature on the topic (Watkins and

Dunne, 2015). They also detailed various people-centred methods consisting of in-depth contextual interviews, narrative user journeys, and wear-testing. But gaps appeared in the precise detailing of the garment designs. The *Sportswear Design Needs Wheel* and *Sportswear Design Detail Pages* are meant to introduce apparel-related barriers and types of design detailing that can be further explored with the user community.

It was also unclear to the designers who this neglected consumer community was exactly, how they could be reached, and how the current industry business and manufacturing models could adequately support them. When one industry interviewee was asked for opinions on why there is not much sportswear on the market for people with physical disabilities, manufacturing and distribution were referenced. This respondent was extremely supportive of this research topic, but he questioned the logistics of reaching these potential consumers. In discussing this market exclusion, he referred to the Paralympics and reflected on athlete-specific tailoring needed for "promo" pieces (performance sportswear for pro-level athletes). Revisiting an excerpt from the industry findings (section 5.1.2.2), it was stated:

> *But I think when we talk about volume and running into quantities and forecasting to be able to do a production line, it must be really challenging to be able to find a tailored product that the brand is going to be comfortable forecasting thousands of units of that one style if they can't quite pin-point where the demographic or where that specific consumer is located and where they can buy the product.*

Multiple assumptions are brought up here. First, Paralympic athletes had been the immediate point-of-reference (which came up as well during the stakeholder feedback). This is unsurprising considering growing Paralympics coverage and the interviewee's considerable experience with pro-athlete apparel. In this research output, the *User Context Wheel* is meant to challenge the perception that Paralympic athletes are *the* target consumers. Yes, they are included, but so are non-Paralympic professional athletes who may be rehabilitating from injury, as are wounded veterans and casual athletes with a long-term or short-term impairment. So, the volume of forecasting and production may expand further than initially assumed as more than Paralympics athletes are considered in this user community. And if an inclusive design approach is taken (combining the existing primary target market and including consumers with an upper limb impairment), those numbers could increase even further. Involving more individuals within the *User Context Wheel* (and beyond even) in a participatory design exploration may yield common design preferences, as happened with the interviews and user workshops. And applying adjustability and mass customisation could work towards meeting a larger range of complex needs.

Where these consumers are located and where to sell the product are addressed with the *User Network* and the *Sportswear Inclusion Map*. First, the *User Network* maps out resources to "pin-point where the demographic or where that specific consumer is located." This vast ecosystem of social media outlets, research and design resources, adaptive sports providers, and disability groups gives multiple routes for purposive collaboration. And it indicates channels for sales and distribution. Inclusive or adaptive sportswear could be advertised in disability magazines or through adaptive sports providers. Rehabilitation centres could potentially sell the garments (Esmail *et al*., 2022). Or, adaptive sports centres might do so as well. As mentioned, two adaptive fitness providers contacted for this study offered to sell sportswear for this consumer in response to the participant recruitment notice. Other retailers in the *User Network*, like prosthetics suppliers, may also give insight into reaching this consumer.

It should not be assumed, however, that these resources are the only retail outlets for this consumer community. One workshop participant indicated he would like to see big brands selling more accessible sportswear, and another said that she does not go to adaptive sellers. The *Sportswear Inclusion Map* supports the notion that there is not one single solution for reaching this consumer group. Many adaptive fashion brands have launched in recent years, some as specialised retailers and some as collections within larger mainstream brands. As indicated, big brands, like Tommy Hilfiger (no date) and Target (2022), currently sell adaptive apparel through their retail sites. Mainstream sportswear inclusion means, in part, selling inclusive or adaptive sportswear through mainstream channels. This includes expanding the notion of who is shopping at established brands and normalising a wider, more diverse consumer base.

A couple universally designed products have been launched by large sportswear companies, as noted in section 1.4. So, mainstream disability inclusion has been noted but is still largely pending at this time. Nike, for instance, launched the universally designed hands-free trainer in 2021 – the GO FlyEase (Tesfaye, 2021). While this shoe was a needed step forward in mainstream hands-free dressing, the release also sparked criticism around its intent. It was billed as universal design, yet Nike never mentioned disability, claim Virdi and Jackson (2021). These authors suggest that disabled consumers were, thus, neglected within the marketing strategy. As profit and mass appeal were maximised, they claim, disabled consumers were no longer the focus of this project.

Virdi and Jackson write,

> *Nike missed a massive opportunity to recognize and validate more forms of disability, especially invisible ones. Acknowledging that some disabilities are less obvious is a more powerful strategy than "for everyone" because it expands, rather than erases*. (2021, para. 12)

The design itself was successful, they suggest, noting that many different disabled users expressed a desire for a pair. But the cost was so high, they state, that many disabled consumers living in poverty were excluded.

Tesfaye (2021) also writes that some feared that Nike's market campaign addressing non-disabled customers, the limited release, and the higher price point meant those who needed the shoes did not have access to them. But there is an opinion, as well, notes Tesfaye that "the shoe's popularity will help normalize accessible fashion" (para. 12). A case can be made that the FlyEase spurred an impactful debate about the exclusion of disabled consumers and the best practices for meaningful inclusion. Cost and effective marketing strategies were both issues of note from the user community participants in this study. These areas need further consideration. Again, the *User Context Wheel* and the *User Network* can give guidance of who to consult and where to reach collaborators to get more user-led insights on cost and marketing.

This type of debate shows that mainstream disability inclusion has many nuances and means different things to different people, mirrored by the varied user responses on the JotForm feedback questionnaires. The *Sportswear Inclusion Map*, as described, supports a spectrum of strategies to meet a broader range of needs. And the options on this map are similar to design and manufacturing examples that appear within apparel offerings and literature, even if not always used to reach disabled consumers. Sportswear is an industry that prioritises innovation and technology (Bielefeldt Bruun and Langkjær, 2016). With this underpinning, the *Sportswear Inclusion Map* gives strategic direction to explore novel ways to meet complex body diversity needs.

Body mapping technology, for instance, could suit the adaptive or mass customised branches of the *Sportswear Inclusion Map*. As described by McCann (2016):

> *[Body mapping] refers to garment engineering that directly links the selection and positioning of textile knit constructions to address physiological demands. Zones of the body are mapped in relation to the selection of fiber types and textile structures*

> *to enhance comfort factors such as moisture management, thermal regulation, ease of movement and muscle support.* (p. 238)

Also, Nike developed the FE/NOM Flyknit sports bra using a knitting technology previously applied in trainers (Anon., 2019; Nike, 2022b). This technology combines multiple shapes and densities in a near seamless garment, making it 30% lighter, compressive, and free from extra elastic. Adidas (no date) offers a maternity collection "designed to flex with your body throughout your pregnancy" (para. 1). Material technologies such as these could be explored for their use in allowing flexible fits, simplifying seaming, and adding built-in support or compression where needed to suit more body diversity.

Seamless knitting technology could be applied in new ways for adaptive garments, or existing garments could be marketed as inclusive. Reebok's (2019) seamless leggings, for instance, are constructed with a "seamless jacquard [that] eliminates pressure points for less chafing and irritation" (para. 2). Indeed, one of the workshop participants who was a wheelchair user found seamless leggings easier to put on and said that they did not leave marks on her skin. With spinal cord injuries, skin sensation can become impaired and no longer give warning if too much pressure or irritation is being applied, according to the Christopher & Dana Reeve Foundation (2022). They recommend smoothing clothing to keep skin safe.

Some sportswear is already conducive to reinventing donning and doffing and allowing for adjustability. Basketball trousers are available as a tearaway option, revealing game-ready shorts underneath. Snaps running up the outseams make it possible for the wearer to "tearaway" the trousers without having to step out of them and, thus, quickly enter a game (Puma, 2021). For an example of adjustability, Boardman offers a cycling jacket with zip-off long sleeves so it can also be worn as a gilet (Halfords, 2022). Continuing to reimagine adjustable options and ways of getting in and out of a garment, as well as considering accessible fasteners, could influence adaptive and inclusive sportswear.

Cost, as mentioned, may come into play and need a further look. "For example, some design choices, such as adding Velcro or a zipper to the side of a garment, can increase manufacturing time and cost while slowing production" (Esmail *et al.*, 2022, p. 81). McBee-Black's (2021) case study of Scheier's collaboration with Tommy Hilfiger, from section 3.6, offers some insights into overcoming these concerns. Scheier's user research, partnership with a willing manufacturer, cost negotiations, and development and testing design innovations to make them production-ready all contributed.

As noted in sections 2.3.1 and 3.6, modular or adjustable garment design of ready-to-wear items could facilitate mass customised fits (Loker, 2007; Watkins and Dunne, 2015; McBee-Black, 2022). Morris (2020) states about her conceptual modular parka, previously discussed in section 3.1:

> *This design showcases that creating apparel that is usable for a wider variety of people is easy to implement with modular features. Using the same materials, the adaptive lower is not cost-prohibitive and may help reach minimum order quantities. Adaptive clothing should not cost more than non-adaptive clothing*. (p. 2)

And, adjustability is incorporated in the Tommy Adaptive line, such as an adjustable waist on adaptive seated jeans (McBee-Black, 2022; Tommy Hilfiger, 2022a).

Mass customisation is already done by some big brand sportswear companies but in limited capacity. Nike (2022a) has customise sections within their men's and women's online categories, offering shoes and team jerseys in this platform. Customisation options are choosing unique colourways for the shoes and selecting player names and numbers for jerseys. Some sportswear designer feedback on the *Sportswear Inclusion Map* considered selection of zipper pulls or sleeve lengths a possibility – beyond what is currently offered. Other feedback, however, indicated that mass customisation of garment construction may not be cost effective or feasible with manufacturer minimum requirements. Carroll and Kincade's (2007) concept of "add-ons" is also a possibility, where the customer can purchase additional pieces to fulfil dressing preferences. For instance, a customer could choose to add on a fabric loop to the zipper puller. Costing structure, again, would need to be examined as charging extra for an add on -- and, thus, charging the disabled consumer a higher price for a usable garment -- is not equitable.

Other emerging areas of assistive wearable technology, like the automated zipper Cliff outlined in section 3.1, could support adaptive and inclusive sportswear (Baharom, 2020). As noted, more innovation and development are needed in some of these areas for ideas to be production-ready. The guidance produced in this thesis is meant to challenge potential industry or social-related barriers (misperceptions or gaps in knowledge) that may inhibit disability inclusion in sportswear. The toolkit provides a starting point that is rooted in practice-informed industry needs and relevance but that is balanced with a disability studies perspective.

7.4 Disability Inclusion: The Bigger Picture

While the focus of this thesis was mainstream sportswear industry design, the research and final output have broader implications. Additionally, the user scope of this study was individuals with an upper limb impairment or difference in order to execute a manageable research project. But the framework, methodology, and resulting toolkit could apply to many areas of disability inclusion. Other design researchers, fashion students, and apparel designers could apply this type of participatory exploration and spectrum of options for inclusion. Considering a wider range of human diversity within mainstream offerings is part of facilitating a more inclusive society. Having more and more inclusive and mainstream adaptive offerings sold by big brands would make it "normal" rather than niche.

The University of Cambridge inclusive design toolkit states that, in order to better grasp diversity, it is essential to look beyond a polarised distinction of disabled and non-disabled (Engineering Design Centre, 2017). This notion is reflected in the *Sportswear Inclusion Map*, which is meant to expand mainstream apparel design approaches to encompass a greater spectrum of needs. Eikhaug and Gheerawo (2010) write that "market segmentation defines people according to how you want to see them, but people-centred techniques allow them to express themselves" (p. 38). Employing a participatory design philosophy and viewing marginalised consumers as neglected rather than an outdated "special needs" group reflects this. Adaptive sportswear or apparel, although designed and marketed for specific consumers, can be done within a mainstream mindset.

While inclusive design methods can help to remedy exclusion, purpose and point-of-view are just as important, Holmes (2018) writes. She states, "treating inclusion as a benevolent mission increases the separation between people" (p. 4). Empathy and reciprocity are needed for marginalised consumers who are sharing their time and experiences with brands for new design and development projects. When designing adaptive apparel, the perspective matters. When a solution is perceived as "for disability", it "might meet all of its functional requirements but still lead to emotional or aesthetic mismatches that can be equally alienating" (Holmes, 2018, p. 117). This is the case for more participatory, exploratory design collaborations. Pullin (2009) writes that teams addressing "design for disability" mainly come from clinical and engineering fields, focusing more on problem solving, and that more creative collaboration is needed. Tools, like the *User Network*, are essential for reaching communities directly for on-going collaboration and deeper understanding.

The *User Context Wheel*, *User Network*, and *Sportswear Design Needs Wheel* shift the design goal away from purely medical or functional needs. Within the *User Context Wheel*, Sport/Fitness Involvement and Sportswear Purpose highlight that the garments are sports-based, not clinical-based. The *User Network* points to many avenues of connection -- social media, sports groups, and disability communities. Clinical areas are there as well but within a larger ecosystem that also includes personal and social connections. The *Sportswear Design Needs Wheel* has a section on values. And values are also indicated on the *Sportswear Design Detail Pages*.

Assessment of the ultimate goals -- functional, emotional, aesthetic, or other -- of a disability inclusion project should have input from the disability community. As noted, the *User Context Wheel* and the *User Network* can be used as maps to include a variety of people who can influence and would be influenced by the research and design outcomes. On discussing user involvement, Shakespeare (2018) writes, “rather than non-disabled people deciding for disabled people, disabled people should, wherever possible, decide for themselves” (p. 159). This is expertise by experience, he states. In complex projects, he adds, professional expertise is essential, but professionals should not have all the power. As previously indicated, functional apparel and sportswear design practices sometimes begin user research after a design project has been briefed (Watkins and Dunne, 2015; Morris and Ashdown, 2018). But earlier user-led explorations may be beneficial in setting up a design brief for disability inclusion in the first instance.

Redefining who is included within mainstream apparel consists of re-envisioning a spectrum of the "norm". Davis (2013), a specialist in disability studies, writes that our world consists of norms; we rank many aspects of our being, such as height, intelligence, and body shape along some imagined range of subnormal to above-average. As Davis asserts, “an important consequence of the idea of the norm is that it divides the total population into standard and nonstandard subpopulations” (p. 3). He, thus, focuses on the construction of normalcy, rather than on the construction of disability. From this perspective, how “mainstream” apparel has traditionally been designed, marketed, and distributed reflects and feeds into a notion of who a “normal” target consumer is. This is also how fashion design has traditionally been taught (Barry, 2020). When viewing population statistics and complexity of body diversity, as are included on the *User Context Wheel*, preconceived notions of the “norm” may be challenged. And, hearing more and more user-participants’ narratives, as in this study, can expand understandings of how certain products meet or fail to meet varied needs and values.

Human beings are complex; industrial design and mass manufacturing outputs do not always reflect this (Holmes, 2018). The output of this research seeks to provide direction to reach a wide array of excluded consumers for participatory exploration and to offer a spectrum of design approaches for overall inclusion. Stemming from a sportswear industry background, this research began with a view that an adaptive sportswear approach was *the* goal for inclusion. As documented, however, community engagement and inductive participatory data collection revealed more routes for apparel inclusion (inclusive, adjustable, mass customised). More research on how we define (and *who* defines) mainstream consumers and strategies for inclusion is recommended for the apparel industry and fashion education practices.

7.5 Reflections on the Research Journey

Implications from this study come from what was learned through doing in addition to what was generated as output. The valuable user-led learnings, unfurling of implicitly held biases, and rethinking the notion of human diversity came through participatory research efforts and community engagement. Readings from various disability studies and participatory design scholars also sparked reflection upon the historic and systemic reasons for ingrained design exclusion in the sportswear industry. Engaging in a disability studies thesis as a disabled researcher also sparked revelations of exclusionary practice and shifts in self-identity. This section, thus, outlines the implications of the chosen research path, methodology, and methods from points of practice-informed and disability studies reflection.

At the inception of this research, an envisioned aim was to explore adaptive sportswear for people with cerebral palsy (CP) who participate in RaceRunning (or Frame Running). "Racerunning is an activity for people with CP employing a pedal-less trike that supports the upper body and trunk, enabling propulsion using the legs;" it allows those with CP "to perform activities at a sufficient intensity to promote health and fitness adaptations" (Phillips, Turner, and Lousada, 2017). Resulting from an exploratory email to a disability sports organisation in London, a connection was made with a young man with cerebral palsy who agreed to an informal chat. While the discussion itself was engaging, it became apparent that the above research aim was too complex for the researcher's knowledge-base, timeline, and resources available. Readings on the variations and complexity of cerebral palsy, as well as the limited locations of RaceRunning communities, confirmed this thought. Reflection on more practical research capabilities, as well as Carroll and Kincade's (2007) insights on including participants by effects on the body rather than disability classification, resulted in the research aim that was implemented.

As mentioned in the introduction, a focus on upper limb impairment was chosen after it was perceived as a gap in adaptive apparel research. Associated apparel-related barriers and functional needs matched the researcher's experience in sportswear technical design. The *User Context Wheel* is, in part, a reflection of what the researcher gleaned of what "upper limb impairment" means to different people and how this might relate to sportswear. It was built from a sportswear designer point-of-view based on participants' narratives and on communications from numerous disability and sports sites. And it reflects design exclusion that can be remedied.

A key turning point of the research journey came mid-way through primary data collection during the 2019 in-person visit to Naidex. This visit provided immersion into a disability innovation trade show on a scale not previously experienced by the researcher. Visiting booth-upon-booth of products, innovation, and services available for the disability community made it clear how lacking these areas are in mainstream media and retail. And how many people are, thus, impacted. The visit also provided the opportunity to network with other people contributing to this ecosystem, such as disability sports providers. As previously indicated, it was one such inclusive sports coach who recommended Black and Stevenson's (2011, cited in Neale, no date) inclusive sport spectrum. This was pivotal in the development of the *Sportswear Inclusion Map*, which is key to impressing upon sportswear designers that there are many routes for inclusion that can balance with industry capabilities. (More extreme shifts in manufacturing should also be explored in future research on radical innovation for disability inclusion in the sportswear and apparel industries.)

A subsequent integral learning moment came through the user workshop recruitment and delivery. Whereas the interview recruitment succeeded in locating a handful of relevant adaptive sports organisations, these were insufficient in reaching enough participants for the workshops. As earlier noted, two months were then spent researching and contacting over 100 adaptive sports organisations, adaptive trainers, disability community support groups, rehabilitation centres, inclusive and clinical research centres, and wounded veteran groups. The scope of excluded consumers, thus, vastly expanded. The recruitment statement was left fairly open to receive who identified with the project, which resulted in wheelchair users being included from this point forward. This extensive user-led process resulted in the *User Context Wheel* and *User Network*, which document the learning and routes explored by the researcher. They can be used as roadmaps for future disability inclusion researchers to follow and build upon.

In the realms of participatory design and adaptive or inclusive apparel design research, there was little guidance or documentation on virtual design research at the time of this study. Providing such virtual alternatives can encourage further inclusion. Virtual interviews and workshops allowed collaborators from around the UK and the US, as indicated, whereas the project would have stagnated if only London-based in-person sessions were available. Additionally, due to the researcher's own physical requirements, virtual options were necessary at times. Platforms like Skype, Zoom, and Miro facilitated remote interactions and virtual modes of design ideation. These technologies made this thesis possible and facilitated the necessary purposive sampling.

Virtual-only interactions have their limitations as well. People without internet access or knowhow, for instance, were excluded from this study. And, commenting more broadly, the shift to virtual life brought on by the pandemic increased barriers of participation for some, as within the deaf community, when online options were not fully accessible (Nović, 2020). Virtual Naidex in 2021 was nowhere near as meaningful for community engagement and contextual exploration of this research as the in-person event in 2019. In 2019, a full day was spent browsing booths on adaptive sports, inclusive and adaptive apparel, and assistive services. Panel talks were attended, and networking was easily facilitated. At the 2021 virtual event, means for networking or viewing products were rather limited. So, while the emergence of virtual options did have vast benefits for this study, in-person participatory engagement also yielded great value.

A case for expanding virtual design research options is enhanced by the researcher's own experience. Traditional academic and design research practices were not always accessible when this project began. Throughout the research experience, compassion for inclusion from the academic research team was apparent. But long-established resources were not always conducive to accessibility. Prior to the pandemic, many talks, workshops, and conferences were arranged for in-person attendance only, and enquiries into streaming access (or recordings even) were met with rejection. In cases where accommodations were made, it took great effort and much correspondence to achieve such.

Grue (2021) calls this the invisible work of disabled people, referring to Arlene Kaplan Daniels' 1987 essay *Invisible Work*. Daniels' "invisible work" refers to domestic and emotional labour (viewed as natural activities) done by women out of sight and out of mind. Grue writes, "[i]n many ways, Daniels' argument applies directly to the invisible work imposed on disabled people by an inaccessible world" (para. 27). Indeed, frequent, and sometimes lengthy, negotiations for disability accommodations was an extra workload to be managed. It can be argued this type of invisible work also applies to consumers who

must constantly search out adaptive or inclusive apparel from specialist retailers or have modifications made to high street offerings.

Once the pandemic hit, our world went virtual. At this time, participation and learning became prodigiously easier for this research path. All the workshops, conferences, and social gatherings that had to be skipped or attended through overexertion were now available in abundance. This virtual shift did, of course, cause great frustration, mental anguish, and difficulties for multitudes of students, researchers, and society, in general. For many, this shift made life less accessible and more isolating, and certain research projects were suspended. It may be that, going forward, availability of hybrid options and readily available accessibility can automatically suit more people without the need for special requests.

The decision to initiate this research with a pragmatic and participatory design approach allowed for awareness, biases, and goals to shift dramatically within the research over the span of this project. As described, the researcher does identify as disabled. But she has not experienced long-term upper limb impairment or a limb difference. So, while traumatic injury and barriers had been experienced first-hand, it was crucial to keep in mind that disability experiences are not even close to universal (Shakespeare, 2018).

The impact of undertaking disability-focused design research as a disabled researcher was unanticipated. Learning about the social model of disability, implicit biases in design, and manufactured (if unintentional) social exclusion was enlightening. Emerging research and more open discussions on inclusion happening both in the US and the UK give hope for a more equal future society, but it will take some work.

One observation was that the term “vulnerable” within a social or research context occurred frequently during this project and, at times, appears in an ableist manner. This term appears ubiquitous in discussions and literature about the ethics of disability research, although it is not used by all authors. Certainly, appropriate ethical parameters and researcher responsibility must be maintained. But is it helpful to view certain groups as inherently vulnerable, or can the label sometimes induce a stigma and an othering effect? This very question emerged for discussion amongst some classified as vulnerable throughout the pandemic. In an article for the BBC’s Disability section, Woodward (2020) asserts that “[t]he V-word was meant to infer protection but instead, for some of the 2.2 million people asked to shield, it felt dehumanising and changed our 21st Century reality” (para. 4). Woodward also quotes Baroness Campbell, a Member of the House of Lords, as stating; “‘I absolutely

hate the word 'vulnerable'. Because I'm anything but. We are not vulnerable people. We are in vulnerable situations'" (para. 13).

Some ethical research guidance that discusses marginalised groups as vulnerable seems to contradict the non-hierarchical, user-led methodology employed for this research. Liamputtong (2007), for instance, in her book *Researching the Vulnerable*, applies the term "vulnerable" for "hidden populations." She expands this to encompass, in part, children and adolescents, older people, disabled people, victims of domestic violence, sex workers, and indigenous populations. But does a label of vulnerable apply to all these distinct people? And from whose perspective?

Speaking at the 2021 Naidex event, Riches (2021) -- a registered blind Paralympic athlete -- discussed common yet misguided phrases said to disabled people. One was, "Let me know if you need any help." While well-intentioned on the part of the asker, Riches points out that using the word 'help' is somewhat patronising. Why is there an assumption that help may be needed simply because a disability is visible? Instead, she suggests, "Let me know if I can do anything" could be an alternative, if indeed it needs saying at all. If people define themselves, appropriate empathy can be developed (Eikhaug and Gheerawo, 2010; Holmes, 2018).

For this study, each participant interaction was a different situation. A few members of an aphasia group expressed interest in a virtual workshop (which did not come to fruition in the end). Moffatt *et al*. (2004) describes aphasia as such:

> *Aphasia is usually acquired as a result of stroke, brain tumor, or other brain injury, and results in an impairment of language, that is, to the production and/or comprehension of speech and/or written language. Rehabilitation can reduce the level of impairment, but a significant number of individuals are left with a life-long chronic disability that influences a wide range of activities and prevents full reengagement in life.* (p. 407)

The aphasia group leader who responded to the workshop recruitment notice mentioned that some members had an upper limb impairment as a result of a stroke or a traumatic brain injury, along with aphasia. In this case, a sudden, life-altering medical condition or accident may trigger aspects of vulnerability, especially if people are involved in a support group. Some of the research participants had a limb difference from birth, however, and some were Paralympic athletes, so situations cannot and should not be compared.

Talking to people who may have been through traumatic experiences or faced systemic exclusion does, of course, require care. Wide-spread and continuous exclusion can be psychologically challenging (Holmes, 2018). In certain situations, a possible phrasing might be “people experiencing vulnerabilities,” as per Dodds and Palakshappa (202 2, p. 152). But “disability is diverse, and it can be tricky to characterise it” (Shakespeare, 2018, p. 5). Shakespeare writes that there is evidence stating that disabled people often report a good quality of life, and not everyone who could be defined as disabled th inks of themselves as disabled. One label for all participants does not capture the nuances of disability and recognise individuals. But appropriate people-centred training, disability awareness, and foresight and compassion for sensitive topics is essenti al and should accompany the toolkit in this thesis.

7.6 Research Limitations

Further reflection on this research project reveals certain limitations for consideration. Many choices were made in research planning to match the exploratory and people -centred nature of the topic. The results are reflective of who was involved and what areas of research were covered. It is recommended that inclusion training and community engagement accompany this toolkit to facilitate empathy building and disability awareness. Disability terminology and ideas around inclusion will, no doubt, need updati ng in the future as social values continue to evolve.

Due to the need for purposive sampling and in -depth qualitative data collection, sample sizes in each data collection phase were relatively small. A range of ages were included, as well as variations amongst types of upper limb impairment, and users identifying as men and women were represented. The research participants were primarily recruited from the US and UK, so the results may reflect specific cultural expectations and communication styles in reference to disability. Future research with more participants, along with more areas of diversity, can increase the scope of inclusion.

A choice was made to illustrate tops in the *Sportswear Inclusion Map*, to maintain cohesion and to narrow a complex area of research. Participants were asked about and discussed sportswear bottoms as well -- leggings, shorts, and trousers were all mentioned. Observations were also made about footwear, accessories (gloves and hats), and exercise equipment. Many suggestions overlapped with needs in tops, such as displeasure with tight fits, drawstrings, and certain zippers. Considerations of grip, reach, fit, and one -handed dressing also overlapped. So, the tools and participatory approach can be applied to other types of sportswear apparel, accessories, and equipment.

As previously noted, the virtual data collection methods enabled participants to take part from many areas of the US and UK. It also meant that the research was able to continue throughout the pandemic, and the researcher's accessibility needs were met. This virtual format also meant, however, that participants were limited to those who had internet access and were familiar with online conferencing platforms. Additions of in-person ideation workshops for adaptive and inclusive sportswear could prove insightful for future work. Sportswear companies or researchers could team with rehabilitation or adaptive sports centres and use the toolkit output of this study as a reference point.

Due to the timeline of this research and the need for extensive community exploration to craft the tools, it was not possible to test the toolkit within an industry application beyond stakeholder feedback. Ideally, the tools can be applied and evaluated within a new product development initiative for mainstream sportswear inclusion of people with an upper limb impairment or difference. Full recommendations for future research opportunities are provided in the final chapter of this thesis.

7.7 Conclusion

The implications of this research output and the experiential learnings have, thus, been outlined for adaptive apparel literature and research, for sportswear industry practice, and for the broader scope of disability awareness and inclusion. Redefining functional apparel design classifications may help to blur the distinction between sportswear and adaptive apparel. When exploring adaptive or inclusive apparel design, the toolkit from chapter six could guide researchers to further explore the scope of target users and strategic design options for inclusion. And, the thesis results are meant to challenge potential industry hesitations over redefining a mainstream audience and to give guidance for proceeding towards achievable inclusion.

This, in turn, may help redefine the "norm" on a larger scale within society as more diversity is represented by mainstream brands. As documented, virtual methods and an exploratory, participatory approach exposed the researcher to multiple perspectives on disability and varied routes for inclusion. These insights are reflected within the tools themselves and recommended for application within future inclusion work. The next and final chapter summarises the full research project and explicates original contributions to knowledge.

Chapter 8: Conclusion

As disability has been marginalised and misrepresented from the mainstream sportswear industry for some time, cycles of design exclusion have emerged (Holmes, 2018). While well-intentioned and ready to address inclusion, designers may, nonetheless, be new to considering disability within industry practice. Thus, the toolkit output and research results of this study offer pragmatic guidance to challenge existing barriers of exclusion and to move towards mainstream disability inclusion within sportswear.

This final chapter overviews conclusions from this research in its entirety, as well as speculations on impact for the future. A summary of the research journey and the key results will be compared back to the overall research aim and objectives from section 1.7. The research questions will be addressed, and the original contribution to knowledge will be outlined. Lastly, recommendations for future research opportunities related to this work will be explored.

8.1 Revisiting the Research Framework

As concluded in the previous chapter, the main learnings and pragmatic outputs from this project stem from the participatory, exploratory methodology. Identified as an underexplored area of research – adaptive and inclusive sportswear with a particular focus on consumers with an upper limb impairment or difference – an inductive approach was appropriate. Whereas the project began with a sole vision of adaptive sportswear for this consumer group, the multidisciplinary literature review and iterative community engagement revealed a broader and more nuanced spectrum of strategies for inclusion.

This project encompassed literature, methods, and findings relevant to both industry practice and academic research. The social model lens and participatory design mindset suited the inductive, user-led approach. Throughout the research journey, primary research methods and strategies for recruitment constantly evolved in reaction to participant engagement and feedback. This adaptability was challenging for the researcher, at times, in terms of planning and forecasting future research needs – but it was also essential. Designing *with* users, rather than *for* users, means the researcher and participants both have influence over direction and outcomes (Sanders, 2002; McCann, 2016; Holmes, 2018). The benefit is a final output that has been heavily influenced by the participants within a practice-informed framework.

8.2 Meeting the Research Aims and Objectives

The research framework and journey served to meet the research aim and objectives. As introduced, the aims of the study were: 1.) to develop tools to guide sportswear designers in understanding the scope and needs of consumers with an upper limb impairment or difference, and 2.) to contextualise this guidance within the practices of sportswear industry design, adaptive and inclusive apparel, and disability inclusion. The research objectives were:

1. To establish a relevant multidisciplinary research framework within the context of the social model of disability, apparel industry practice, and participatory design research;
2. To conduct a critical literature and practice review of functional apparel design, adaptive apparel design, sportswear design, and inclusive design ;
3. To identify potential gaps in awareness between sportswear industry practice and the user community;
4. To iteratively engage stakeholders in an exploration of the perceptions of, barriers to, and solutions for sportswear design for people with an upper limb imp airment or difference;
5. To distil findings into pragmatic guidance for sportswear design inclusion, evaluate with stakeholders, and refine results based on feedback.

Research objective one was to establish a relevant multidisciplinary research framework within the context of the social model of disability, apparel industry practice, and participatory design research. This was met by exploring and specifying the contextual framework for this project. The introduction chapter covered the mainstream apparel market space and gap of adaptive and in clusive sportswear. Throughout the research, adaptive and inclusive apparel brands were tracked through Google searches, social media networking, trade show visits, and news articles. While the number of SMEs and big br ands selling adaptive apparel increased throughout the course of this research, it is still considered a niche and limited market at the time of finishing this dissertation. Through readings on disability studies, the social model of disability was identif ied and applied to this research as a lens to challenge constructed barriers to equal participation through design. Disabled consumers are often excluded, in part, from traditional sportswear design and apparel industry practices, which limits access to and choice of apparel options. This exclusion appears to stem from and perpetuate apparel, industry, and social-related barriers. Participatory design approaches that related to pragmatic design practice inspired

a research exploration that took direction from the disability community and stakeholder insights.

The practice and literature reviews in chapters two and three align with research objective two (conduct a critical literature and practice review of functional apparel design, adaptive apparel design, sportswear design, and inclusive design). As noted, literature on functional apparel design classifies sportswear and adaptive apparel as two distinct categories (Gupta, 2011b; Watkins and Dunne, 2015). These often emphasise a user-centred design process, which works to gather in-depth and multidisciplinary user research. The FEA Model, however, reminds designers that functional apparel must consider the culture, expressive needs, and aesthetic needs of the target user in addition to functional needs (Lamb and Kallal, 1992). Areas of inclusive design and participatory design offer strategies for user collaboration, which can help to challenge industry or social-related barriers (perceptions) pertaining to marginalised consumers (Holmes, 2018).

Considering a more physically diverse population may seem at odds with traditional apparel industry practices of mass manufacturing, quick timelines, and forecasting based on previous seasons (which may not have included disabled consumers) (Press and Cooper, 2003; Mpampa, Azariadis, and Sapidis, 2009; Carroll, 2010b; Taylor and Timmons, 2015). Selected research has been done on assessing and prototyping sportswear for neglected consumers (McCann, 2016; Bragança *et al*., 2018) using both co-design and UCD methods. The results are sportswear design suggestions for the "active aging" and wheelchair rugby players, as well as a call for more collaborative design research in these areas. Carroll and Kincade (2007) investigate universal design for apparel, which they conclude may be feasible for industry production. In this case, however, office attire has a different purpose, design features, and function than sportswear. McBee-Black (2021, 2022) and Paganelli (2021) offer suggestions on apparel manufacturing options for consumers with greater body diversity. Carroll and Kincade (2007), McBee-Black (2021), and Paganelli (2021) all, however, note that ableist bias or misunderstanding of disabled consumers within the apparel industry may inhibit inclusion of this consumer group. Guidance for mainstream sportswear industry design for consumers with an upper limb impairment or difference was found lacking from the literature.

From the above contextual exploration and practice and literature reviews, iterative and participatory data collection was premised around research objective three (identify potential gaps in awareness between sportswear industry practice and the user community). First, exploratory stakeholder interviews were conducted with data grouped between user participants and industry participants. Each stakeholder was asked about

views towards sportswear for people with an upper limb impairment, speculated needs, and best practices to achieve these results. Community engagement (social media, email correspondence, and disability events) and user design workshops yielded findings relative to the above points. These phases of data collection, data analysis, and mapping of interactions and results met research objective four (iteratively engage stakeholders in an exploration of the perceptions of, barriers to, and solutions for sportswear design for people with an upper limb impairment or difference). Findings were then distilled into pragmatic guidance for sportswear design inclusion and evaluated with stakeholders, and the results were refined based on feedback (research objective five).

Thus, part one of the overall research aim was fulfilled. Part two was concluded through a reflection on how the tools differ from or build on previous publications on inclusive design toolkits, adaptive apparel research, and sportswear industry practice. This was discussed in the previous two chapters, along with commentary on the broader implications of the findings and of the research journey on disability inclusion. The methodological approach and research framework contributed to the aims in the following manners:

- Participatory design - Stakeholder perspectives and experiences shaped the research direction and final output.
- Practice-informed research - Project development, data collection and analysis methods, and the final output remained relevant to industry needs.
- Social model of disability - Apparel, industry, and social-related barriers to disability inclusion were identified.
- Participant-led insights - The final output focuses on user needs and values.

8.3 Research Questions, Part 1: Understanding and Addressing Barriers

In meeting the research aim and objectives, the research questions were addressed. Referring back to section 1.6, the first set of research questions were:

a) What are the barriers to sportswear design inclusion for this consumer group?
b) What guidance is needed for industry designers to realise and overcome these barriers?

In line with the social model of disability, a multifaceted collection of barriers to sportswear inclusion for this consumer group emerged from the research. First, from the user interviews, workshops, and feedback questionnaire, apparel-related barriers were

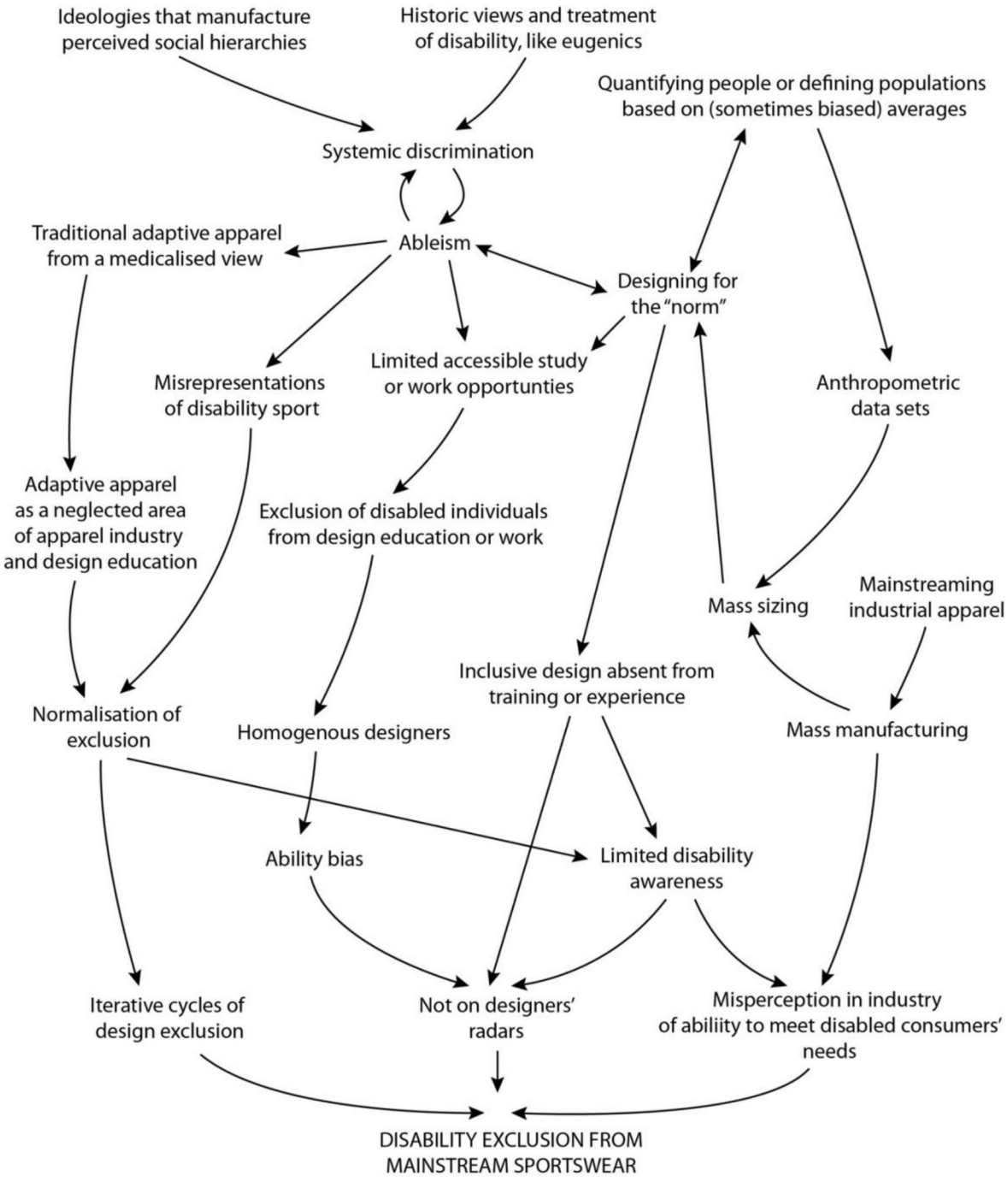
indicated. These include areas that contradict users' needs, values, or functional requirements. Barriers found were:

- Price point that is higher for adaptive apparel
- Standard sizing that does not account for variations in body shape
- Adaptations that require asking someone else for help or going to a tailor
- Donning/doffing that requires two hands, strong grip, or dexterity
- Placement of pockets that is inconvenient to reach
- Adaptive wear that is unfashionable or is limited in choice
- Fastenings, like zippers or buttons, that are too fiddly
- Access points or fabric (tight or rigid) that is not convenient for donning/doffing
- Restrictive cuffs or rigid sleeves
- Fabric or fit that interferes with external equipment, like a prosthetic or wheelch air
- Accessible trims, magnets or Velcro, that do not function properly

Other industry or social-related barriers were identified in the literature and practice reviews. Figure 8.1 maps a network of these interrelated barriers. It was inspired by Cheng's (2017) Lambda World Cádiz keynote presentation on category theory applied in life to think about the world around us. Category theory, she explains, is an abstract area of mathematics that deals, logically, with how things work. She uses category theory to illustrate the context of a phenomenon by mapping the contributing factors upwards by continually asking "why" at each point.

The following map was generated from Cheng's example. By starting with the base problem of design exclusion of people with an upper limb impairment, stratified reasons were speculated upwards through a system of potential causes. Some reasons for this exclusion, as noted in previous chapters , can be attributed to embedded ableism, inaccurate media portrayals of disabled athletes, older medicalised views of adaptive apparel, traditional apparel industry practices (such as mass manufacturing and anthropomorphic data sets for sizing) that exclude diverse bodies, and apparel design training that does not consider disability (Watkins, 1995; Lamb, 2001; Mpampa, Azariadis, and Sapidis, 2009; Carroll, 2010b; Berger and Lorenz, 2015; Holmes, 2018; Barry, 2020; Martínez-Bello *et al*., 2021).

Fig. 8.1 - Industry and Social-related Barriers to Disability Inclusion in Mainstream Sportswear Industry Design



Many of these barriers were echoed in the primary research findings, appearing in the results of the industry stakeholder interviews and feedback sessions. Some sportswear designers, for example, were unsure of the scope of consumers who might wear adaptiv e or inclusive apparel. This is understandable within the scope of the above barriers map that shows inclusive design may not have been commonly taught or applied in education or in industry practice, for multiple reasons. Potential reluctance on the part of those making the

business decisions within a sportswear company was suggested as a limiting factor to addressing mainstream disability inclusion – if forecasting or manufacturing costs were unknown. Perhaps one reason for this potential reluctance comes from a reliance on forecasting or sales knowledge based on proven successes of past seasons. These past seasons, however, may be based on apparel collections exclusive of disabled consumers. Thus, a cycle of exclusion perpetuates.

As noted, support for this area of research was high amongst the sportswear industry designers who participated. There was also a surprise observed at the scope of the exclusion around this consumer group, as well as an uncertainty of how to gauge, reach, and serve this community within the mainstream sportswear industry. Primary research revealed that while the sportswear designers were supportive of this topic and skilled in people-centred functional apparel research, guidance was needed on:

- Who this consumer group is;
- Where to reach them;
- How to support them within mainstream sportswear.

Tools that focus on the scope, complexity, and context of this consumer group were revealed as relevant, in the first instance, to building greater awareness. There was an indicated need of guidance for reaching individuals (consumers) who could use and inform this type of sportswear design. And practical strategies for designing sportswear that balance user needs and values with industry practice were also deemed necessary. As presented in chapter six, the tools developed within this research project were designed and reviewed accordingly. The *User Context Wheel and Statistics* highlights the scope and complexity of consumers with an upper limb impairment or difference. The *User Network* provides a route to reach diverse members of this community in order to learn further about the context of disability sport and sportswear design needs. The *Sportswear Inclusion Map* identifies a spectrum of options to design and develop sportswear for disabilit y inclusion within industry parameters. The *Sportswear Design Needs Wheel* and *Sportswear Design Detail Pages* pinpoint specific apparel-related needs and values to provide a focus for ideation of adaptive and inclusive sportswear. And finally, the participatory design approach taken in this research may assist industry designers in identifying and challenging bar riers to effective mainstream inclusion, which leads to the second set of research questions.

8.4 Research Questions, Part 2: Relevance and Application of Participatory Design

Also from section 1.6, the second set of research questions were:

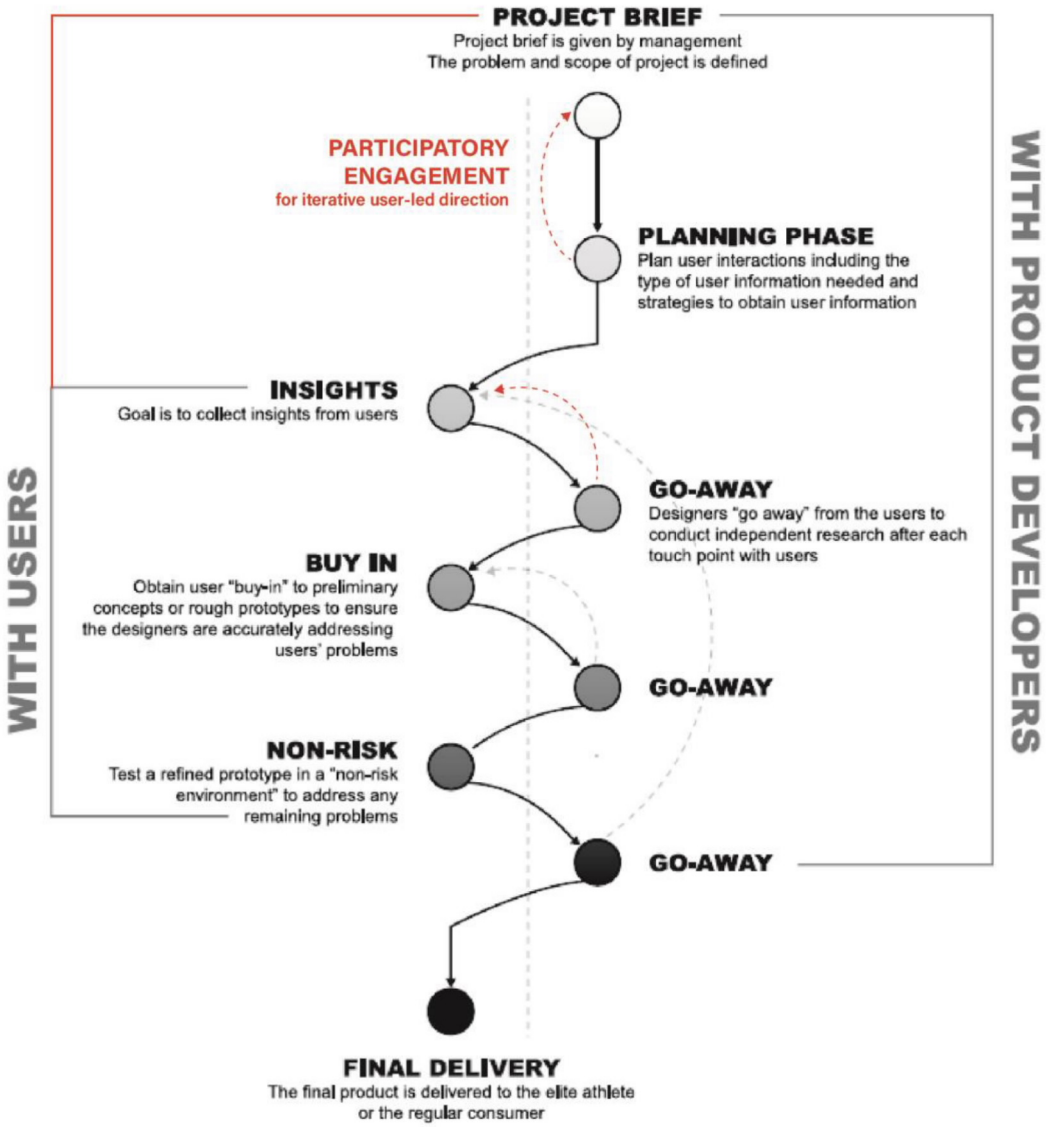
a) How can participatory design contribute to sportswear design for individuals with an upper limb impairment or difference?
b) What guidance is needed for industry designers to adopt a participatory design component to their practice?

As evidenced in the literature and practice review, participatory design can be an empowering and informative approach when designing with communities that have been chronically marginalised (Demirbilek and Demirkan, 2004; Moffatt *et al.*, 2004; Kidd, 2006; Ehn, Nilsson, and Topgaard, 2014; Sanders and Stappers, 2014; McCann, 2016). The non-hierarchical, collaborative mindset can aid in overcoming potential industry bias by giving voice to those who have been underrepresented (Holmes, 2018). As Shakespeare (2018) writes, valuing expertise by experience "closely accords with the key disability movement slogan of 'nothing about us without us'" (p. 160). Within this study, the participatory design methodology allowed for research direction to follow stakeholder, and particularly user, insights and needs.

In the first three chapters, it was established that adaptive and inclusive sportswear is limited both from the market and in design research, so an exploratory and user-led approach was appropriate. As previously stated, the researcher had solely envisioned adaptive sportswear when the project launched and only understood a wider concept of sportswear inclusion through stakeholder engagement. Options of inclusive, adjustable, and mass customised sportswear to reach a wider consumer base with greater body diversity became apparent. The scope of this consumer group also was evidently larger than previously understood by the researcher -- the description of "upper limb impairment" had first been used until "limb differences" was added after one particular user interview. The recruitment parameters were expanded during the workshop phase when wheelchair users self-identified within the project scope. Design details for more suitable sportswear were learned from participants' contributions, and values became known through the user workshops. Also, lived experiences of users' own problem solving and design innovation proved highly valuable knowledge. As noted, one interviewee described his realisation, during a flight, that seatbelt material may be better at securing his arm in place during sport than his provided brace. He then went through the process of crafting a mock-up and testing in-action.

In-depth user research for new knowledge acquisition is commonplace in high -performance or technical sportswear design, as reported by Morris and Ashdown (2018). As they found, however, new product development in sportswear sometimes relies on designers' past experiences or does not involve users at all phases of the design process. With Holmes' (2018) notion of unintentional ability bias, this could pose challenges if designers are new to disability inclusion. So, an update to the approach for user research may be beneficial. Referring back to Figure 2.5 in section 2.3, Morris and Ashdown's *Procedural diagram of product developers' interactions with users*, the user engagement begins after a project is already briefed and planned. Initiating user interaction earlier to guide the project brief and planning phase may be effective when designing for marginalised groups.

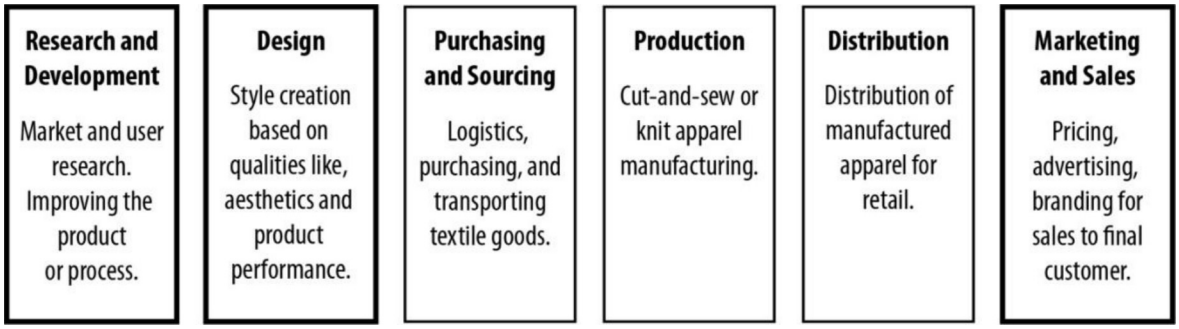
Fig. 8.2 - Modified Procedural Diagram of Product Developers' Interactions with Users. Adapted from Morris and Ashdown © 2018, reprinted by permission of Informa UK Limited, trading as Taylor & Francis Group, http://www.tandfonline.com.



Following learnings from this research journey, early participatory engagement with the disability community could precipitate user-led direction of the project's problem scope. User collaboration during the planning phase could provide an insider perspective on what type of information is needed. Thus, Figure 8.2 shows a proposed modification to Morris and Ashdown's (2018) procedural diagram. Ideally, there would also be more touch-points with users along the development journey so there is more reliance on user direction. Hobbs-Murphy, Morris, and Park (2022) also support increased consumer touch points in the adaptive apparel design process.

Reflecting this proposed early-stage and iterative participatory intervention, the *Stages in the Apparel Industry Process* diagram (Figure 1.1 from section 1.8) appears below, updated as Figure 8.3. Stages appearing in bolded boxes may benefit from applying a participatory exploration, along with this research output, for broader apparel industry inclusion. Much project definition and scoping is done, for instance, with research and development. Insights might also be explored on expanded retail channels to consider, such as physiotherapy centres. Marketing and sales, as previously suggested, could apply user-led direction for an inclusive strategy. Thus, the approach and output of this study are recommended for intervention beyond just the role of design.

Fig. 8.3 – Stages in the Apparel Industry Process with Opportunities for Participatory Exploration.



The sportswear designers interviewed for this study were familiar with practising extensive user research for new product development. But there was also a general uncertainty, as has been mentioned, of where to reach these consumers, who these consumers are, and how to accommodate diverse physical needs within an industry context. From the industry interview results described in section 5.1.2.3, it was found that greater awareness around the scope and complexity of potential disabled consumers was needed if entering the adaptive or inclusive sportswear market. This was corroborated by the final industry feedback, as outlined in section 6.2.3. Again, there appear opportunities for greater user

partnership and deeper contextual learning within traditional sportswear industry practice around disability inclusion.

The original tools presented in chapter six are designed, in part, to guide participatory user engagement. In particular, the *User Network* is a roadmap to reach members of this complex user group, as well as to understand the ecosystem of stakeholders surrounding the target community. The *User Context Wheel* shows a scope of potential users to include in potential collaborations. Finally, the *Sportswear Design Needs Wheel* and *Sportswear Design Detail Pages* provide directional topics for a collaborative user needs and values exploration.

8.5 Contributions to Knowledge

Original contributions to knowledge come from the research journey, the participatory exploration, and the development of the Sportswear Design Disability Inclusion Toolkit. The knowledge pertains to:

1. New tools for the sportswear design community to gain greater contextual awareness, routes for meaningful collaboration, and multifaceted design approaches to disability inclusion;
2. Identification of barriers related to sportswear design for inclusion of individuals with an upper limb impairment or difference;
3. Awareness of specific functional and value-driven preferences in adaptive or inclusive sportswear for individuals with an upper limb impairment or difference;
4. Reflections on participatory and virtual engagement with the disability community, and disabled researchers, within adaptive apparel and design research practice.

The first point refers to the toolkit from chapter six. This toolkit is original, based on the findings and participatory experience of this study. As a practice-informed output, it can fit within existing models and methods of inclusive design, participatory design, and functional apparel design. The new tools are intended to support sportswear industry designers in realising greater contextual awareness, routes for meaningful collaboration, and multifaceted design approaches to disability inclusion . Adaptive sportswear might consist of expanding a sense of the “normal”’ mainstream sportswear consumer and a collaborative approach for greater representation. The toolkit can also be used by apparel design researchers, students, and instructors -- applied to sportswear or a broader scope of disability inclusion.

The second item was explicated above in answer to the first set of research questions. Identifying multifaceted barriers to sportswear inclusion is in line with the social model of disability. A system of industry and social-related barriers was mapped above in Figure 8.1. And apparel-related barriers, as listed in section 8.3, appeared throughout the primary research findings. Some of these identified barriers support findings in previous literature on adaptive apparel, such as fiddly closure function and reach required for donning and doffing (Watkins and Dunne, 2015). Other identified apparel-related barriers in sportswear appear new to this study: restrictive cuffs; magnets or Velcro that do not function properly; and adaptations that require asking someone else for help. So, by involving this specific community with a focus on sportswear, an expanded and more targeted list of design barriers emerged.

In reference to the third point, the user interviews, workshops, and feedback findings revealed some optimal design considerations to make sportswear more inclusive of or adaptive for this consumer group. Collaborative and innovative idea generation is needed to move sportswear inclusion forward. From the findings, considerations include:

- Accessible trims and fastenings that stay closed, require less grip, and can be used with one hand
- Slick texture inside garment
- Well-placed, sizable pockets
- Tops that open at the front or are loose enough to pull over-head
- Sleeves that can be rolled up and secured in place
- Sleeves that can be removed or detached at certain lengths
- Custom sleeve lengths, measurements, and fabrics
- Built-in or removable loops for dressing
- Ability to make self-adjustments or modifications (independence, individuality, and not having to make a special request for adjustments)
- Inclusion by big brands and mainstream aesthetics (not obviously adaptive looking)
- More varied fits for greater physical diversity
- Reasonable cost

As with the identified barriers, some of these items support what was found in the literature on adaptive apparel: accessible fastenings; a focus on aesthetics; and removable or adjustable sleeves (Lamb and Kallal, 1992; Watkins and Dunne, 2015; Bragança *et al*., 2018; McBee-Black, 2022). Other items are new, such as rollable sleeves on jackets and the value in being able to make self-modifications. Strategically-placed loops for dressing and functional pocket considerations specific to sportswear are underexplored details as

well. Finally, mass customised options for sleeve lengths and fabrics, or for zipper or closure options, is an intriguing and emergent notion. Manufacturing capabilities and costs can be explored further. Overall, findings lead to a more holistic picture of needs, values, and solutions for this consumer group, specific to mainstream sportswear.

Finally, the last item is addressed through the second set of research questions and the overall research journey. Many functional apparel design processes apply a user-centred design approach for systematic and in-depth user research (Gupta, 2011a; Watkins and Dunne, 2015; Morris and Ashdown, 2018). This established practice ensures a multidisciplinary assessment of complex user needs and solutions. Lamb and Kallal (1992) further recommend identifying (functional, expressive, aesthetic) needs *with* users at the start of a design process to give them more control over the outcomes. McCann (2016), as well, encourages co-design innovation in a sportswear initiative for age-related consumer marginalisation. For her, this supported empowerment of an excluded group.

From the iterative and participatory exploration with multiple stakeholders in this study, it appears more user collaboration could be impactful in setting a design brief, in the first instance, for disability inclusion. This could facilitate a more meaningful and user-led sportswear new product development inclusive of consumers with an upper limb impairment or difference. A deeper understanding of this scope of consumers, specific contextual awareness, and an expanded vision of the mainstream could benefit from early participant collaboration. Virtual methods, such as online collaborative design ideation brainstorming, could assist in reaching more disabled consumers for a broader impact. More methods for virtual, or hybrid, design research collaboration and knowledge sharing may also allow for better inclusion of disabled researchers. This will be expanded upon below in the following section.

8.6 Future Recommendations

It is hoped that the above contributions to knowledge can spur further discussions and research opportunities around adaptive apparel and disability inclusion. Certain suggestions from the stakeholders and user community that were engaged during the study fell outside the scope of the research aim but indicate intriguing ideas for future recommendations. Effective inclusive marketing strategies, for instance, were requested by some of the sportswear designers. This was indicated in the user feedback form as well.

Some marketing insights did appear during the user interviews and workshops, suggesting a participatory research methodology and user-led exploration may help facilitate future

research in this area. In terms of representation, one interviewee from the user group commented that, even within the realm of upper limb impairment and differences, everyone's experience is unique. During the user workshops, one participant suggested that marketing to wheelchair users should include showing images of the clothing for sale actually on a model who is a wheelchair user. One participant who gave user feedback on the *Sportswear Inclusion Map* wrote: "make something that is easy for all instead of custom for individuals but would need to be marketed to those who would appreciate and recognize the difference and the need". As noted in the findings, other participants preferred the adaptive, adjustable, or mass customisable options.

Some questions around marketing were raised with the criticism of Nike's GO FlyEase launch (Virdi and Jackson, 2021), mentioned in section 7.3. Questions arose around: Who is this shoe for, and who does it benefit? Why is it marketed as universal design and not adaptive design, and how was this choice received on a larger scale within the disability community? Why is disability not mentioned in the product description, and should it be? More collaboration with the disability community, specifically focused on marketing and representation, is needed.

As noted in the limitations section 7.6, although the *Sportswear Inclusion Map* shows tops, other types of sportswear can benefit from the toolkit. Sportswear bottoms, footwear, gloves, hats, and various exercise equipment all appeared in user interviews and workshops as areas that need to be reworked for better disability inclusion. This suggests that more inclusive design, participatory design, and disability awareness can be incorporated into several areas of the sporting goods industry.

Similarly, other areas of fashion and apparel design could benefit from this research approach. During the feedback sessions, one stakeholder mentioned that these types of design tools could relate to other areas of apparel design exclusion or body diversity. He also linked the research to emerging ideas of clothing design for health. Many user interview and workshop participants also mentioned other types of apparel. Jeans, bras, and button-up shirts were discussed for apparel-related barriers, which can be addressed further with this type of research methodology and toolkit output.

As noted, some participants commented on the cost of adaptive apparel or sportswear. Relative to this dissertation, adaptive sportswear should not cost more than similar mainstream counterparts. Beyond this thesis' scope, access to and availability of low cost adaptive apparel is an area for further exploration. This is particularly critical considering

the extra health and medical expenses some may face or social barriers that may limit employment (Shakespeare, 2018; Chae, 2022).

Further application or expansion of the toolkit relating to design for disability inclusion, on a broad level beyond apparel design, is recommended. As noted, one disability innovation designer who gave stakeholder feedback mentioned that colleagues had asked for a potential participant map similar to the *User Network*. An inclusive designer, as well, indicated that they are often asked by researchers for help locating participants. So, a map for this purpose may benefit more areas of disability and inclusion research.

The development of the tools and this line of research provides an intriguing opportunity for sportswear, or apparel, inclusion of other areas of physical disability. As mentioned, a few of the workshop participants were wheelchair users. Apparel-related barriers, needs, and values relating to lower limb impairment, spinal cord injury, and wheelchair use emerged from these discussions. Temperature regulation and access to a catheter, for instance, were indicated. One participant also wondered if his personal assistant would have a different opinion on what would make dressing easier. A research focus on mainstream sportswear specifically for wheelchair users could build off this study's methodology and output. Many other areas of disability inclusion within mainstream sportswear also need investigating. Individuals with visual impairment, dwarfism, or sensory sensitivities, for instance, could be involved in exploratory research. A question is then pondered: can mainstream sportswear be truly universal, or are many areas of adaptive apparel needed?

Further investigations on sustainability, pricing, manufacturing, distribution, and sales are also recommended. Still, the toolkit can provide direction for consumer scoping and ideas for mass manufacturing for seemingly diverse needs. While working within industry parameters, mass customisation and adjustability options, could also support disability inclusion by allowing consumers more autonomy over their own preferences and independence in dressing. More research is needed here. Additional case studies (like McBee-Black 2021, 2022 and McBee-Black and Ha-Brookshire, 2022) on successful adjustable, mass customisable, adaptive, and inclusive apparel design initiatives from a range of brands could offer insights on design, development, and manufacturing in this area.

Previously speculated in section 7.2, training apparel design students to be more inclusive-minded when entering industry is essential to mainstreaming disability inclusion. As mentioned, Barry (2020) notes there is still a need for more inclusive thinking within fashion design education. Testing the sportswear design inclusion tools from this study for

relevance and effectiveness in fashion design pedagogy is, therefore, recommended for future research.

As previously mentioned, Kabel (2019) suggests that more involvement of disabled designers within design teams can enhance representation. This means that design education, design workplaces, and design research must be inclusive of and accessible for disabled students, workers, and researchers. As noted, Grue (2021) writes that continuously asking and pushing for accommodations can be exhausting. It also creates an unbalanced workload in comparison to non-disabled peers or colleagues. More research on what disability inclusion means within academic practice and the design industry is needed. Areas of focus can be inclusive research and design methods, workspaces, and networking and knowledge sharing platforms. Further development of virtual garment technology and research methods could offer greater access to some disabled designers or researchers, in addition to including more consumers.

8.7 Conclusion

In the 2021 ITAA conference proceedings, McBee-Black *et al*. (2021) comment on the notable expansion of adaptive apparel scholarship and marketplace offerings in the previous 5 years. They state:

> *The apparel industry's increased interest and the increasing impact of PWD on the consumer marketplace suggest that adaptive apparel is emerging as a formidable addition to the apparel marketplace for many apparel brands and retailers. The PWD consumer is poised for significant contributions from both apparel brands and apparel scholars. Additional research is warranted as the adaptive apparel marketplace increases. Adaptive apparel scholarship could serve as a conduit of information and guidance for the adaptive apparel brands and retailers who are either expanding or entering the adaptive marketplace.* (p. 2)

Indeed, as evidenced in the introduction, practice review, and literature review, enhancing disability inclusion within the apparel industry has become a priority amongst select scholars and brands.

Still, even with increased interest from consumers, designers, and researchers, disability inclusion within the mainstream apparel industry remains limited (Leonard Cheshire, 2019; Foster, 2021; McBee-Black *et al*., 2021; Paganelli, 2021; Esmail *et al*., 2022). Apparel, industry, and social-related barriers perpetuate exclusion of disabled consumers. Additional

knowledge exchange and awareness between apparel designers and disabled consumers remain needed.

Mainstream sportswear design inclusion means widening the perception of who a mainstream consumer is -- envisioning a more representative scale of diversity. Within this study, engaging multidisciplinary stakeholders, experienced sportswear industry design ers, and (most crucially) sportswear consumers with an upper limb impairment or difference, inclusion strategies have emerged. The tools presented here serve to broaden the scope of who is excluded, show a route to find meaningful collaborators, and offer a spectrum of design strategies for sportswear inclusion. They also indicate which aspects of sportswear might pose barriers to some consumers, such as inaccessible fastenings or pocket placement, so specific solutions can be generated. Values of choice in styles, mainstream aesthetics, and ability to self-modify are indicated. It is hoped that these outputs can be expanded and updated as thinking and methods around disability inclusion and design research continue to progress.

Through a participatory approach and a social model of disability lens, the tools are built on user-led insights of barriers to and needs for sportswear inclusion. As practice-informed design research, the tools are targeted to match the needs of the sportswear industry in better understanding and reaching excluded disabled consumers. This research journey highlighted the importance of an iterative participatory exploration with a marginalised community to realise the potential scope and impact of exclusion before beginning a design initiative. Needs, values, meanings, and strategies for inclusion emerged from the research participants' perspectives. In conjunction with early user collaboration, sportswear designers may be particularly well-placed to realise and meet the needs of disabled consumers. Their specific training and skills around functional apparel design, in-depth user research, and biomechanics considerations match elements required for adaptive apparel design. But, again, the first steps are guidance on disability awarenes s and connecting with the excluded communities, such as shown in this study's results.

Corporate willingness to understand, represent, and include disabled consumers meaningfully is, of course, a barrier. It is this researcher's hope that the current expa nsion, at whatever pace, of the adaptive and inclusive market will further propel broader industry inclusion. Multiple design strategies, like adaptive, inclusive, adjustable, or mass customised sportswear, along with a wide scope of potential consumers, s uggest that mainstream disability inclusion can meet both consumer and industry needs. Big brand launches of adaptive apparel and universal design could spur potential growth in this area. For broader inclusion, it is critical that more disabled people are represented through

apparel offerings, in marketing campaigns, and within design processes themselves. More research is needed in these areas to shift the notion of who is considered and shown to be "mainstream." Finally, along these lines, virtual, hybrid, and alternative methods for design research can be further explored to enhance inclusion. More research and design collaboration with and leadership from the disability community is warranted.

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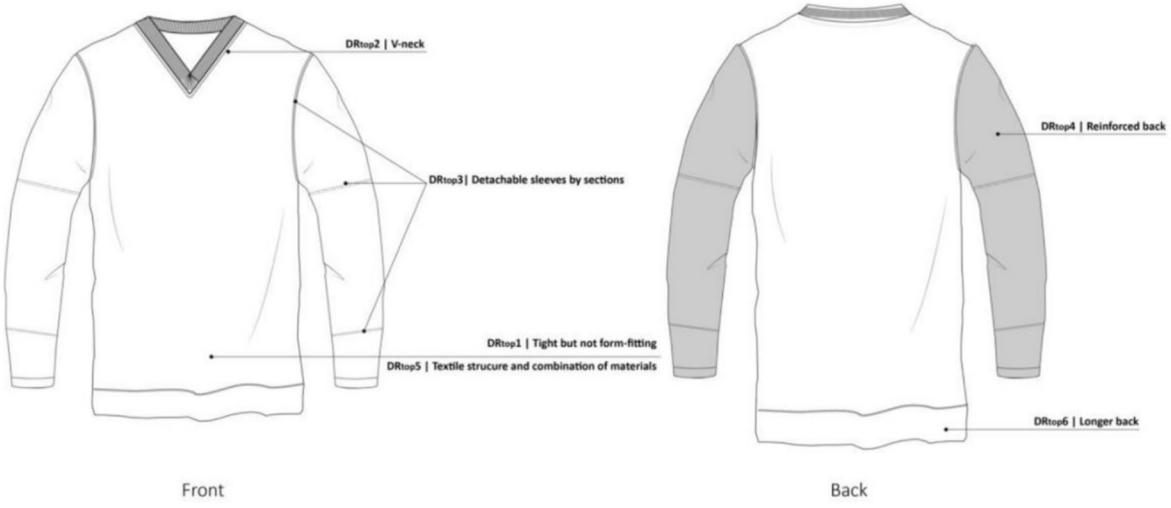
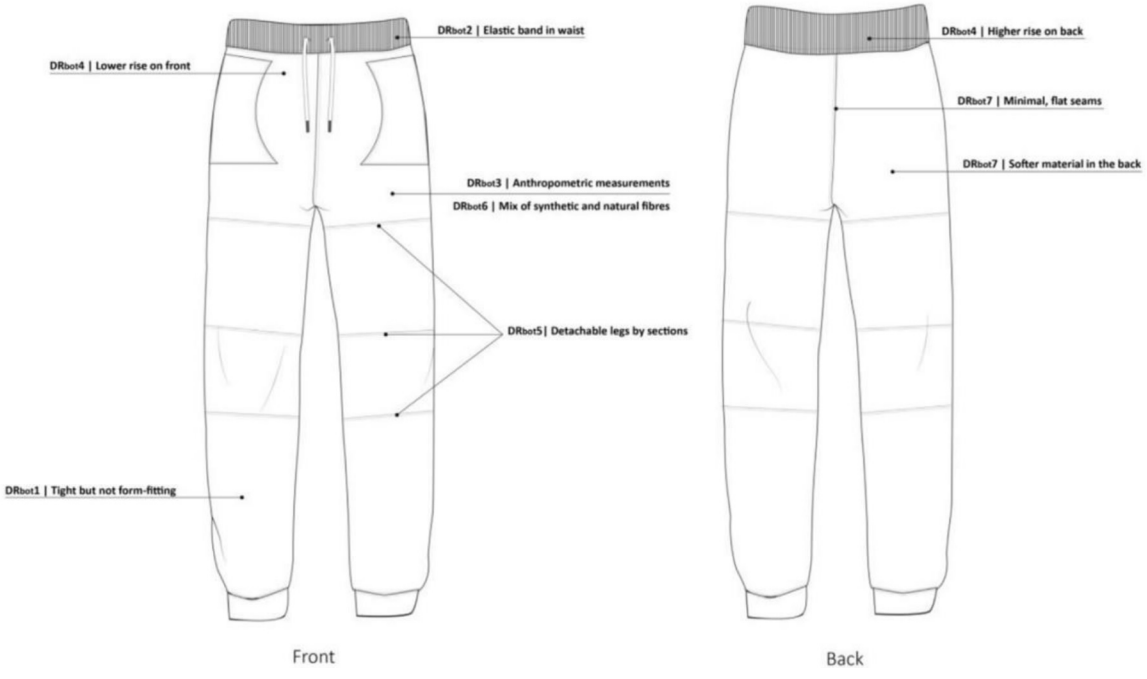
Appendices

Appendix A: *Wheelchair rugby apparel design recommendations from Bragança et al. (2018)*

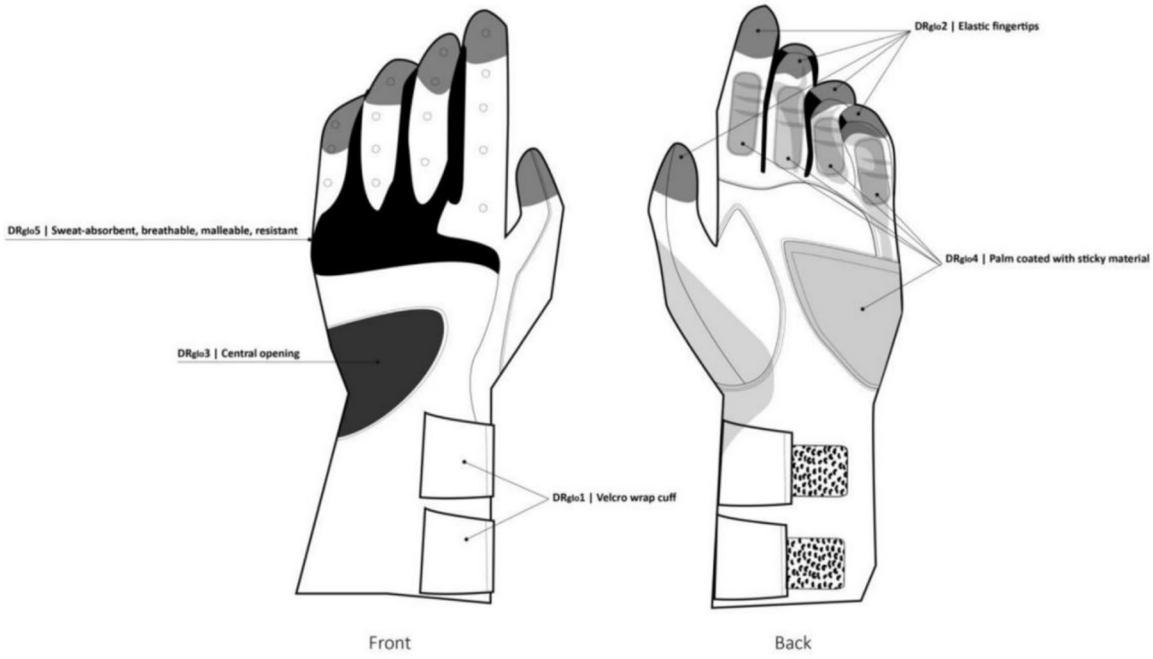
Summary and visual representation of the design recommendations for the tops (Fig. 6, p. 16) © 2018, reprinted by permission of Elsevier.



Summary and visual representation of the design recommendations for the bottoms (Fig. 7, p. 18) © 2018, reprinted by permission of Elsevier.



Summary and visual representation of the design recommendations for the gloves (Fig. 8, p. 20) © 2018, reprinted by permission of Elsevier.



Appendix B: *Interviews topic guides*

User group

Study description:

I'm looking at the process of designing sportswear or athletic wear that specifically suits people with an upper limb impairment. I won't be actually designing the sportswear pieces; I'm gathering research on what people want in sportswear and how designers and other professionals can best work in collaboration with the customer to understand what they really want and need in sportswear. I'm particularly interested in your point-of-view as someone who may use this product.

What will happen today?
This will last about 30 minutes. I have a few questions for you, and I will just mostly just sit back and listen to what you have to say. I'm really interested in your experiences and point-of-view. There are no right or wrong answers; just your viewpoints!

Ethics and Results:
I will remind you that we can stop at any time during the interview or skip any questions, just let me know. Any information I get today will be made anonymous, and this data will only be used for this study. I'm going to audio record our discussion (no video recording) so I can later transcribe it and analyse the text to help me get some answers for this study. The final project will be a PhD dissertation that includes recommendations on accessible sportswear design techniques.

Do you have any questions before we get started? Is it ok for me to turn on the recorder?

Questions

1.) Can you please tell me what sports or types of fitness you enjoy?

2.) What types of athletic wear do you prefer?

3.) Can you tell me about some of your recent experiences with athletic wear? (can you think of a negative/positive experience you've had?)

4.) What would you change in athletic wear that would improve your experience?

5.) Have you made any adjustments to your own apparel?

5.) If you were an athletic wear designer, would questions would you ask yourself to find out changes for athletic wear?

6.) What types of professionals have the expertise to create sportswear that would work better for you? (Anyone beyond designers that has good knowledge for this type of product?) Who else?) Challenges?

7.) Did we miss anything important?

End

Thank you for your time.

A reminder that I will be analysing the results from multiple interviews to find key themes to explore further later in my research. Participatory design relies on the contributions of the participants, so I would be very grateful if you are able to provide some feedback on the themes I find. This may not be for another month or two. Anyone who provides feedback at that time will be entered into a drawing for a $35 Amazon voucher. Whether or not you choose to give feedback, which is not mandatory, you are welcome to request to see the transcript and the results. You will be able to remove any data from if decide you don't want it used, but I need to know in a short amount of time as eventually the data from all the interviews will be mixed together so I won't be able to separate it at that point.

Please do reach out if you have any follow-up questions or issues at any time! And I am inform you or later results.

Any final questions?

Industry group

Study description:

I'm looking at the process of designing more accessible sportswear or athletic wear for people with an upper limb impairment. I won't be actually designing the sportswear pieces; I'm gathering research on what people want in sportswear and how designers and other professionals can best work in collaboration with the customer to understand what they really want and need in sportswear. I'm particularly interested in your point-of-view as someone who may use this product.

What will happen today?
This will last about 30 minutes. I have a few questions for you, and I will just mostly just sit back and listen to what you have to say. I'm really interested in your experiences and point-of-view. There are no right or wrong answers; just your viewpoints!

Ethics and Results:
I will remind you that we can stop at any time during the interview or skip any questions, just let me know. Any information I get today will be made anonymous, and this data will only be used for this study. I'm going to audio record our discussion (no video recording) so I can later transcribe it and analyse the text to help me get some answers for this study. The final project will be a PhD dissertation that includes recommendations on accessible sportswear design techniques.

Do you have any questions before we get started? Is it ok for me to turn on the recorder?

Questions

1.) Can you please tell me your most recent job title and a brief description of your experience?

2.) How do you assess what is needed for someone with an upper limb impairment?

3.) Is it customized? Have you come across similarities dealing with hand or arm impairments? Are their solutions you think could be more universal or include many with similar impairment?

4.) Can you think of ways these patterns and solutions could be incorporated into sportswear?

5.) Who would you want to collaborate with to design sportswear for someone with a mobility restriction in the arms or hands? Probe: Why/What would they? Who else?

6. Can you think of any challenges of these different people collaborating together? Benefits? What else?

7.) Did we miss anything important?

End

Thank you for your time.

A reminder that I will be analysing the results from multiple interviews to find key themes to explore further later in my research. Participatory design relies on the contributions of the participants, so I would be very grateful if you are able to provide some feedback on the themes I find. This may not be for another month or two. Anyone who provides feedback at that time will be entered into a drawing for a $35 Amazon voucher. Whether or not you choose to give feedback, which is not mandatory, you are welcome to request to see the transcript and the results. You will be able to remove any data from if decide you don't want it used, but I need to know in a short amount of time as eventually the data from all the interviews will be mixed together so I won't be able to separate it at that point.

Please do reach out if you have any follow-up questions or issues at any time! And I am inform you or later results.

Any final questions?

Appendix C: *Participant information and consent form*

Sample participant information sheet

Title of Research Project:
A Participatory Design Approach to Sportswear for People with Upper Limb Impairment

Name and Position of Researcher:
Jennifer Poage, PhD Candidate, London College of Fashion, University of the Arts London (UAL)

I invite you to take part in my research. Before you decide, I would like you to understand why the research is being carried out and what it would involve for you. Please carefully review this information sheet, and let me know if I can answer any questions you have. I can be reached at j.poage0720171@arts.ac.uk at any time. You may also contact UAL's Research Management and Administration team at researchethics@arts.ac.uk with any concerns or issues.

What is the purpose of the study?
This research aims to present guidance for sportswear designers to approach better inclusion of consumers with upper limb impairment. It uses a participatory methodology to include stakeholders in the research to get a better understanding of their needs, challenges, and ideas for solutions.

Why have I been invited?
You are considered a key stakeholder in inclusive sportswear design, and your experiences and knowledge are critical to this research. Your input is highly valued!

Do I have to take part? Can I decide to withdraw at a later time?
Participation is entirely voluntary, and you have the right to withdraw before or during the workshop. You may also withdraw consent for use of your contributions up to two weeks after the session is conducted. This can be done by informing the researcher or UAL's Research Management and Administration team at the above listed emails.

What will happen to me if I take part? What will I have to do?
The workshop will be conducted online, last for 1 ½ hours, and will be scheduled at a time convenient to you and the other participants. During the session, you will be asked to contribute to a few group brainstorming activities about your preferences in sportswear, barriers with sportswear, and ideas to make designs better. The researcher will send an agenda prior and will facilitate the session. After the workshop results have been analysed by the researcher, you will receive an email that summarises the themes found and asks for brief feedback, which is voluntary. This final feedback will be anonymous, collected though an online form, and is not needed to receive the incentive.

Incentives
Each participant will receive a £20 (or USD equivalent) Amazon gift voucher after the workshop session as a thank you for taking part.

What are the possible disadvantages and risks of taking part?
No new designs or sportswear will actually be produced in this study, and it is not affiliated with any brands. The purpose is to study *how* to make a better design process, not to actually make new products. You will be asked to think about current challenges with sportswear. If any discomfort or sensitive issues arise, you may pause or log out of the session.

Intellectual property generated from the research and participant contributions will belong to the researcher. Participants are not allowed to publish or commercialise any information or results arising from involvement in this study.

What are the possible benefits of taking part?
The results will be used to contribute to a practical framework for a more inclusive sportswear design practice, which will be presented in a research dissertation and potentially other academic channels.

What happens when the research ends? What will happen to the results of the research study?
The session will be recorded so the contributions can later be analysed, and themes will be identified. The final research result will be presented in a PhD thesis. The research may also be used for related academic publications or conferences. You will be able to access a copy of the final research results upon request.

What if there is a problem?
If at any time, there is an issue, the participant is encouraged to inform the researcher or UAL's Research Management and Administration team at the above listed emails. If you prefer different terminology to what is being used in this study, please inform the researcher.

Will my taking part in this study be kept confidential? What will happen to my data?
Some demographic information (age, gender, ethnicity, location, description of limb difference or injury) will be collected prior to the workshop. Participants can provide this information by clicking on an emailed link that will lead to a secure, anonymous online form. You have the right not to disclose any personal or confidential information during the workshop session. Participants must agree to keep discussions from the workshop confidential and respect the privacy of all workshops attendees.

Participants may turn off their video feed during the session if they choose. All participants will be made anonymous in the final thesis and any other publications. The recording and other identifying data will be stored on an encrypted device and used only for the purpose of this study or other relevant academic contributions. The data may be shared with the PhD supervisors, and the recording will be deleted once no longer needed.

Who has reviewed the study?
The plan for this study has been reviewed and approved by University of the Arts London.

Thank you for taking the time to consider taking part in this study!

Sample consent form

Title of Research Project:
A Participatory Design Approach to Sportswear for People with Upper Limb Impairment

Name and Position of Researcher:
Jennifer Poage, PhD Candidate, London College of Fashion, University of the Arts London (UAL)

Please read the following statements and check Yes or No. If satisfied, add your signature below.

	Yes No
1. I confirm that I have been given, read, and understood the information sheet dated 19 Nov. 2020 for this research study. I have had the opportunity to consider the information and ask questions, and I have had these answered satisfactorily.	____ ____
2. I confirm that I was made aware that the sessions will be recorded, and I freely give my consent.	____ ____
3. I understand that my participation is voluntary and that I am free to withdraw before or during the workshop. I may also withdraw consent for use of my contributions up to two weeks after the session is conducted.	____ ____
4. I consent for the findings to be published in the above named dissertation and to be used in relevant academic publications or conferences.	____ ____
5. I confirm that I have been made aware that my anonymity will be maintained in the final dissertation or other academic publications and that my data will be protected.	____ ____
6. I agree to keep discussions from the session confidential, respecting the privacy of my fellow participants.	____ ____
7. I agree not to publish or commercialise any information or results that arise from my involvement, and I understand that intellectual property remains with the researcher.	____ ____
8. I acknowledge that if I have any further questions or concerns I may contact Ms. Poage at any time. Also, if preferred, UAL's Research Management and Administration is available at: researchethics@arts.ac.uk University of the Arts London, 5th Floor, Granary Building, 1 Granary Square, King's Cross, London, N1C 4AA	____ ____

Name of participant: **Signature:** **Date:**

Name of researcher: **Signature:** **Date:**

Appendix D: *Sample interview transcript*

File: **fi616a10 -- IMG_4122.m4a**
Duration: **0:20:51**
Date: **28/02/2019**
Typist: **705**

Interviewee: 2

START AUDIO

Interviewer: Okay, they seem to both be going now. I just wanted to start off asking your current job title and function, if you don't mind?

Respondent: Yeah, yup, so right now, I'm a senior apparel designer, and I work for the [redacted] brand, at the moment, working on lifestyle, sports licensing apparel.

Interviewer: Okay. And can you tell me about, just briefly, experience you've had with athletic wear? When you were at [redacted], did you work with some more performance-based pieces?

Respondent: Yes, I did, I did. I worked with a lot of different fabrics for many different sports, so I focused on tennis for a while, and then women's training in general, more for the Studio collection that we've done, so a lot of nylons, spandex, poly spandex, and then I also designed for [redacted], when we first had the collaboration. I was fortunate to interview with the athletes and talk to them about, basically, their range-of-motion and things that they require for the garments.

Interviewer: Was that men and women in [redacted] or…?

Respondent: I focused on women, yes.

Interviewer: Okay, that's clear. When you did [redacted] and, I guess, the other lines, have you worked on tops and bottoms?

Respondent: Yes, yes, so yeah, tank tops, T-shirts, leggings, shorts and then also some cover-up pieces, so sweatshirts and some jackets.

Interviewer: This is pretty broad. I think we could focus a bit on, maybe training. You've said general training for women's Studio, and then [redacted]. Is that a bit different, what went into that?

Respondent: Well, it's similar but different. Similar to Studio because it's the same fabrications. Maybe we had higher price points for [redacted], so we were able to work with nylon, where in the training categories, I was in the price point mid-tier, so it was more poly spandex, but the aesthetics were very similar, and the weight was similar as well. I would just say price points were the big thing.

Interviewer: Sticking with those areas, can you name a few key characteristics you consider to be top priority in sportswear?

Respondent: I would say- you mean properties like wicking properties, that type of thing?

Interviewer: It can be, yeah, anything.

Respondent: Yes, okay, okay. I, for one, as a designer and as a consumer, I think it's really important to have recovery within the fabrication, so having some elastane in there so that the fabric can go back to its original state. I feel like that's important. Also, the hand feel of the fabrication, so you want to be comfortable in it, no matter what you're doing, and then the weight, the weight of the fabric is also very important. Depending on which season, if it's fall, you want it to be

heavier. If it's spring, you want it to be lighter but also support you enough to do so.

Interviewer: What do you think are key characteristics in sportswear for an athlete who has an upper limb mobility impairment, which would be loss of motion or restricted strength in the hand or arm?

Respondent: I see. I would say recovery would be important, the fabric recovery, so that it supports them if they need it. Also, range-of-motion, so maybe you have ventilation or vents, gussets, that type of thing, that can give them range-of-motion that they need, that's probably the most important. …think more about that.

Interviewer: Yeah. Oh, that's okay. If you think of anything that you want to add back on to a prior question, that is fine as well.

Respondent: Okay, great.

Interviewer: If designing sportswear specifically for this consumer, how would you go about assessing specific needs?

Respondent: Well, first, I would do some research on the consumer, so this target person and what their restrictions are, what their needs are, and then I would design around that. Again, where they need range-of-motion, where they need support. There are a lot of technical fabrics that can do wicking and cooling, so there are a lot of other properties that could go in.
I think, for me, I would need to know more information about the person, the consumer, to see the best way to accommodate them.

Interviewer: What techniques would you employ to actually get this information from them?

Respondent: Oh, oh, I see, so if it would be possible to have a one-on-one conversation with them, or a factsheet to do more research, or if I knew their impairment, I could do my own research. If there's a certain disability, a health situation, I could do research and then design based off of that information.

Interviewer: What sorts of garments do you think would be best modified for someone with an upper limb mobility impairment?

Respondent: To modify, so, sorry, could you…?

Interviewer: Yes, that's a good question [pause] that you think you'd have to design differently from what you currently design for the mass market?

Respondent: Right, let's see. I think maybe an important thing would be how they put the garment on and off, so take that into account. If they have their use of their arms or not, if someone else is putting the garment on them, so maybe it needs a larger neck opening, a looser arm hole, so I think fit is also very important and comfort as well. Does that answer your question?

Interviewer: Yes, thank you.

Respondent: Okay.

Interviewer: You mentioned arm hole and neck, so we're thinking tops here?

Respondent: Right, yes, I see. I have been focusing on tops, right.

Interviewer: Do you have anything to expand out on other types of garments?

Respondent: Oh, right, so we're specifically talking about upper mobility?

Interviewer: Yes, the person does have an upper mobility impairment, yeah.

Respondent: I see what you're saying, I see, okay, so then for bottoms, it would be similar where it would make it easy for them to put the garments on and off, maybe not slim all the way to the ankle, maybe more of an open pant, a drawstring, so it can be adjustable. I think any details that could make it adjustable, or maybe a tab at the ankle, adjustable cuffs, that type of thing.

Interviewer: Going back to the design process and assessing needs, if this was going to be a collaborative format, what other stakeholders or professionals would you like to have in a full collaborative design session for this project?

Respondent: I would think it would be good to have a pattern maker, possibly, who specialises in fit, a material developer as well, so that they can focus on the performance of the fabrication, to go more in depth in what each fabric can do. A scientist would be good, but also someone in the medical field. I think someone who is an expert with these disabilities would be an important person to work with.
Then, the consumer themselves. Again, I think I mentioned that earlier, but if you could have an interview with someone and know a little more about their situation, that makes it more helpful.

Interviewer: When you mentioned, "Scientist," can you be a bit more specific?

Respondent: Right, so for example, [redacted] works with [redacted] and they do exploratory things, so maybe it's good to hear that side, more of the technical information where they can

specialise in the product, elevate the product, offer something that I couldn't as a designer.

Interviewer: You don't have to divulge specifically about [redacted], but in theory, if you can answer this, is it a specific subset of science or specific expertise within the general field of science?

Respondent: There probably is. To be honest, I don't know a lot about it because I haven't been involved in that, so I'm not quite sure.

Interviewer: You also mentioned someone from a medical field with expertise on the disability. Is there a specific type of medical person you mean by that?

Respondent: Yes, possibly a physical therapist would be good, or even a doctor who specialises in whatever the situation is, if it's a disease, or someone who would have more information, yeah.

Interviewer: Okay, looking back here, I see patternmaker, material developer, so we have some people from the fashion industry, we have science and medical fields, and then we have the consumer.

Respondent: Yes.

Interviewer: Is the anyone else?

Respondent: Well, the designer, of course.

Interviewer: Yes, right.

Respondent: Yup. Oh, am I missing someone? Well, you, if you're doing this study, whoever's doing the research, or maybe the caretakers as well, if they have a caretaker, nurse.

Interviewer: We have a lot of different people working together on this project. Can you think of any main challenges you see in these different people collaborating on this project?

Respondent: Yes, that's a good question, so many different points-of-view and opinions, where maybe the designer has an idea, and the patternmaker might tell them if it's possible to execute, so if the construction is possible. Sometimes that happens in general. You come up with a creative design and there are limitations with it. It is helpful to work together when everyone has a point-of-view and an expertise, and then you can come up with a solution.
So yeah, back to your question about working with all these people, so I think it's probably best to get some points-of-view, but then narrow it down to a smaller group of people so that you don't have too many opinions. I think, again, it's important to gather all the information you can at first, and then you can dive deeper into the product.

Interviewer: Other than different points-of-view, can you think of any other challenges or barriers to this collaboration?

Respondent: To what? Working with multiple people?

Interviewer: To the specific people that we mentioned before.

Respondent: Right, let's see, any limitations? I'm not quite sure. Nothing's coming to mind.

Interviewer: It's okay. We sort of touched on this, but can you maybe specify the key benefits that come from all these people working together?

Respondent: Oh, sure, yeah, so everyone having their expertise. Every point-of-view from the medical to the physical therapist, the

designer, maybe the developer, so everyone coming with their knowledge to come together.

Interviewer: Interesting, you said the, "Developer," which wasn't in the first list.

Respondent: Oh, sorry, I-

Interviewer: Which is fine, so-

Respondent: Yes, so I think when I said, "Material," someone that works in the material. I think I was generalising saying, "Developer".

Interviewer: Oh, okay, thank you. Just back a bit, when you mentioned the caretaker, why did you include that on the list?

Respondent: I'm not sure exactly what illnesses, or I don't know the situation exactly, but I know people that have been in my life that had impairment issues through different diseases, that they had people taking care of them, so they had a nurse having to dress them, that type of thing.
I had a cousin who had ALS, so I witnessed people having to help him out, his wife or his nurse having to get him dressed, so that's what I was putting into mind when you said, "Impairment".

Interviewer: Now that we've run through this list of different people, and what they can contribute, I just want to return to the question of, can you think of key qualities and priorities that would go into sportswear for someone with an upper limb mobility impairment, in case you would like to expand at all?

Respondent: Key priorities? Easy range-of-motion, things designed specifically for the impairment, so like I had mentioned before,

a certain kind of a neckline design, ventilation, having gussets, that type of thing, repeating what I said last time.

Interviewer: Yeah, that's fine.

Respondent: Yes, trying to think what else. I think having customisation is important, adjustability, yeah, and that's about all.

Interviewer: No, that's fine. Just looking back, we're going to wind this down now. I have a few key words I pulled out, is range-of-motion, recovery. You had arm holes, neck holes, getting in and out of a garment, having someone help or not, and then we looked at the collaboration of a developer, patternmaker, scientists, medical person, and then the consumer, and talking to the consumer, and having an interview.
This is the end, so I just want to see if you have anything you would like to add, or you think that anything was missed?

Respondent: Not at the moment, can't think of anything. I hope that I gave you enough info. I hope that helped out. I'm not that familiar with the situation, but hopefully, I could give you some point-of-view from my design point-of-view, from a design end?

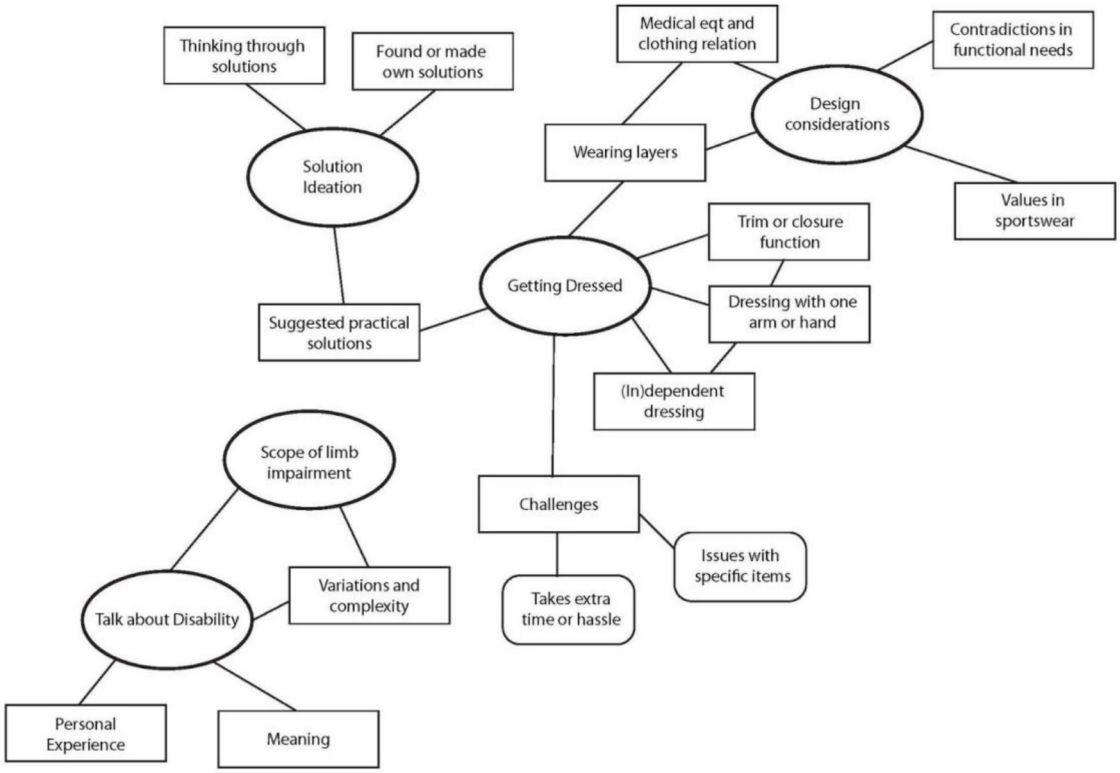
Interviewer: Yeah, yeah, that's good. I am going to stop the recorders now.

Respondent: Okay.

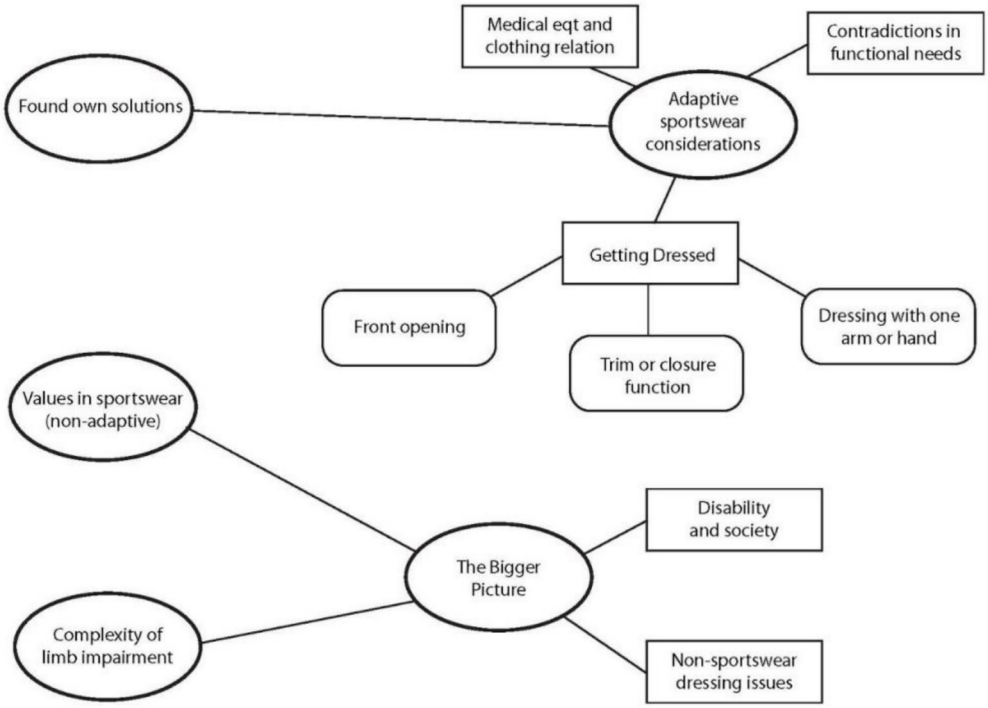
END AUDIO

Appendix E: *Thematic analysis maps for interviews data*

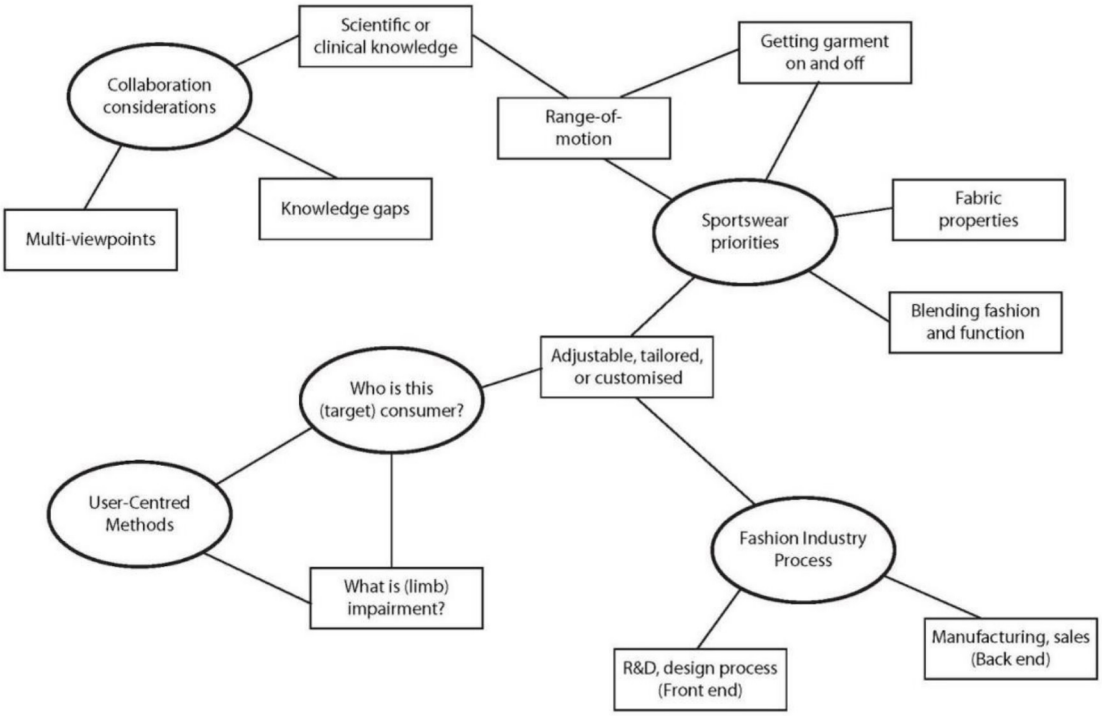
User group – Initial map



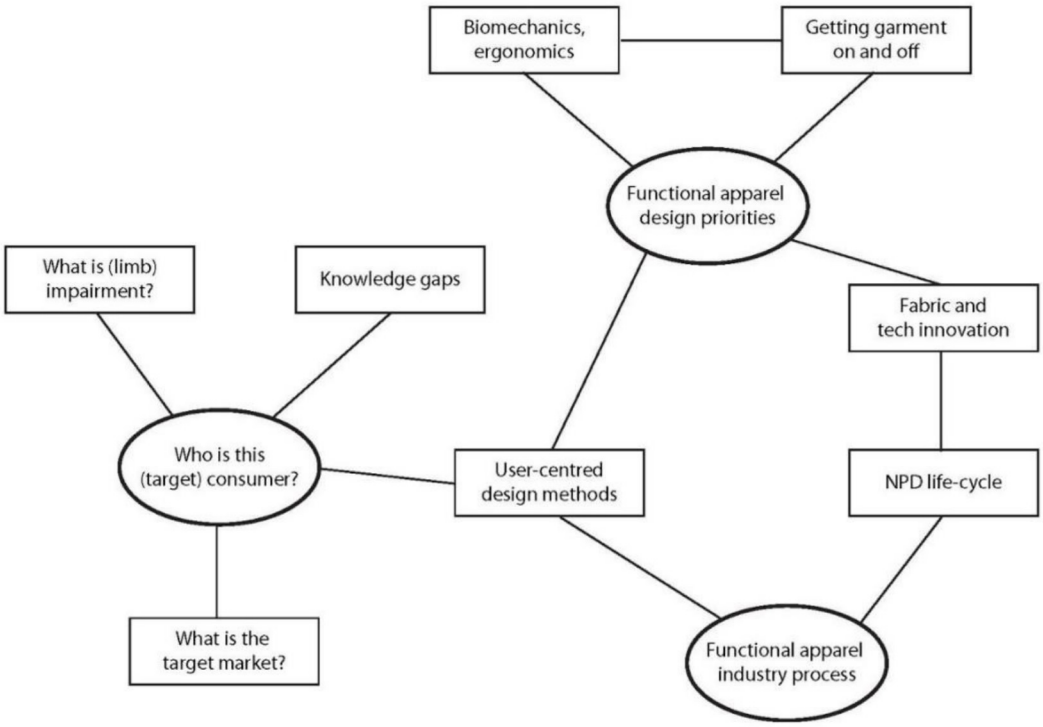
User group – Candidate map



Industry group – Initial map

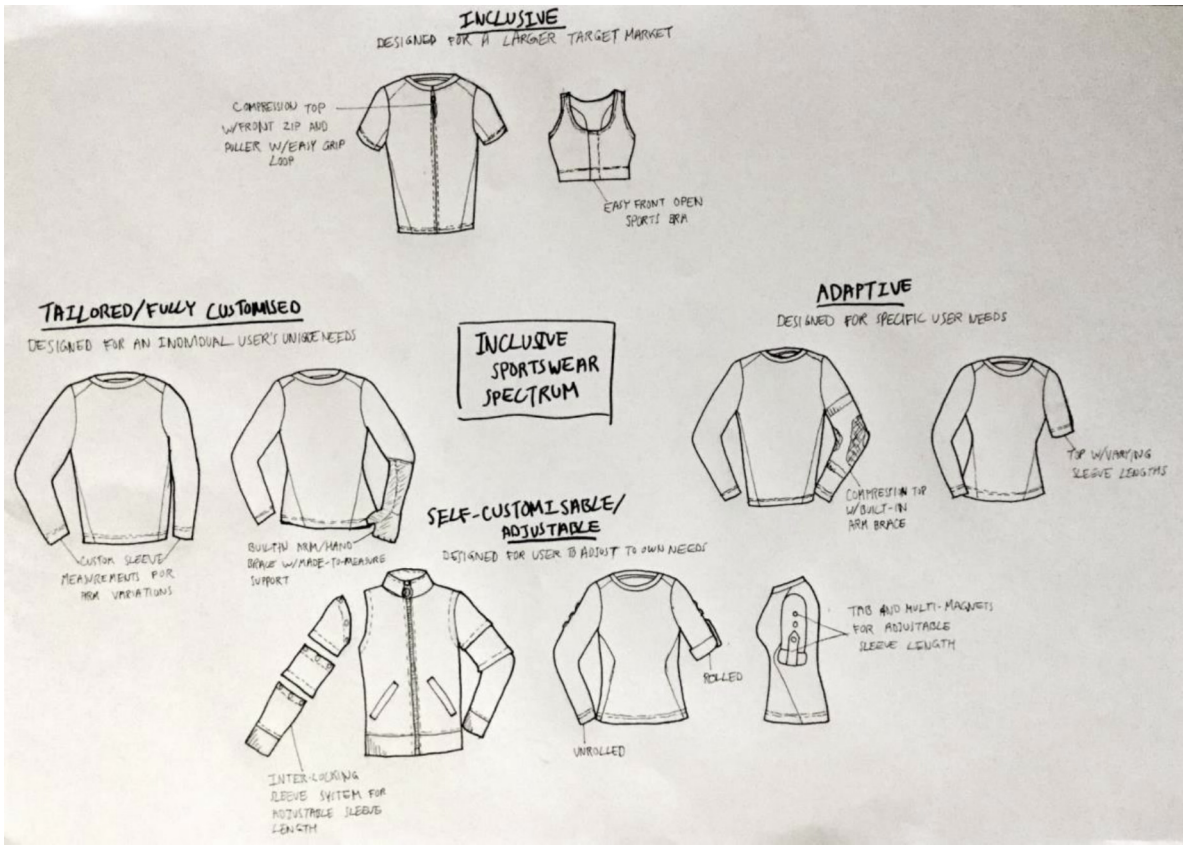


Industry group – Candidate map



Appendix F: *Emerging data from interviews results*

Multiple design strategies for sportswear inclusion - First version of the Sportswear Inclusion Map



Appendix G: *Workshops topic guide*

Welcome

Greet participants as they sign-on.
Sort out tech issues (working mic, videos on or off.)

Introduction

Intro myself:

- PhD from LCF, UAL.
- Worked in the sportswear industry and moved to design research.
- (Have an acquired, hidden physical disability.)
- Interested in approaching research and design in a way that supports a wider range of people.

What will happen today:

- Overview the research.
- Activities (screen share) - past experiences, future ideas, points to improve (if time), feedback.
- Debriefing, questions.

Aim of study:

- This PhD aims to explore guidance for sportswear designers to approach better inclusion of consumers with upper limb impairment.
- Participatory methodology to include stakeholders.
- Get your direct input about sportswear.
- No garments being made, just talking today about ideas.

Ethics:

- Recorded (not started yet). It won't be shared beyond supervisors.
- You can choose how much personal detail you want to contribute to the discussion. Won't use anyone's names or identifying info in the final report.
- Open and positive. If anyone feels discomfort at any time, please let me know, or simply sign off! Let me know if a break is needed.
- There are no right or wrong answers here! I am looking for your honest opinions, and any and all ideas.

Are there any questions or concerns?

Write down demographics info if preferred over link.

Do I have your permission to start recording?

Sportswear Experience Journey *(User Experience Map)*

Intro:

- Think about a bigger picture of sportswear design, not just the workout.
- How it affects you at key points of interaction with sportswear.

- Pros and cons of your own past experiences with sportswear.
- Show example.

Any questions?

Run activity.

Wrap-Up:

- Thank you!
- Look at the whole journey and notice any patterns.

(Turn-off screen share or break if needed.) ok to move on?

Post-Its *(Post-It Solution Brainstorming)*

Intro - Part 1:

- Brainstorm solutions for better sportswear.
- What do you want in sportswear, new or old ideas?
- Can repeat from last activity and think of new solutions.
- One on each post-it.

Run activity - Part 1.

Intro - Part 2 (if time):

Now we are going to group all the ideas into themes. (Show example.)

Run activity - Part 2.

Wrap-Up:

- Thank you.
- Review.

(Turn-off screen share or break if needed.)

Priority Chart (if time allows) *(Market Priority Chart)*

- Organise the most important ideas on this chart.
- Based on post-its we created in the last activity.
- Place on chart.

Run activity.

Wrap-Up:

- Thank you.
- Review.

Feedback

- Help me know if the research is heading in the right direction.
- How you felt about participating.

First, what went well?

What can be improved?

What is missing?

Debrief

- Thank you greatly for your time and your contributions!
- Email shortly with a debriefing statement.
- You will have two weeks to contact me if you decide after all that you do not want today's contributions to be used in the study.
- £20 (or USD) Amazon voucher in the next few days as well even if you decide you don't want your contributions used.
- After all the sessions are analysed and themes are identified, I will send you each an email summarising the findings (in a few months).
- Provide anonymous feedback about the accuracy of the themes or about the research in general. This feedback is voluntary.

Any questions?

Thank you!

Appendix H: *Emerging data from workshops interactions*

People and places surrounding the user group - First version of the User Network

Complexity of upper limb impairment and sportswear – First version of the User Context Wheel

Situational
Acquired
Congenital
Progressive
Short-term
Permanent
injured professional athlete
Para athlete
wounded veteran
people with an upper limb impairment
people with an upper limb difference
someone with a short-term injury
- broken bone, surgical recovery
Use of brace or other aid, perm
wheelchair user
non-wheelchair user
prosthetic
temp cast, sling

Medical
Cerebral Palsy
Stoke
Multiple Sclerosis
Muscular Dystrophy
Shoulder disarticulation
Limb loss / amputation
Limb difference
Frozen shoulder
Spinal cord injury
traumatic brain injury
brain hemorrhage
Arthritis
Parkinson's

Physical
Impaired range-of-motion
Restricted dexterity
Muscle weakness
Paralysis
Limb asymmetry
Limited reach
Reduced grip strength
Loss of nerve sensation
Muscle loss / atrophy
Muscle, tendon, ligament damage
Nerve damage
Joint or cartilage damage
Labral tear
Joint dislocation
Bursitis
Broken bone / fracture
Carpal tunnel

Sportswear
Base-layers:
- Cycling tops
- Compression shorts/tops
- Sports bras
Mid-layers:
- Running tops
- Tees
- Hoodies
- Full-zips
- Tanks (vests)
Outer-layers
Gloves
Shoes
Hats
Trousers
pro-athlete apparel
casual athletic wear
rehabilitation or medical use
leisure wear

Sport or fitness activity
Golf
Cycling
Yoga
Rowing
Running
Swimming
Sailing
Diving
Climbing
Para rugby
handcycling
dance
training
Cross fit
Paralympics track
Nordic skiing

Sportswear values and needs
Easy to don and doff
Adjustable sleeves
Pocket for phone
One-handed dressing
Easy grip
Independent dressing
Sport specific
Moisture wicking
Comfort
Material properties
Price
Fit
Works with brace or aids

Barriers

Cost of custom-built garment or "special" design
Designed for two-handed dressing
Designed to pull overhead
Tight fit with no front or side openings
Limited suitable offerings
Complex fastenings
Interferes with brace or other aid
Required grip for dressing
Narrow openings in cuffs, pockets, or gloves

Personal

"I walk three to four days a week, and play golf.
I play golf a lot. I'm not any good at it but I like playing."
"Again, my wife would have to help me dress because
trying to get it around my body and then close it with
the left hand was difficult to do. When I got out of the
hospital I was able to put t-shirts on."
"they have a million prosthetics out there and each one
presents their different challenges when it comes to
collaborating with apparel in general"
"The other thing, we're all… brachial plexus injury
people are unique, yeah?"
"I don't ever wear prosthetics, mostly because they're
expensive, but then also I've just- I was born with one
hand, so they just kind of get in the way for me"
"The more people I meet within the disabled world,
the variations of… even just arm amputations within
one arm is completely different."
"So, for the most part I'm trying to get back into going
to the gym because I gained weight since my surgery,
which obviously I knew would happen."
"So like, my mobility can change over the course of a
few days"
"I don't really wear shorts when I run so it's usually like
capri length like, what are they called? Like stretch
running pants, yeah, like running leggings."

Excerpt from reflective notes on workshops recruitment

GLOVES!! And feedback from others in responses. User community insights (even from non-users.) learning about more types of upper limb impairment: MS, MD, CP, brachio injury, shoulder disarticulation, amputation, stroke, loss of dexterity or weakness from age, limb difference from birth, nerve damage, muscle damage or atrophy, arthritis, carpal tunnel, short term (sprain, bursitis, broken bone, labral tear)

Comment on types of dis orgs (charity, activist, by type like blemsa, community-led) in UK and US. Type of adaptive sports programs in UK (wounded vet, CP, DSC, limb loss) and US (by sport like golf or diving for vets, vet programs, open regional, ski, sled ski, rehab). Some in CO with "for the disabled"

Disability rights UK gets too many requests and are a small membership charity so not able to help. The targeted adaptive sports, personal appeals, social media and wounded groups seem best.

Getting responses from people about lower limb - can't use in data collection but can write up in insights and for broader implications. This is needed for others as well as upper limb!

Carers, family members, charity and sports group (physio??) organisers see this all day and can contribute! Really need to the direct user input, to hear from them themselves, but the outer circle can give insights and provide directions as well. A lot of people know someone! And support this.

Learning from Twitter. Language and attitudes. Insider point-of-view. Resources. But is it an echo chamber? Or a good balance to academic reading? Similar I think.

Maybe the point of these workshops is not to design the garments or even to get the precise data (although that would be useful). The point is to learn how to engage with the community.

Appendix I: *Thematic analysis process for workshops data*

1. Listened to audio for each individual workshop while reviewing results on Miro. Corrected any vague post-it note text, and colour code post-its for each activity as indicated below. Added an identifier tag to the bottom left of every post-it, specific to each participant. Wrote down observational notes on the participants' contributions as well as key insights from the open discussions at the end of the workshop.

Yellow = Ideas relating to upper limb impairment
White = Personal preferences, non-disability related
Blue = Ideas relating to wheelchair use, non-upper limb related
Turquoise = Ideas relating to spinal cord injury (or other condition), non-upper limb related.

The above image is a sample of raw data and coding for the brainstorming activity for each participant. Please note this participant is American so US clothing terms are used.

2. Read through challenges posted in each user experience map and reviewed the write-ups of the end of workshop discussions. Made notes on barriers identified:

- Price point (for adaptive)
- Variations in body shape with standard sizing
- No visuals or sizing info for wheelchair users
- Making adaptations requires asking (dependence) or tailor (expensive)
- Difficult put on or take off (various reasons - grip, reach, dexterity, pulling, requires two hands)
- Can interfere with prosthetic/external equipment
- Placement of pocket (wheelchair, arm placement)
- Adaptive wear is sometimes not fashionable

3. Read through opportunities posted in each user experience map. Only in one case did a few key ideas not get carried over to the brainstorming activity, so these post-its were copied over to include in the thematic analysis.

4. Read through results for each brainstorming activity. Reread notes taken on emerging themes made throughout the workshops:

- Able to make self-modifications! Adjust for own needs and needs at a certain time. Normalise options and give people control over own situation
- Can also relate to shopping (sizing info or pics showing wheelchair)?
- Built-in wearable, extras (thermal pockets, WB control, stomach warmer) - or make as add on? Swap out items or details? Mass customisation.
- Pulling on garments not good - grip. One handed-better.
- Many values not related to impairment or difference - just regular human variations and personal values.
- Effects of equipment, wheelchair or prosthetic harness
- Interactions with clothes, fabric, construction, trims, placement of items
- Access to harness, catheter, bag, electro stim.
- Adaptable or customisable:
  - Can choose sleeves (length or fabric) or placement/type of pocket.
  - Detachable or tear away sleeves.
  - Adjustable loops

5. Put all post-it ideas from brainstorming activity for all workshops together on one board.

6. Sorted into initial groups. Label and relabel themes as groups are formed. Assigned sub-themes.

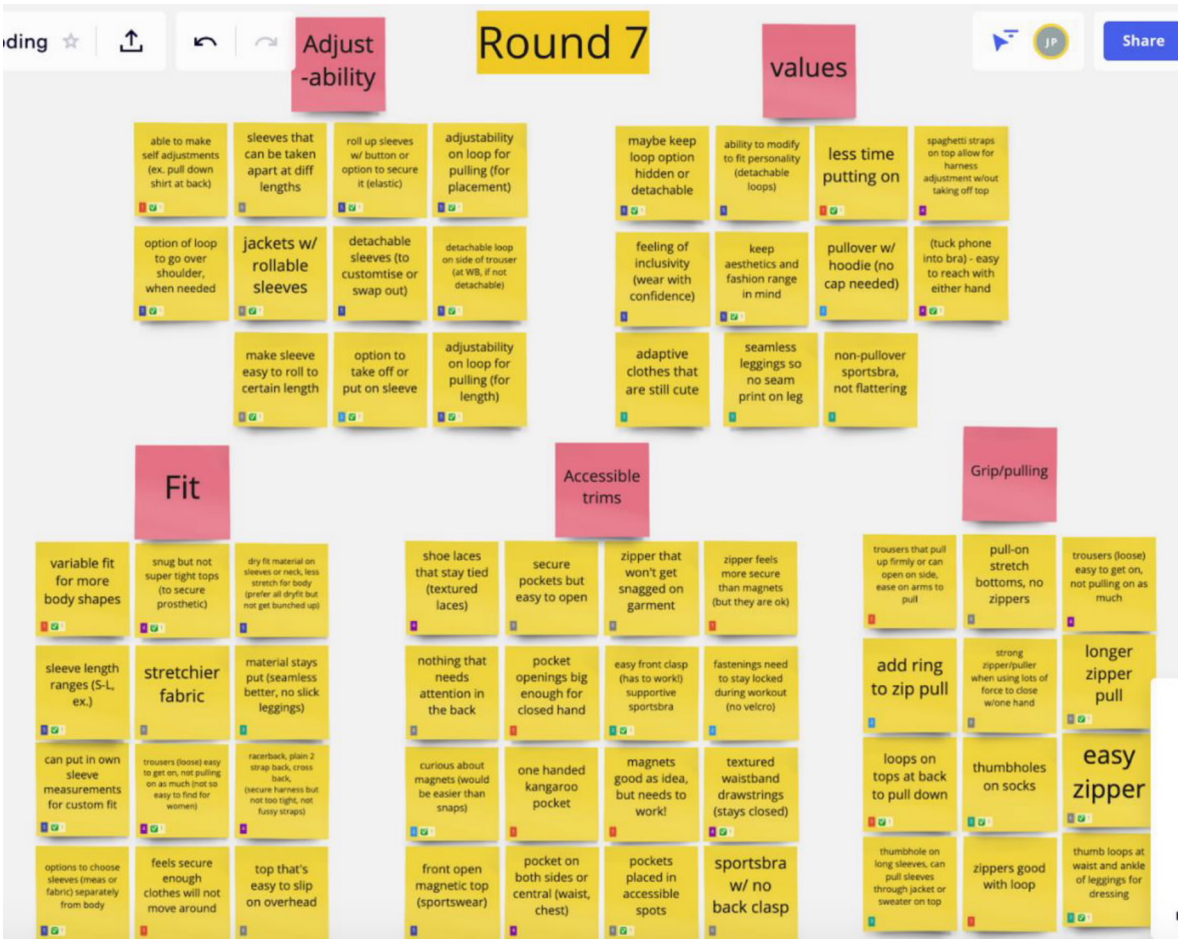
7. Reviewed themes (dark pink) and sub-themes (light pink). Removed or reassigned ideas that are singles or in small groups. Made sure themes have ideas from a distribution of participants. Wrote-up summary of themes.

8. Deleted items that are personal preferences (white), not related to disability. Removed ideas that are related to wheelchair use (blue) or conditions not specific to upper limb impairment (turquoise). Made note of these contributions for future reference but did not include further for this upper limb impairment focus.

9. Reviewed and consolidated themes and subthemes. Revised written summary of themes.

10. Revise themes again and consolidated int o final themes.

11. Copied over all post-it notes from the green boxes of the priority charts -- “Very important! Not on the market” - for all participants. (These are the key market gaps and areas for designers to first address.) Added a sticker to each post-it note in the grouped themes that matched a note from the priority chart green box.



12. Wrote-up final results in Findings chapter.

Appendix J: *DMI: Academic Design Management Conference paper*

22nd DMI: Academic Design Management Conference Impact The Future By Design
August, 2020

An Inclusive Approach to Sportswear (Athletic Wear) for People with Upper Limb Impairments

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Recently, inclusive fashion has seen an uptake by a handful of brands, but the disabled community is still largely underrepresented and underserved by the market. While Nike and Under Armour both have limited inclusive offerings, mainstream sportswear is predominantly designed for non-disabled consumers. This paper presents PhD research from the London College of Fashion, which looks at an inclusive approach to sportswear design for people with upper limb impairments. The Social Model of disability, in which disability is seen as socially created through imposed barriers, is applied to look at removing barriers through design. A literature review reveals that an overall design approach to inclusive sportswear for consumers with upper limb impairment is lacking. Under a pragmatic, participatory design methodology, stakeholders are considered collaborators for this project, and their input guides the direction of the research design and final output. People active in fitness who have upper limb impairment, sportswear designers, and other industry/research experts were interviewed about sportswear design needs. Engagement with other community members, such as disability sports coaches, allowed for further insider feedback. Finally, an 'Inclusive Sportswear Spectrum' for design strategy is proposed.

***Keywords**: Participatory Design, Inclusive Design, Universal Design, Sportswear, Athletic Wear*

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Introduction

In the UK, 13.3 million people indicated they were living with a disability in 2017/18, according to a survey from the UK Department of Work and Pensions (2019). The Centers for Disease Control and Prevention (n.d.) reports that there are 61 million adults in the US living with a disability. Despite these vast numbers, this community seems to have been underrepresented and underserved by the fashion industry. Indeed, disability charity Leonard Cheshire (2019), in collaboration with online magazine Disability Horizons, recently surveyed 206 people in the UK with a disability or long-term health condition. 75% of the respondents stated that mainstream fashion in the UK does not meet their needs. Furthermore, 96% feels that there is not enough representation of disability in the fashion industry. These statistics indicate that there is a sizable consumer group that has largely been marginalised by the fashion industry. It is a matter of urgency, from consumer wellbeing and fashion marketing points-of-view to cope with this problem. Further opportunities exist to expand into this marketing and business niche and to enhance wellbeing and representation of this marginalised group.

The term 'adaptive apparel' is used for clothing designed for specific needs not met by mainstream styles, such as a dress shirt with magnetic closures in place of buttons for those with dexterity issues. Traditionally, adaptive apparel has been provided by smaller companies selling only this type of clothing. Silverts, for example, offers adaptive apparel for consumers with rheumatoid arthritis, stroke victims, or wheelchair users (McCullough, 2016). In recent years, some mainstream brands have expanded their offerings into this market area. Tommy Hilfiger (n.d.) has an 'Adaptive' line of apparel with functional modifications that make it easier to get dressed and provide more comfort. Bottoms for wheelchair users, for example, have less fabric at the front and higher backs to avoid front bunching or insufficient back coverage. A 'Kids Easy Dressing' range is sold by Marks and Spencer (n.d.b.), which is 'all about comfort.' Some items include a discreet opening for feeding tubes, and soft cotton fabrics are used throughout the collection. A few sportswear companies have entered this market as well. Nike sells a line of footwear -- FlyEase -- that can be opened and closed at the back with one hand, calling it 'a new standard in universal design' (Nike, n.d., para. 2). In 2014, Under Armour launched a range of products that used the MagZip, which is a magnetic locking zipper that can be manipulated with one hand (Regenold, 2014). Still, this is a recent trend with very niche offerings leaving room for market expansion.

For many, team sports offer elements of cooperation and socialisation (Hall, 2012,) and sport can be a recreational activity as well as a primary method for maintaining good health (DePauw & Gavron, 2005). While professional disabled athletes often have corporate sponsorship for apparel, this excludes the amateur disabled athlete or casual consumer (DePauw et al., 2005). A lack of appropriate apparel can increase barriers to community participation and can also impede rehabilitation (Kabel, McBee-Black, & Dimka, 2016). Sometimes negative biases or assumptions may prevent brands from designing to include marginalised groups. For instance, false preconceptions may exist that inclusive design costs too much or that it does not look aesthetically pleasing (Plumbe et al., 2010). Also, designers may not be aware of the needs of marginalised consumers, or they may not be equipped with the skills or tools to address them (Clarkson, Coleman, Keates, & Lebbon, 2003). The contemporary sportswear industry largely fails to consider or cater to people living with a disability, which reinforces barriers to inclusion within mainstream fashion and within areas of sport and wellbeing. Whether this exclusion stems from preconceived biases or lack of appropriate training, more awareness and practical guidance is needed for designers.

Therefore, the aim of this paper is to present an inclusive strategy for sportswear design for people with upper limb impairments. Through collaborative participation, stakeholders are brought into the research and inform a design approach to tackle areas of exclusion in sportswear. Thus, designers can potentially challenge perceptions that either they or their organisations are not equipped to design more inclusively.

Literature Review

Disability and Inclusive Design

Following disability studies terminology in the UK (and the Social Model of disability), phrasing such as 'disabled consumers' or 'disabled people' will be used to reference their disablement by society (Office for Disability Issues, 2018; Goodley, 2017). Multiple models and viewpoints exist for defining and researching disability. While the Medical Model sees disability as inherent to the individual, the Social Model views disability as being created by socially imposed barriers (Goodley, 2017). Other models, like the 'bio-psycho-social model' from the World Health Organisation's International Classification of Functioning, Disability and Health: ICF (2001), considers biological, personal, and social factors that may frame disability. The research presented in this paper applies the Social Model as a lens to look at how design can work towards breaking down barriers of exclusion.

Perhaps more of a British approach, according to Goodley (2017), the Social Model has been applied to areas of activism, policymaking, and politics. Within the realm of design, the Social Model relates to inclusive approaches. Barnes (2011), writes that both the Social Model and the ICF's 'bio-psycho-social model' highlight how intensely disablement is influenced by the physical and cultural environment. One proposed solution for this, he presents, is universal design -- a 'design for all approach [that] is widely linked to discourses of social inclusion and human diversity' (Barnes, 2011, p. 68).

While the term universal design originated in the US, Plumbe et al. (2010) write, the similar term inclusive design is prevalent in Europe. The authors discuss inclusive design as 'an approach to design and a business strategy' and add that 'it aims to design mainstream products, services and environments that are accessible and attractive to the largest possible number of people' (Plumbe et al., 2010, p. 6). An example, they note, is easy-open packaging designed to assist people with arthritis that is also adopted as a convenient alternative for the mainstream market. Inclusive design, they note, accesses multiple viewpoints and perspectives from real people to generate user-friendly and innovative products. While inclusive design was traditionally applied to older and disabled consumers, it is now extended to a variety of abilities, ages, genders, and cultures.

Watkins and Dunne (2015) classified both sportswear and adaptive apparel as functional apparel, and they stress the need for multidisciplinary expert input in this field of design. They write that functional apparel design requires the blending of creative processes from fashion design with evidence-based methods from engineering. Gupta (2011) concurs that expert collaboration is perhaps needed most in the design of functional clothing, which has specific end-use requirements.

The Social Model of disability, inclusive design, and functional apparel design all provide key theoretical and practical components for inclusive sportswear design. If, perhaps, a person with limited function in their arm or hand cannot work a zipper on a windbreaker or put on a sports bra overhead, then, the 'disablement' lies within the design of the apparel. To design innovative and functional solutions, users must collaborate directly with a team of sportswear designers, pattern makers, sports biomechanics experts, and other industry experts. These results, in turn, may also be beneficial to a broader range of mainstream consumers due to ease of use, promoting more inclusion within sportswear.

Adaptive and Inclusive Apparel

Research on adaptive and inclusive apparel stems from a variety of fields -- from engineering to fashion -- true to the sector's required multidisciplinary expertise. As such, research aims also range from assessing user needs through focus groups to finding practical design solutions through codesign. Methodologies rely on different levels of user involvement, either direct or indirect.

Coming from the medical arena and following the Medical Model of disability, Nicholson et al. (2001) present a study on the effects of lycra garments on the upper-limb function and movement of children with Cerebral Palsy. The children's improvement in mobility was evaluated using the Paediatric Evaluation of Disability Inventory, and data was gathered through wear-testing specialised lycra garments and carer questionnaires. Results were deemed poor as improvement was slight, and the children suffered loss of independence and had issues with toileting during wear-testing. In the end, more barriers were imposed on these children with the use of the lycra garments.

Bragança et al. (2018) take an engineering and human factors, user-centred approach in their research on sportswear design needs of wheelchair rugby players. Through focus groups and questionnaires, contemporary sportswear was assessed, problems identified, and possible solutions determined for this consumer. Design recommendations were then presented for wheelchair rugby apparel, which Bragança et al. note is lacking from the market. The study was also meant to raise awareness of those needs and promote inclusivity of disabled athletes. Further opportunities in this area would be to include creative approaches along with the engineering process. Fashion or sportswear designers could provide design trends and take the users through an iteration of evaluating and refining the designs.

McCann (2016) also presents research on sportswear in her case study of the UK Research Councils' research project 'Design for Ageing Well.' While trade magazines and events have stressed the importance of fitness for health and well-being for the ageing population, few, if any, references have been given to appropriate sportswear for this group, McCann writes. This, she asserts, has led to a gap in trend forecasting design requirements for this neglected consumer. Through an iterative codesign program, users, industry stakeholders, and outside experts were engaged in designing an outdoor sportswear system with assistive technology for men and women ages 60-75. The collaborative methodology 'empowered older users in expressing their needs to industry stakeholders' (McCann, 2016, p. 252) and 'practice[d] in breaking down barriers between the disparate disciplines' (Timmins and McCann, 2015, p. 205).

Carroll and Kincade (2007) present a qualitative study, 'Inclusive Design in Apparel Product Development for Working Women with Physical Disabilities.' They postulate that the most significant barriers

to seeing disability considered more in the fashion industry are preconceived notions that it is too costly and conflicts with existing apparel lines or brand image. These biases may stem from 'a lack of interaction exist[ing] between the constraints of the consumer with disabilities and those of the apparel industry' (Carroll et al., 2007, p. 294). Through interviews and wear-testing with working women with physical disabilities, the user group was found to have similar needs in clothing, based on clustering of common symptoms rather than disability classification. Thus, they conclude, an inclusive approach would work for the fashion indus try since reaching this consumer is not as costly or as complicated as perceived. Since sportswear involves more engineering in materials and construction, however, more research is needed to determine if these results would translate into this arena.

The collaborative, human-centred methods found in this literature review greatly influenced the methodological framework for this project. Similar to the 'Design for Ageing Well' project, this study seeks to break down barriers of exclusion around sportswear design and give users and stakeholders an equal voice in the outcome. Rather than an outcome of tangible sportswear designs, however, an overall design strategy for inclusion is presented. The concept of grouping consumers with similar symptoms (upper limb impairment) rather than medical diagnosis (arthritis or traumatic injury, for instance) stems from Carroll et al.'s study. Investigating sportswear instead of office attire, however, requires added elements of sport, function, and biomechanics to consider, which brings in a multidisciplinary perspective.

Methodology

This research is pragmatic since it is multidisciplinary, taking cues from areas of critical disability studies, disability sport, functional design, fashion design, and inclusive design, and it focuses on design practice. Saunders et al. state, 'pragmatists recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there are maybe multiple realities' (Saunders et al., 2012, p. 130). For pragmatists, they state, the importance of research findings come from their practical consequences. As inductive research, the final output of this study is defined by the findings from the qualitative data collection and analysis. The research is exploratory and is continually adapting based on new insights gleaned from the on -going literature/practice review, community interaction, and iterative data collection (Saunders et al., 2012).

A participatory design methodology is used. Spinuzzi writes that a participatory design methodology can use a variety of methods, like interviews or analysis of artefacts, and that 'participants' cointerpretation of the research is… an essential part of the process' (Spinuzzi, 2005, p. 164). Participatory design places the designer as researcher, he writes, to eng age stakeholders and users in an iterative ideation process, which leads to more effective results. It can be applied as a methodology, for instance, in product design to serve marginalised consumers (Demirbilek & Demirkan, 2004; Moffatt, McGrenere, Purves, & Klawe, 2004). Or it can promote social innovation to give an active voice to under-represented groups through community design (Ehn, Nilsson, & Topgaard, 2014). Many current inclusive and adaptive design research centres employ participatory design in their practice. The Open Style Lab in NYC uses cross-industry, collaborative design to provide adaptive apparel solutions to a variety of disabled clients. They 'team designers, engineers, and occupational therapists to conceive and build accessible wearables that address the needs with and for people with disabilities' (Open Style Lab, n.d., para. 1). At the Helen Hamlyn Centre in London, Silke Hoffman's research project 'Improving Post- Mastectomy Lingerie,' aims to create empathetically designed bras for post-mastectomy breast cancer patients. Fashion design probe toolkits are used in workshops with participants to understand their values and experiences (R oyal College of Art, n.d.). To make sportswear design more inclusive, those previously excluded must be central to the research. And to find solutions that work for both the end-user and the industry that will manufacture the goods, stakeholders and users alike should contribute. For complicated functional apparel, like sportswear for people with physical disabilities, other areas, such as biomechanics and pattern making, can provide further multidisciplinary expert knowledge.

Research Design

This research began with an online market survey of brands offering adaptive apparel to determine the current market landscape. A practice review of research centres and academics working with adaptive and inclusive apparel (and relevant product) design was charted to recognise methods and approaches used. A critical literature review including theory and applied research on disability studies, inclusive design, participatory design, functional apparel design, and disability sports highlighted recent thinki ng, conceptual overlap, and gaps in these areas.

Both inclusive and participatory design require an understanding of the community involved (Plumbe et al., 2010; Spinuzzi, 2005). An overview was done of UK disability statistics and government policy,

disability sport programs, and areas of disability activism. The parameters for participant recruitment, design of the interview questioning route, and overall aim of the project were iteratively adapted based on responses to recruiting notices, visits to disability/sports events, and discussions with other relevant researchers and stakeholders.

The results discussed in this paper relate to the findings of the primary data collection -- in-depth interviews with users and stakeholders of sportswear for people with upper limb impairment. Upper limb impairment falls under the category of physical disability, and, for this study, includes people with full or partial loss of limb; manual dexterity; or range-of-motion in the shoulder, arm, or hand. The participants (who were over 18 years of age, male or female, and engaged in sport or fitness) either had a limb difference from birth, an acquired impairment through injury, or a congenital condition. Physical disability was cho sen as a focus due to the researcher's background in sportswear technical design and construction, and a more significant gap was seen in apparel design research for upper limb impairment rather than lower. Other stakeholders were defined as: sportswear designers, sports biomechanics researchers, and related industry experts, such as apparel developers or pattern makers.

The aim of the interviews was to explore the current space for adaptive sportswear design, including goals, values, and language used amongst the stakeholders. Objectives were to determine what barriers may exist for this target consumer group and where stakeholders may hold conflicting perspectives. Thus, the participants (and data) were split into two groups: 1.) 'users', and 2.) multidisciplinary 'experts'. Table 1 lists the participants.

Table 1 Interview Participants

	Location	**Description**
User group:	USA	Lost use of hand through injury
	USA	Lost use of arm through injury
	UK	Lost use of arm through injury
	USA	Born without a forearm
	USA	Multiple shoulder surgeries, congenital condition
Expert group:	USA	Senior sportswear designer
	USA	Senior designer for apparel and innovation (sportswear)
	USA	Head of apparel (sportswear)/creative director
	UK	PhD candidate in bioengineering, biomechanics of rowing
	UK	Pattern designer/developer, wearable orthotics

As this PhD is at the University of the Arts London (2017), the university's policy on ethics was followed. This includes, but is not limited to, ensuring data protection, privacy and confidentiality, and informed consent of participants. The UK Department for Work and Pensions (2014) offers a guide for researching disability, which was considered for all participants. Since some of the questions related to challenges users may have experienced with current sportswear (a potentially sensitive topic), this l ine of questioning was indicated beforehand. No one was asked for personal or medical information.

Data Collection and Analysis

Interview sampling was purposive as participants were specially selected to meet the research aim (Saunders et al., 2012). As such, recruitment of participants who fit the criteria proved very challenging and took several months due to the niche area of this topic. The scope was widened to include a broader range of upper limb differences, men and women, and stakeholders/users from the UK and North America. Snowball and self-selection techniques (Saunders et al., 2012) were applied by contacting disability organisations, posting on social media, and appealing to contacts in the adaptive sport and sportswear industries. In the end, five users with varying upper limb impairments were recruited, as well as five experts -- sportswear designers, a biomechanics researcher, and an orthotics apparel pattern cutter.

All participants were given participant information sheets before the interviews and asked to sign consent forms. 30- minute online interviews were conducted over two months through a Skype research account. Using Skype for interviews, with proper safeguarding considerations, can remove geographical and physical barriers to get a more diverse range of participants (Lo Iacono, Symonds, & Brown, 2016). Semi - structured interviews allowed for experiential anecdotes and unexpected findings (Saunders et al., 2012) while still following a specific questioning route to meet the aim. The wording of the questions varied between the two groups but addressed the same topics.

Questioning Route Topics:

- Current challenges with sportswear design for this consumer
- Ideas to improve sportswear design for this consumer
- Methods to determine this information
- Potential barriers for user and multidisciplinary collaboration

Interviews were audio-recorded and transcribed by a third party. Transcriptions were reviewed by the researcher and separated into two data sets for analysis, as noted above. Braun and Clark's (2006) thematic analysis, along with the QDA software Nvivo, was used to identify prevalent themes within each group. Participants were each sent a summary of themes found from their data set for review and comment, following participatory design philosophy. Three participants chose to respond, and each agreed with the results. Reflexive notes were recorded after interviews to 'acknowledg[e] the ways in which the researcher actively contribute[d] to the data [she was] generating' (Barbour, 2008, p. 55). Reflective notes were also taken throughout the interview and analysis process to track theoretical and practical research developments.

Findings

The main and sub-themes found from each data set are illustrated below in final thematic maps (Figures 1 and 2) with a summary of the most crucial themes following.

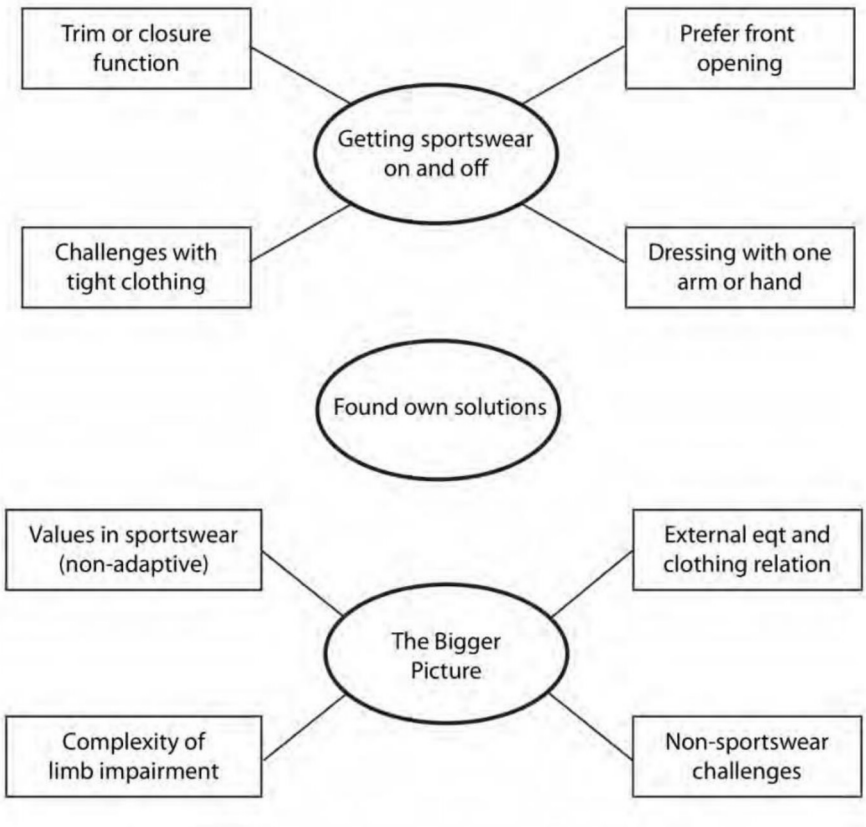

Figure 1 'Final Thematic Map – User Group' ©2020 Jennifer Poage.

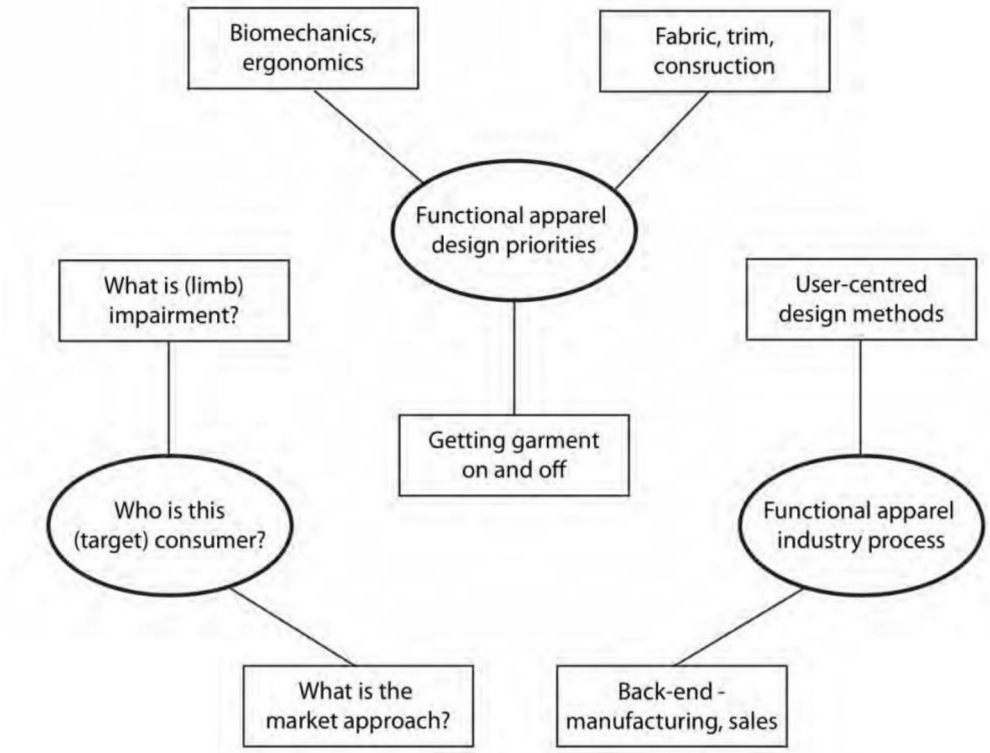

Figure 2 'Final Thematic Map – Expert Group' ©2020 Jennifer Poage.

From a pragmatic design perspective, common themes in sportswear design needs emerged. And most of these needs could be met through small adaptations to currently available sportswear, suggesting an inclusive design approach would be beneficial, similar to the findings of Carroll et al. (2007). The main struggles with (and suggestions to improve) sportswear involved donning and doffing -- putting clothing on and taking it off. Adding front openings to more garments, like sportsbras or compression tops, for instance, may be one effective solution. But while all participants in the user group had an upper limb difference or impairment, their symptoms, experiences, and outlooks varied greatly. As one participant said, 'the more people I meet within the disabled world, the variations of… even just arm amputations wi thin one arm is completely different.' So, while inclusive solutions like adding front openings or easy-grip closures could remove some barriers in dressing, a wider spectrum of solutions may be needed.

Inclusive and adaptive sportswear design is a very new and niche field, and no one in the multidisciplinary expert group had experience in this particular area. An unexpected finding was that this group speculated design solutions that closely matched what the user group said. This may be that sportsw ear designers have the training and an understanding of how the body works, which is necessary for functional apparel design. On the whole, their solutions were generalised, however, including broad suggestions of altering trims, fabrics, and construction but without precise details. Personal solutions generated out of necessity and described in detail emerged as an impactful theme from the user group. The user group provided more tangible ideas for improvements, such as specific types of draws trings or lacings that were easier to manipulate. For instance, a participant stated, 'we'd end up always putting a piece of string or leather strap inside the zipper to make it longer, something more, maybe a loop there so I could pull it up with one fing er.'

Amongst the expert group, ideas of upper limb impairment were talked about in many different ways. The expert group referred to: those with illness, people needing carers to dress, and injured athletes, for instance. One expert also suggested looking at how injuries or conditions change with age, if at all. Someone with a progressive illness needing a carer to dress may have vastly different sportswear needs from a professional athlete who is rehabilitating a temporary arm injury. But both may have difficulties pulling on a tight top overhead, for example. Either way, a more explicit definition is needed around:

1.) how this consumer is defined by industry.
2.) what this consumer group expects from the sportswear industry.
3.) what preconceived biases around this consumer may exist from industry professionals.

Development and manufacturing practices emerged as a point of discussion. To successfully bring inclusive sportswear to market, meaningful designs are not enough. Considerations, like sales, profit, and forecasting, were mentioned as integral to reaching this consumer. As the focus of the interviews was on design, these other areas need to be explored further. Amongst the experts, a variety of design strategies were mentioned (i.e. offering fully customised garments for individuals or inclusive designs that could work for a larger group.) As one designer said, 'I think a lot of these garments that we're talking about… Is it something that you'd be manufacturing in a very high volume or is it something that's going to be more tailored and custom-made for that specific user as well?' A range of these design approaches within industry may better address the individuality and complex context of upper limb impairment seen amongst the user participants.

Discussion

Design Strategy

As Shakespeare (2018) states, disability is complex and exists on a spectrum of symptoms and severity, which is echoed by the interview findings. So, a sole option or viewpoint for inclusive sportswear may be less effective (and less inclusive) than a range of solutions -- an 'Inclusive Sportswear Spectrum'. This approach is also seen in disability sports programs. In addition to being influenced by the interview results and elements of disability theory, the proposed Inclusive Sportswear Spectrum mirrors a model of inclusion for disability sport. Black and Stevenson (2011) present 'The In clusion Spectrum incorporating STEP' (STEP stands for space, task, equipment and people to adapt and modify sports activities). They write, 'The Inclusion Spectrum provides physical activity/sport teachers, coaches and volunteers with different methods of supporting inclusion. By delivering activities differently we can balance different needs within the group and so helping to maximise the potential of all young people' (Black et al., 2011, para. 2).

The Inclusion Spectrum Framework:

- *Everyone can play – naturally inclusive activities based on what everyone can do with little or no modifications...*
- *Change to include – everyone does the same activity using adaptations to provide both support and challenge across a range of different abilities...*
- *Ability groups – participants are grouped according to ability - each group does a version of the same activity, but at a level which suits the individuals in each group...*
- *Alternate or separate activity – individuals work temporarily on specific skills leading to more successful inclusion in the whole group...*
- *Adapted physical activity and disability sport – aspects of physical activity based on adapted physical activity or disability sport programmes can be included in all approaches.* (Black et al., 2011, paras. 3-7)

The Inclusive Sportswear Spectrum (Figure 3) presented here offers a range of design strategies to include consumers with upper limb impairments. They vary in: specificity to an individual's needs, the potential size of the target market, and manufacturing and costing requirements. It is intended for more significant and more meaningful consumer inclusion.

The Inclusive Sportswear Spectrum Framework:

- Inclusive -- mass-market styles that benefit the primary target market AND previously excluded consumers. Examples would be a sports bra or compression top with a front opening.
- Adaptive -- bulk manufactured styles suitable for consumers with shared limb difference needs (but not necessarily suitable for consumers without limb differences.) An example would be a compression top with a built-in arm brace.
- Self-customisable -- bulk manufactured styles that can be modified by the consumer to suit their specific needs. An example would be a top with adjustable sleeves that can be rolled and secured at varying lengths.
- Tailored – a one-off fully customised style to fit a consumer's personal needs and measurements

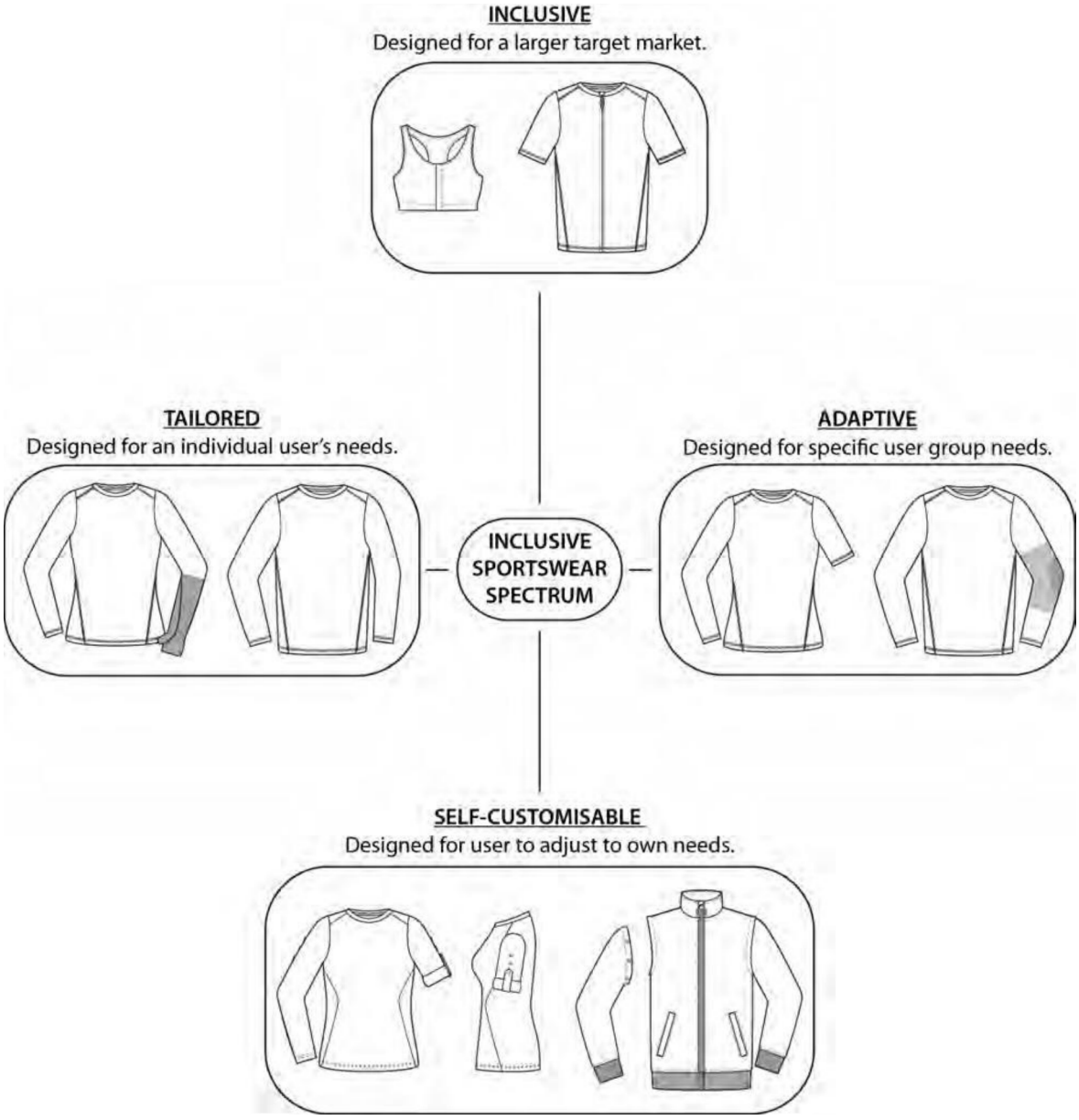

Figure 3 'Inclusive Sportswear Spectrum' ©2020 Jennifer Poage.

This framework should not be viewed as stagnant or complete. And certain categories can overlap. A self-customisable top with adjustable sleeves could also be an inclusive style, for instance, and be adopted by the primary target market. Moreover, technology like seamless knitting or 3D printing may allow a consumer to self-customise a tailored garment. As sportswear technology, disability awareness, and methods for inclusion shift, so should this framework.

Implications

Inclusive design not only removes barriers of exclusion to marginalised communities, but it can also be good business, according to Plumbe et al. (2010). They write that inclusive design can help companies with their social responsibility platforms to enable human rights, promote sustainability, and embrace social inclusion and diversity within and beyond the organisation. Besides, they state, design techniques can be applied at low cost but yield a high return on investment

sby reaching more people through innovative solutions. Doing human-centred research, as they describe, is cheaper than technology research and product development.

While inclusive design is not a new concept, -- the UK government coined this term in 2000 as 'products, services and environments that include the needs of the wides t numbers of consumers' (Plumbe et al., 2010, p. 9) -- it is not commonplace in the fashion industry. Nike's FlyEase shoe is described as 'universal design' on their website (Nike, n.d., para. 2), and Under Armour's MagZip could also be considered as such. But these are minimal examples. The Inclusive Sportswear Spectrum is meant to take ideas of brand and sportswear inclusion further. Interview participants did reveal options of one-handed dressing as an advantage, which the FlyEase and MagZip achieve. Whi le useful, the MagZip, however, simply replaces traditional zippers, while the interview participants suggest adding new openings or altering sleeve construction as well. The findings suggest that a wider scope is needed for more effective inclusive design innovation and, thus, greater representation within the sportswear industry.

The Inclusive Sportswear Spectrum also seeks to remove barriers of exclusion from a disabilities studies perspective. Ableism revolves around the notion that a 'normative individual' exists and promotes a distinction between 'perfected naturalised humanity' and those who do not fit this perception (Campbell, 2009, p. 6). Shakespeare counters this ideology with the statement, 'human perfection does not exist' (Shakespeare, 2018, p. 5). Berger and Lorenz (2015) argue that ableism is so ingrained in society th at it remains an unconscious bias affecting the lives of disabled people. Viewing upper limb impairment, or other so-called disabilities, as just one of many variations of human existence may help redefine what is 'mainstream.' Inclusive sportswear items and an inclusive sportswear industry offering a spectrum of options fit within this belief system by addressing the natural complexity of people.

Perhaps greater adoption for inclusively designed products would be to market them simply as standard offerings and, thus, widen the primary target market to include disability rather than delineate it. For instance, Marks and Spencer (n.d.a.) offers girls' 'Adaptive Leggings' in their 'Easy Dressing range.' What makes them 'adaptive' are smooth, flatlock seams and a hidden care label to keep skin irritation minimised. Flatlock seams are already used in mainstream sportswear to reduce skin chafing (Reebok, n.d.; Fabletics, n.d.). This kind of detailing could be marketed and distributed as inclusive, expandi ng the scope of the primary target market rather than imposing a distinction (or barrier) between labels of 'mainstream' and 'adaptive'.

Limitations and Future Research

These interviews and community engagement are the first stages of the PhD primary research. Further iterations of design workshops and stakeholder feedback will serve to expand the data corpus and triangulate methods for richer results. As the sample set is relatively small and purposive, the results are presented as an exploration and introduction to this niche topic. Also, the focus was strictly on sportswear for people with upper limb impairment as a solitary condition. While inclusive design and participatory design can be applied to a vast range of marginalised communities, the Inclusive Sportswear Spectrum should not be taken as a generalisation. The opportunity is open to see how and if it applies to other areas of f ashion and disability and how it might further evolve.

The literature review and primary research of this project focus mainly on the front-end of the design process -- problem definition and ideation of solutions -- to match the researcher's background and research timeline. Further research on back-end development and manufacturing, as well as other business operations, like sales and marketing, would be beneficial to refine the viability of the Inclusive Sportswear Spectrum. Following a participatory design and Social Model approach of empowering communities and removing barriers, users should be involved in conversation and collaborat ion with manufacturers and sales teams to expand on ideas of inclusion by sportswear brands. Accessing a more extensive scope of users, in addition to more experts in the fields of sports science, engineering, and biomechanics, along with professionals from the fashion industry, can maximise a multidisciplinary skill set and address barriers caused by preconceived biases.

Barry (2020) states that the fashion industry is shaped by how we educate future fashion designers and claims that 'the current state of fashion education prevents inclusivity in our industry.' (Barry, 2020, para. 3). Faerm (2012) writes, 'as the world demands better solutions for concerns…, educators are providing opportunities for students to become future "agen ts of change"' (Faerm, 2012, p. 4). To this extent, it could be impactful to explore the application and expansion of the Inclusive Sportswear Spectrum within fashion design curricula as a means to reassess 'the norm' in fashion and sportswear.

Conclusion

The most critical (and practical) implications based on the literature review and primary research findings are the great potential that inclusive design and participatory design can have on sportswear for people with upper limb impairment. Through participatory design, stakeholders' personal experiences with sportswear can be maximised to elicit a more meaningful and inclusive design strategy. For the interview participants, inclusive styles could be an effective solution. Small adaptations are all that is needed to make certain styles more user-friendly, such as adding a front opening to tight tops. And it may be that the primary target market would see advantages as well to garments that are easier to d on and doff. An Inclusive Sportswear Spectrum may provide even more opportunities for industry to remove barriers of exclusion by providing greater options in choice and more accessible garments for more people.

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Appendix K: *User group feedback JotForm questionnaire*

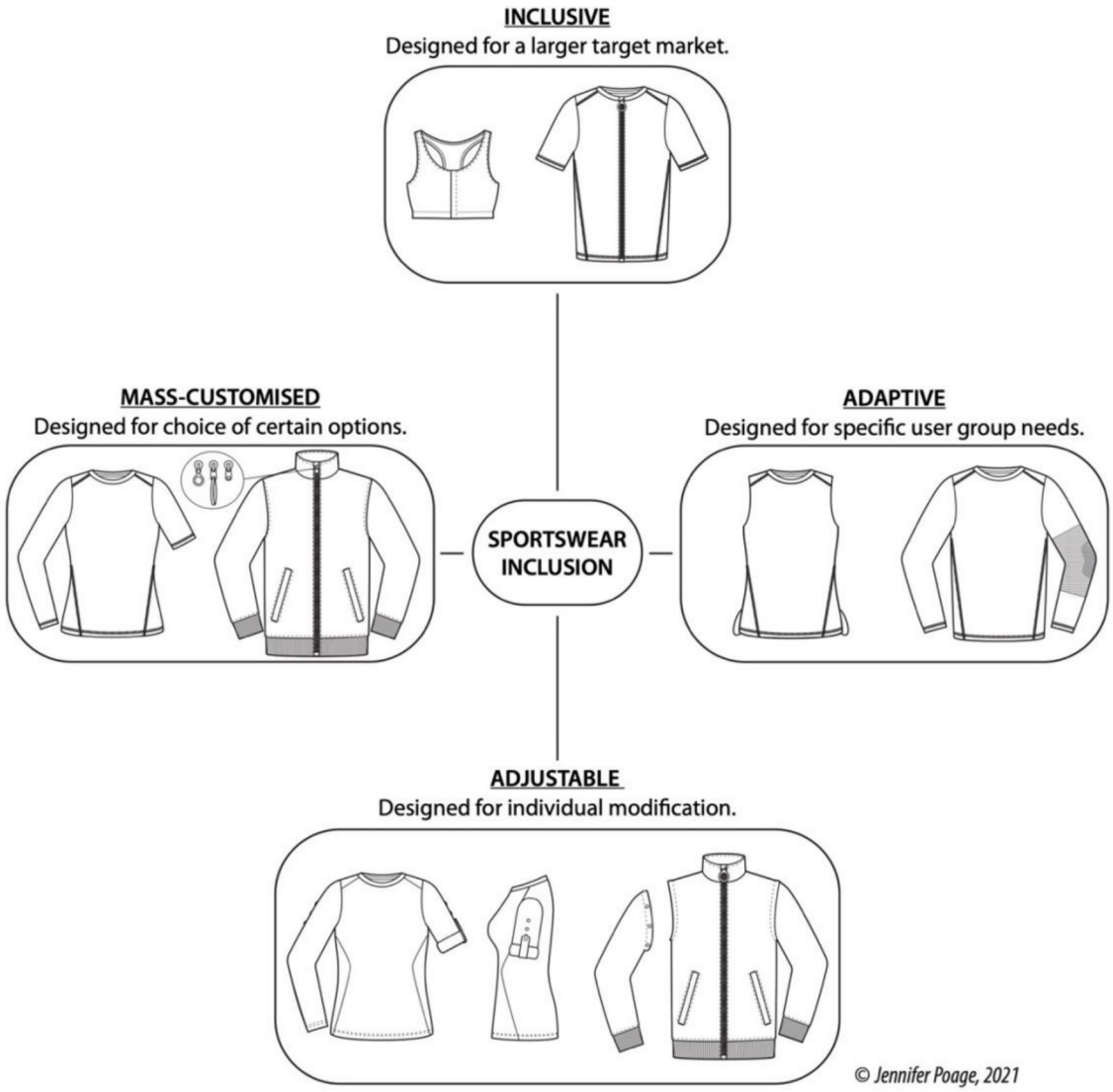
Sample, including two versions of the Sportswear Inclusion Map and feedback questions

Please review the diagram and description below. This has been created by the researcher based on previous interviews and workshops. Following, you will be asked for feedback.

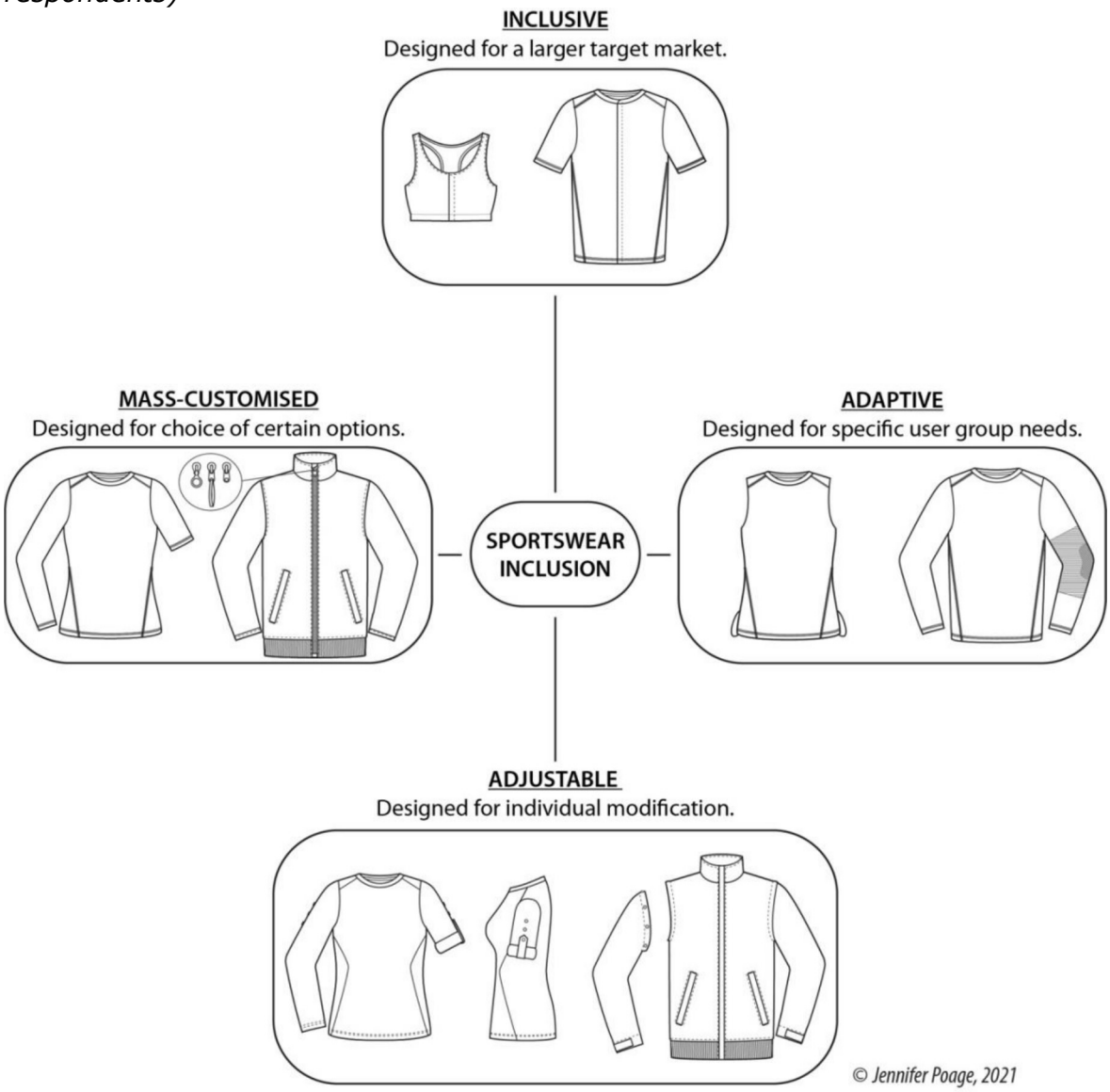
The Sportswear Inclusion diagram presents multiple design strategies for mainstream sportswear brands to better include people with upper limb impairments or differences.

This is a guide for designers and retailers to create and sell garments in many different ways for greater inclusion. But I would like to know if these options are appealing and useful to consumers, like yourself!

(Version of the Sportswear Inclusion Map for the first two questionnaire respondents)



(Updated version of the Sportswear Inclusion Map for remaining questionnaire respondents)



The options are:

Inclusive

Garments are designed to be easier to use so that a larger range of consumers are included. Examples would be a sports bra or a tight-fit cycling top with an accessible front opening. The idea is that mainstream styles are suitable for many different people.

Adaptive

These garments are designed to benefit a specific consumer group -- a smaller group than the previous option. For instance, thumbholes or loops attached to the hem (on a top) or waistband (on bottoms) may be preferable to some consumers. These added elements allow the wearer to pull down or pull up a garment without the need for tight grip.

Adjustable

Adjustable garments are designed for the consumer to make modifications to suit their own preferences. For example, long sleeve tops or jackets could have sleeves that roll up and secure in place with magnets. Or sleeves could be fully detachable or come apart at certain lengths.

Mass-Customised

These garments allow the consumer to choose from options when purchasing. One example would be a choice of zipper pullers, with a larger grip or a fabric loop -- or to replace the zipper with magnets or velcro. Another choice could be a selection of sleeve lengths for either arm.

Have you seen any of these options at sportswear brands? Which ones?

Which option(s) appeals to you most and least? Why?

How can the Sportswear Inclusion options be improved?

Do you have any other feedback for the researcher?

Thank You!

Your submission has been received.

*Thank you for taking part in this study! Please note the following: in case of questions or concerns, contact Jenn Poage at **j.poage0720171@arts.ac.uk** or UAL's Research Management and Administration team at **researchethics@arts.ac.uk***

Appendix L: *Stakeholder feedback topic guide*

Sample topic guide, including the tools shown

Intro (5-10 min)
Welcome and settling in. Any tech issues.
Overview of study aim.

- Aim of developing guidance and tools to give better awareness to sportswear industry designers around disability inclusion and how to bring consumers with an upper limb impairment or difference into mainstream offerings. Done user research and developed some guidance and now looking for input from designers who might not necessarily have worked previously in adaptive apparel.

Intros and ice breakers for participants.

- A bit more about myself.
- Names, area of sportswear design, user research.

Agenda, any ethics issues (recording, etc.)

- Will show a short presentation on the research and review the original tools. Want to know from you opinions on the tools, if they are new and seem viable. Will guide through feedback questions for discussion after they are presented.
- No right or wrong answers. Just opinions based own experience. This is about getting perspectives from mainstream sportswear industry.
- **Will be recording** -- can turn off video feed. You don't have to answer or divulge anything confidential. In turn, I ask that the tools I show here and the discussion be kept confidential (must preserve originality before PhD is published.)
- Any questions?

Research Presentation (10 min)
Present brief overview of the full project:

1. Working title (Sportswear Inclusion for people with upper limb impairment) and aim - to develop practical guidance for sportswear designers to better address people with an upper limb impairment or difference in hand, arm, or shoulder.
2. Methodology - PD to let the neglected consumer community dictate needs and preferences and contribute their expertise from experience.
3. Methods - Skype interview with users and with industry experts. Virtual design ideation workshops to find barriers, ideal solutions, and market gap. Map how the process followed.
4. Gap - Gap in knowledge and awareness. Tools needed to understand, reach, and serve consumers in industry.

Run through visual tools and their purpose. (5 min)

1. Wheel - There are many factors to consider when designing for this consumer group -- much complexity, individuality, and areas to consider when designing fit-for-purpose and meaningful sportswear. Also, how many people this affects and are excluded from mainstream offerings. Maybe a larger consumer base than realised.
2. Network - Previous social and industry exclusion of this community plus inherent complexity of disability means much community engagement and PD exploration is needed. How to reach the right people for collaboration, marketing, etc. if not known to industry or designers new to this field?
3. SI map - If people are so complex, how to develop and produce effectively and meaningfully for groups of consumers?

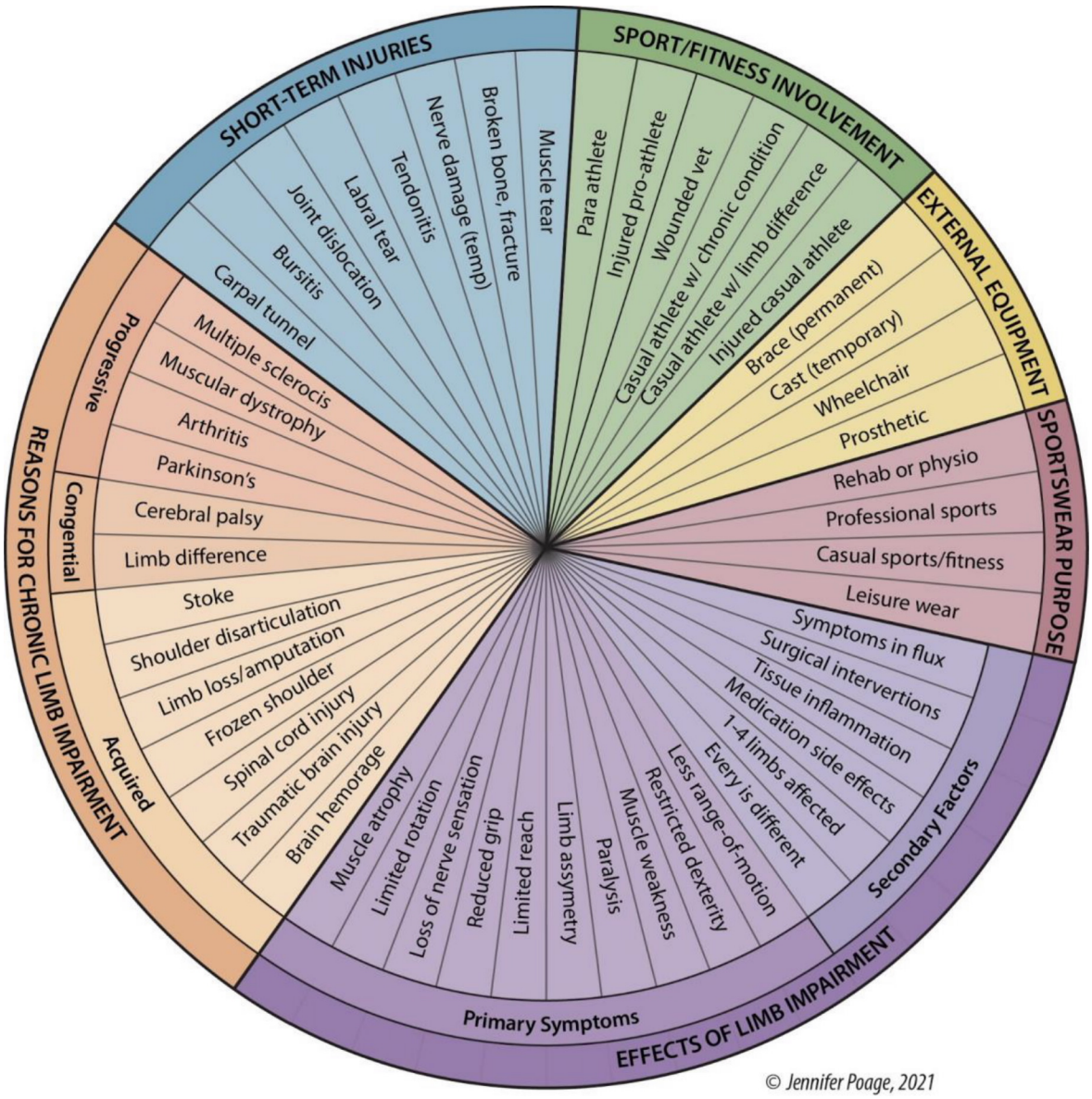
Explain what feedback is needed.

- Are these visual new to you? Do you see benefits? What is confusing or missing?

Evaluation Discussion (30 min)

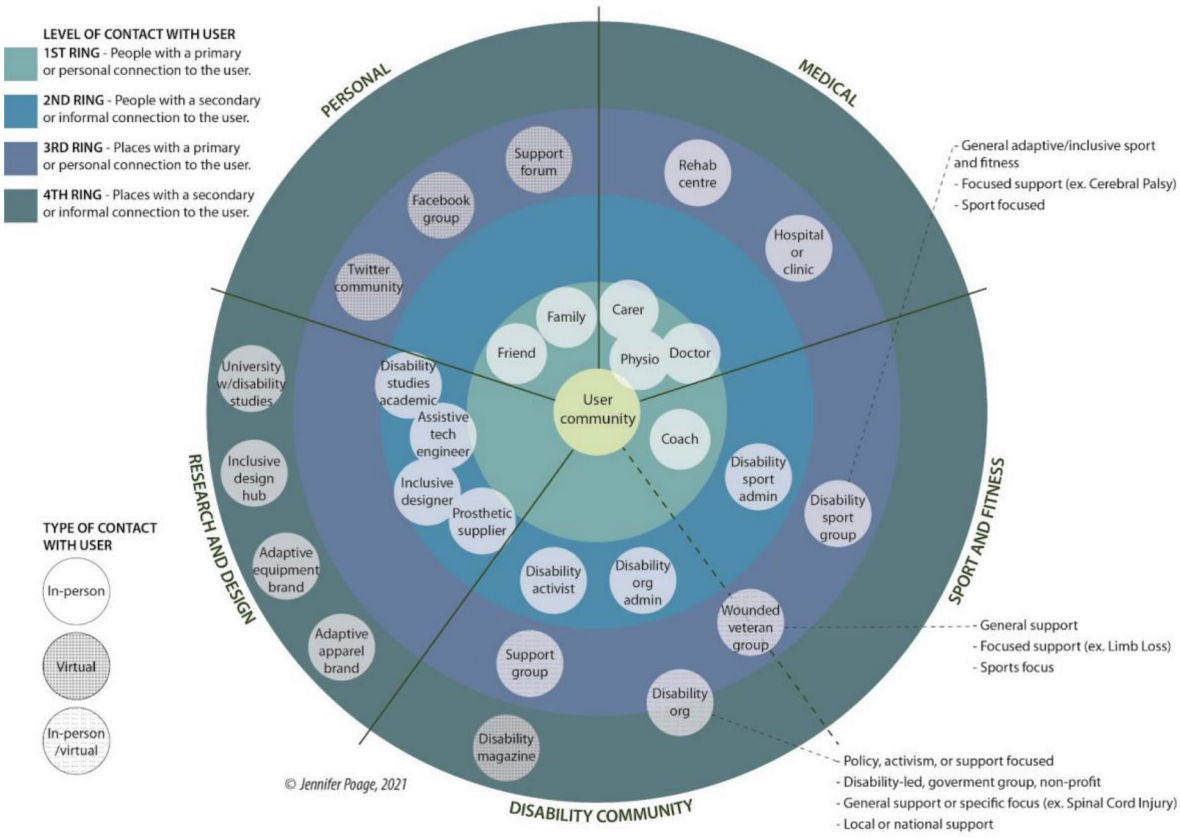
Stats and User Variables Wheel (~8 min)

- First thoughts (Is it clear? How do you read it?)
- Would it be useful in your practice if branching into an inclusive market? Why or why not?
- How can it be improved?



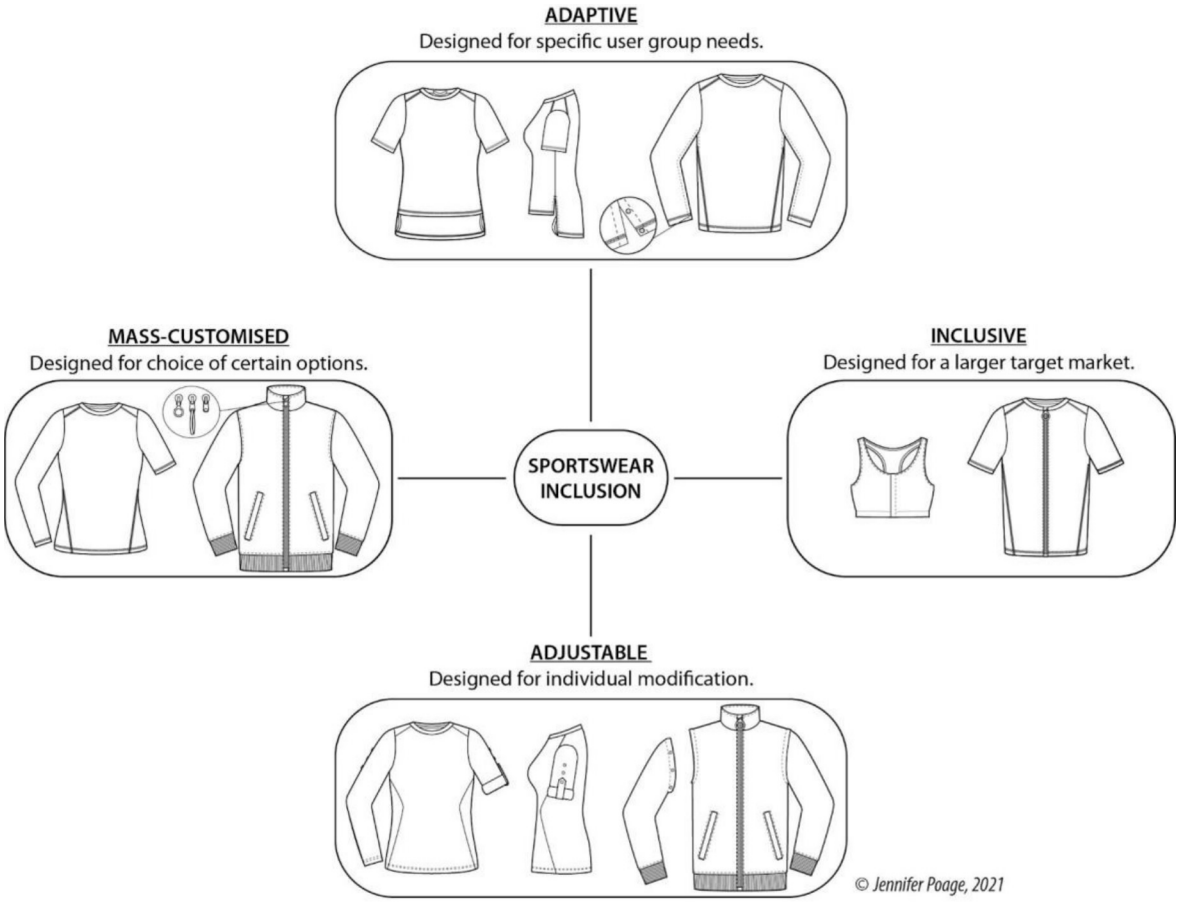
Ecosystem (~8 min)

- First thoughts (Is it clear? How do you read it?)
- Would it be useful in your practice if branching into an inclusive market? Why or why not?
- How can it be improved?



Sportswear Inclusion (~8 min)

- First thoughts (Is it clear? How do you read it?)
- Would it be useful in your practice if branching into an inclusive market? Why or why not?
- How can it be improved?



Overall (~6 min)

- What is missing?
- It is clear that these are tools and not representations or categorisations of "disabled people"?
- Other uses?

<u>Wrap-Up (5 min)</u>

Final comments.

- Comments will be used to revise the tools and write up the results of the thesis.
- Up to two weeks to withdraw contributions. After will be embedded into research.

Questions or concerns about this session.

Debrief and thanks!

Appendix M: *Stakeholder feedback data summary*

User Wheel	- This tool was generally well received, designers called it eye-opening and jarring to see excluded consumers on this scale. - Clarify terms (shoulder impact, symptoms in flux.) - Explore visuals to explain impairment "life-cycle." - Add personal quotes/stories for people-centred impact and empathy. - Mock-up breakout option with more information about effects on body and specific relevance to sportswear design, specific design considerations. - Remove spending power? (too business focused when the aim is more for social good, but may be good to indicate there is a commercial need.) - Include stats in visual as numbers were impactful to designers. - Expanded perceived scope of this consumer group, had thought mainly of most visible (wheelchair users) so full scope was not known (like arthritis.) - Several designers suggested adding in age ranges for the consumer segments.
User Network	- Mock-up breakout page of more info. - Add/correct terms, like charity and recruitment agency. - Discuss value and quality of engagement with diff stakeholders. - Make sure colours, layout, etc. are readable on screen and in print outs. - Different countries and markets (age groups) will have their own relevant resources.
Sportswear Inclusion Map	- Have fewer sketches with zippers, show other closure types. - Remove top w/built in arm brace (replace with magnet openings to fit prosthetic or brace.) - Revisit detachable sleeve on jacket. - Update detail pages with technical callouts, could drill deeper into branches for design innovation and application of individual design solutions. - Mass-customisation most challenging for industry, cost and minimums. - Some branches seen already in industry (adjustable, mass customisable) but not for this consumer and not in terms of functional options for more inclusion.
Overall comments	- More empathetic and applicable user research info needed: barriers in clothing, needs and opportunities. - Other tools can accompany this: ergonomics charts, body mapping, empathy building tools. - Other knowledge and considerations are needed for designers: there is real need in industry to address this market, disabilities studies framework, proper understanding of consumer clinical and value-laden needs. - Future research: add age ranges of these consumers, marketing considerations, where do consumers already buy sportswear or find solutions.

Reflective notes	- All participants needed! all stakeholders had valuable input on different points and perspectives - user validation critical to make sure output options are meaningful (physio had knowledge of commonalities). - Sportswear designers emphasised wheel as insightful, impactful to realise this large scope of consumers, and agree more awareness is needed, they provided pragmatic feedback very relevant to application in industry. - Disability innovation and inclusive designers were least relevant, had tips for researching and discussing disability, not specific for sportswear design needs. - Full collaboration needed, future work in codesign and more multidisciplinary workshops with stakeholders and users needed.