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Article type : Original Article

Title: **Measuring the frequency of consumer hair combing and magnitude of combing forces on individual hairs in a tress and the implications for product evaluation and claims substantiation.**

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Abstract:

Objectives: It is commonly assumed that, due to the long growth cycle of hair, multi-cycle combing, and strength and fatigue testing using thousands of cycles is relevant for product evaluation and claim substantiation. The objective was to assess the frequency and magnitude of combing forces on individual hairs against a hypothesis that fibres on a consumer's head rarely experience significant loads during routine combing.

Methods: Single fibres were removed from a tress, attached to a load cell and replaced in the tress. Combing of tresses, guided by in-vivo measurements, measured the frequency of significant loads defined as '*events'* ≥1g over 30 combing sets (set = 10 comb strokes @~25cm/sec) with intermediate tangling. Asian and Caucasian hair was assessed by dry, wet, bleached-wet and bleached-dry combing.

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A questionnaire of 231 Asian and Caucasian women established daily frequency and number of comb strokes for the whole head.

In-vivo combing videos of 10 women (5 Asian, 5 Caucasian) were used to establish in-vivo and tress combing speeds.

Results:

The questionnaires returned an average combing frequency of 1.7x/day (range 0-5) and average number of strokes 16±2.3 per head/day (95% CI). Video analysis measured combing speeds of 22-35cm/s across hair types.

Tress data confirmed individual fibres are unlikely to experience repeated loading or significant loads in all but wet combed persulphate bleached hair. 'Events' of ≥1g - dry combing gave an event probability of 0.2 and average load of 1.7g over 30 comb sets. Dry combed bleached samples returned a probability of 0.23 and 0.3 respectively. Wet combed virgin Asian and Caucasian hair gave a probability of 0.1 and 0.47 respectively. Wet combed bleached hair gave a probability of 1. The addition of a conditioner to bleached hair reduced the event probability to <0.1

Conclusion:

During combing, individual fibres may not experience any significant loads and are unlikely to experience repetitive loads >10g

The low number of comb strokes and low event probability is in keeping with consumers growing their hair long and in good condition. The data indicates the need for a significant rethink of methods used for product evaluation and claim substantiation.

Introduction:

The main aim of combing or brushing is to bring a disordered array of hair fibres to an organised style considered acceptable to the owner. The total array on a mature head is composed of >100,000 fibres although their position and length affects the potential degree of disarray and fibre-fibre interaction. At the immediate scalp fibres are anchored in follicles and in perfect alignment thus creating a pre-emptive hair style. Within a short length of growth those same fibres are able to interact or tangle with many other fibres. Once the individual fibre length exceeds half the circumference of the scalp, each fibre can interact with any and every other fibre resulting in increased disarray, tangles and knots. In the three regions of fibre length i.e. at the scalp, mid-fibre and fibre-ends one would anticipate different degrees of damage from the same cosmetic procedure or insult e.g. combing. Therefore, frictional forces and loads experienced by any fibre will be different depending on its length and position in the hair array.

In addition, the ease of detangling, aligning and forces experienced by fibres will be dependent on combing speed. If speeds are high and faster than the rate at which the hair can detangle the fibres will be forced in to tight curves placing high load forces at angles to the longitudinal axis of the fibre i.e. parallel load elongation or fatigue experiments to breakage would not adequately reflect the direction of mechanical forces during combing to remove the tangle.

Combing or brushing hair is often considered one of the most common and damaging aspects of a normal hair care regimen. However, this must be kept in perspective as many women grow hair to considerable length while exposing it to a vast array of cosmetic practices. Cyclical combing [1,2] and fibre fatigue [3] measurements are routinely used to measure the protective effects of hair cosmetics, especially conditioners. A reduction in combing forces, reduced hair breakage, the presence / absence of split ends or increased duration to fibre failure in such tests are used to make claims of increased hair strength or improved resiliency. All of the methods are characterised by repeat insults often running to many thousands of cycles. This is justified with the simple calculation of an estimated consumer combing habit multiplied by the age of the ends of the fibres. For example, the ends of hair 24cm in length may be 2 years old resulting in a calculation of 2 x 365 days x 10 comb strokes per day = >7000 comb stokes or fatigue cycles. However, this simple calculation is an over simplification of the typical consumer habit and each hair fibre will experience far fewer comb strokes or fatigue cycles during its lifetime.

As a separate consideration, hair fibres can show evidence of cuticle damage within 1cm of the scalp surface. But perhaps most curious is that as you progress from the scalp the fibres show evidence of damage all around the fibre i.e. the complete circumference of an approximately circular fibre has been damaged. This clearly cannot be caused by combing or brushing alone as each fibre is approached only from one side, and most fibres are unlikely to contact the comb or brush.

In this paper we pose the hypothesis that any single hair fibre rarely experiences either significant combing forces or long term, cyclical loading. With an additional understanding of the array we will begin to question the high cycle number test designs common to the industry for measuring ingredient and product effects. In turn this will identify a need for new methods and protocols to identify and test ingredients and formulations.

Methods:

5 gram, 32 cm hair tresses (Kerling International) containing approximately 3000 hair fibres either untreated (virgin) or bleached were used throughout the study. Three fine Chinese (Asian) black hair tresses and three fine European (Caucasian) brown hair tresses were used for each assessment. Comb tine spacing allowed for 20 tines (19 spaces) to cover the whole tress equivalent to an estimated 160 fibres between each adjacent pair of tines. For each experiment the tress is fixed in position. A single hair was cut at the proximal end from the tress, attached to a load cell (range 0 -100g), and re-introduced to the tress ensuring complete freedom of movement of the fibre and recording at the load cell (Figures 1 & 2) Before each dry combing cycle the hair was tangled using a blow dryer for 45 seconds. For wet combing each tress was dipped in to water between each combing set. A ‘combing set’ was defined as 10 consecutive comb strokes and each tress was combed for 10 sets, five from the front and five from the back of the tress. All combing was conducted by hand at ~21-25cm/second. Load cell force values were recoded every 10ms and all forces >1g were considered as a loading ‘event’. Where the load continued at >1g for each 10ms interval it was assumed to be a single, continuous event. ‘Count’ was defined as the number of events occurring in 1 combing set.

Load cells with a range of 0-100g were designed to the required specification and manufactured by Applied Meausrements Ltd. Berkshire, RG78PN, UK, linked to a PC via a USB strain gauge digitiser.

Experiments were conducted to establish whether combing from the front, side or back of the tress affected the interaction of the comb with the identified fibre or whether it was obscured by other fibres due to its location in the tress. Additional tests where the identified fibre was purposely tangled in the tress were also conducted.

Tresses were assessed according to treatments i.e. dry, wet, virgin (untreated), bleached or bleached and conditioned. Bleach protocol: Wella Professional Multi-Blondor Powder and Wella Professional Welloxon Perfect Peroxide Developer 12% 40vol, was used to bleach the hair tresses for 20 minutes at 35°C. The hair was processed without the in-box conditioner to provide an unmasked state of damage for testing.

To establish consumer relevant combing speeds and the number of comb strokes typically used to comb the head, two additional methods were used. To measure combing speeds in-vivo videos of consumers were assessed for various hair lengths and included repeated dry tangling. Subjects were instructed to comb their hair 10 times starting from the roots. After the 5^{th} stroke, fibre entanglement was induced with a hair dryer for 20 seconds. For frequency of combing throughout the day and number of comb strokes used each time the head is combed a consumer survey was used composed of 145 Asian and 86 Caucasian females of varying hair lengths and styles.

Key to terminology:

An ‘event’ – a force value ≥1g at the load cell

Comb set – 10 sequential comb strokes applied to a pre-tangled tress.

Results:

In-vivo data for combing frequency and combing speed:

An estimation of the number of times women comb their hair each day and the number of comb strokes used each time they comb their hair was generated using questionnaire data from 231 participants (Table 1).

Table I: Estimating the number of comb strokes and frequency of combing throughout the day.

Responses		Number of combing strokes used (strokes)					
		1 – 7	8 – 14	15 – 21	>21	0	Total
Daily combing frequency (no. of times)	0 – 1 (mid: 0.5)	45	22	12	14	9	102
	2 – 3 (mid: 2.5)	61	35	11	12	0	119
	4 – 5 (mid: 4.5)	2	4	0	1	0	7
	>5 (mid: 5.0)	0	2	0	1	0	3
	total	108	63	23	28	9	231
Average no of comb strokes							16 ±2.3(95%CI)
Average daily combing frequency	1.7						

For daily combing frequency calculations mid point values were used e.g. for combing frequency questionnaire data of 2-3 times per day a mid point of 2.5 was used. The data from table 1 gives an estimated average daily combing frequency = 1.7x (range 0-5) and an average number of comb strokes per day of 16±2.3 (95%CI). For individuals combing their hair on average 1-2 times per day we can estimate a figure of 10 comb strokes in total for the whole head each time they comb their hair.

Videoed combing speeds from 10 individuals (5 Asian and 5 Caucasian, Tables 2a & 2b) all with hair shoulder length or longer indicate a typical consumer combing speed of >20cm/second.

Table 2a. In-vivo combing speeds of Caucasian women (≥ shoulder length)

Subject	Stroke 1 (cm/s)	Stroke 2 (cm/s)	Stroke 3 (cm/s)	Stroke 4 (cm/s)	Stroke 5 (cm/s)	Average (cm/s)
A	17.5	21.4	22.6	27.4	22.3	22.2± 3.5
B	25.0	26.3	27.0	21.8	24.8	24.9± 2.0
C	25.1	21.9	21.0	30.2	25.8	24.8± 3.6
D	22.0	19.4	23.9	19.9	26.5	22.3± 2.9
E	31.1	30.2	27.9	31.0	28.1	29.6± 1.5

Table 2b. In-vivo combing speeds of Asian women (≥ shoulder length)

Subject	Stroke 1 (cm/s)	Stroke 2 (cm/s)	Stroke 3 (cm/s)	Stroke 4 (cm/s)	Stroke 5 (cm/s)	Average (cm/s)
A	26.1	20.4	28.5	27.1	27.6	25.9± 3.2
B	23.0	22.1	22.3	20.5	30.4	23.6 ± 3.8
C	36.0	29.7	30.0	18.4	23.3	27.4± 6.7
D	20.9	30.5	26.3	33.5	39.3	30.1± 6.9
E	30.7	39.6	33.0	29.2	41.7	34.84± 5.5

Combing speeds for ex-vivo tress experiments (table 3) were designed to match in-vivo combing speeds

Table III. Combing speed ex-vivo based on in-vivo measurements.

Hair Type	State	Stroke 1	Stroke 2	Stroke 3	Stroke 4	Stroke 5	
Asian	Dry	5.31	5.5	11.0	22.7	26.3	
	Wet	7.6	12.9	13.9	26.0	24.6	
Caucasian	Dry	7.3	25.6	27.8	27.7	24.4	
	Wet	10.9	20.9	25.1	26.0	28.8	
		Stroke 6	Stroke 7	Stroke 8	Stroke 9	Stroke 10	Mean (cm/s)
Asian	Dry	24.8	29.3	29.3	32.4	37.8	22.4± 11.3

	Wet	27.9	23.6	25.6	27.2	27.5	21.6± 7.3
Caucasian	Dry	26.4	29.7	32.3	31.6	33.6	26.6± 7.4
	Wet	29.7	27.1	29.5	26.7	29.3	25.4± 5.7

Load cell data overview (Table 4):

The data in Table 4 summarises the frequency and magnitude of loads experienced by each test fibre within a pre-tangled tress. A comb set was defined as 10 comb strokes on a pre-tangled tress. The tress was re-tangled after each set and combed for a total of 30 comb sets. The data shows that for dry hair, normal or bleached and Caucasian or Asian, the fibre does not experience a measured load (event) of ≥1g in every comb set. Indeed, the probability of such an 'event' is low (≤0.3 for 30 comb sets). The maximum load recorded in dry combing even for bleached Caucasian hair (12.3g) and an average load of <2g.

Wet virgin hair returns an event probabilty over 30 comb sets of <0.5 for Caucasian and 0.1 for Asain hair respectively.

Wet, virgin Caucasian hair shows a marked increase in the probability of an 'event' although there is no significant change in the maximum force compared to dry hair. Wet, persulphate bleached Asian and Caucasian hair returned an event probability of 1 with all comb sets registering loads ≥1g and a drammatic increase in the number of events per comb set compared to virgin hair. The bleach treatment, in the absence of a conditioner, resulted in excessive tangling. As a result the tresses could not be fully combed and readings were taken over the bulk length of the tress but not through the end tangles. The addition of a conditioner to wet, bleached hair, showed the expected reduction in the probability of both an event and average load for both Caucasian and Asian hair types compared to unconditioned wet or bleached, wet hair.

Table IV: load cell data. V=virgin, B=bleached, C=conditioned. 'Event' = a recorded load ≥1g. 'Comb set' = 1 tangled tress combed 10 times.

	Hair type	Treat	N (Comb set)	No. of comb sets in which an event occurred	Total events in 30 comb sets	Min. count in 1 comb set	Max. count in 1 comb set	Min. load (g)	Max. load (g)	Avg. load (g)	Probability based on 30 comb sets
Dry	Asian	V	30	6	6	0	1	1.20	5.77	1.78	0.20
		B	30	7	7	0	1	1.12	4.53	1.38	0.23
	Caucasian	V	30	6	17	0	9	1.16	4.03	1.77	0.20
		B	30	9	14	0	3	1.11	12.3	1.79	0.30
Wet	Asian	V	30	3	3	0	1	1.14	1.16	1.08	0.10
		B	30	30	508	3	31	1.80	12.3	2.06	1.00
		B+C	30	0	0	0	0	0.00	0.00	0.00	0.00
	Caucasian	V	30	14	17	0	2	1.07	3.04	1.37	0.47
		B	30	30	365	5	28	1.90	7.61	2.04	1.00
		B+C	30	2	2	0	1	1.17	1.60	1.26	0.07

Load 'events' were defined as a load ≥1g then returning to a load of <1g. A continuous reading resulting in a load ≥1g for sequential time intervals was measured as a single event and not as multiple loading events (fig 1.)

Discussion:

Robbins [4] estimated the average combing force on a single fibre as 39.5g (range 16-110) in a tangled curly tress. This assumes all fibres contribute to the combing resistance or measured force. The paper does conclude that all fibres, unless involved in a tangle and experiencing a significant load causing them to break, will remain within the elastic or Hookean region of the tensile curve. However, that allows for a large force range including zero force and gives no indication of how often the fibre is involved in a loading event.

The force experienced by the group of fibres between any pair of comb tines is not equally distributed across all fibres. Frictional forces on those fibres in contact with the comb result from pressure applied by the user and radial outward pressure from the hair bundle as it is guided and compressed between the tines. It is our contention that very few fibres experience significant tensile or frictional loads during combing compared to the total number of fibres brought in to a parallel array by a relatively low number of comb stokes across the head. To this end the minimum load classed as a loading 'event' was set at ≥1g i.e. low enough to measure a force and low enough to avoid setting a threshold at a random point on the elastic component of the hair tensile curve.

The probability of a fibre undergoing an 'event' i.e. a load over 1g is not constant. When the hair is first tangled the possibility of a single hair being involved in the tangle and recording a loading event is at its maximum for the experiment. After the first comb stroke much of the tangle is removed. By the second or third comb stroke all of the tangle is removed and one reverts to combing an aligned array. Here the forces are due to comb to hair friction, and hair to hair friction or adhesion and are expected to be ≤1g on individual fibres. Therefore, the expected frequency of a loading 'event' is not constant in any consumer or laboratory combing scenario and should decline throughout the test or styling process.

The effect of position of the test fibre was also checked. For all experiments the test fibre was placed towards the front of the tress with respect to the comb and operator. Exploratory combing from the side and the back of the tress showed no effect on the results. In addition, the test fibre was purposely tangled in the tress to ensure that a result would be measured and not missed when known to be present.

An additional consideration was defining the recording intervals. Small intervals e.g. 10ms will record a single 'event' load as a series of data points whereas the fibre will have experienced a single, continuous loading event. Therefore, summing the number of data points ≥1g does not equate to the actual number of loading events. Each loading event was examined and defined as an applied load for a period of time and then the recording returning to approximately zero.

Individual fibres or hair tresses used for fibre studies and product evaluation are often described as "virgin" indicating no previous chemical treatment. However, these are taken from real heads leaving the owner with sufficient hair to retain a reasonable hair style. The samples, although described as "research grade hair" will have already experienced many wash, dry, comb or brush cycles. It is, therefore, out of the consumer context to add an additional several thousand comb or stress cycles to measure a product benefit as only the fibre portion at the top of the tress would experience so many multiple insults in real life. Using the data presented one can conclude that a high number of comb or stress cycles is very unlikely to occur on a consumer's head even if starting at the root and will not occur when starting with a purchased hair sample where the proximal end has been cut many centimetres from the scalp.

Laboratory testing using individual fibres and the resulting conclusions or claims makes the assumption that all fibres are exposed to the same frequency and magnitude of loading forces during combing. While it would be correct to conclude that a treatment can deliver an effect to an individual fibre, that effect may be of little relevance if the fibre never undergoes the loads or frequency of loading used in the experiment. Under the reported experimental conditions approximately 160 fibres are guided between each pair of tines. Therefore, one either concludes the measured force is equally divided across all fibres at every stroke (estimated 0.3g/fibre) or a few, or one fibre experiences the total measured force of ~5g (maximum 12g).

Combing and wear experiments, therefore, give an indication of what might occur on head and give similar results e.g. low numbers for hair breakage over several thousand comb cycles that one might see on a normal head of long hair. However, these tests probably exaggerate the magnitude of a product effect and a benefit that might not be found on most consumers' heads. Multi-cycle fatigue experiments at higher loads e.g. ≥10g may reflect fibre properties when considered as an engineering substrate but probably have little direct relevance to performance on heads. Indeed, product testing at loads of <10g and < 100 cycles may be a more realistic and appropriate set of parameters.

From on-head videos, combing speeds below10cm/s were not observed even after tangling the participants' hair for 20 seconds with a hair dryer. All in-vivo combing speeds (table 3) were in excess of 20cm/second and are expected to be higher in a non-test or home situation. This raises the question of whether stress strain or cyclical loading measurements conducted at low rates of extension or detangling can predict the in-vivo situation or measure relevant product benefits. In contrast, one must consider the cause of broken fibres that clearly appear on consumers' heads. The mantra is that hair should first be detangled at the ends before combing through from the scalp. Failure to do this combined with the measured combing speeds results in the comb hitting a tangle at high speed. The load is spread across a number of fibres but not equally between all fibres in the tangle or passing through the comb. It is expected that some fibres will be extended into the yield or post yield region resulting in lifted cuticle scales and transverse fissures or fractures [5,6]. However, the majority of fibres will be protected from such events by a) not actually experiencing such catastrophic loads and b) the feedback loop between the combing hand and resulting stress placed on the scalp and neck, in turn providing a shock absorbing reduction in load i.e. the consumer stops combing when it hurts or conveys a damaging force. Therefore, and in line with the results presented, not all hairs should be expected or claimed to suffer the same events equally.

An extension of the data was to consider how many times individual fibres might be combed when part of a whole head. If one now assumes an average number of comb strokes for the whole head of 16 per day spread across a head of ~120,000 hair fibres. The chance of a fibre contacting the comb at any time would be remarkably low. Using the tress data 10 comb strokes for a tress of ~3000 hairs equates to 400 comb strokes /day for 40 tress-equivalents making up the whole head. Therefore, even in this very exaggerated combing scenario the probability of a fibre being involved in a combing event is remarkably low unless bleached, unconditioned and wet combed. If one considers 16 strokes/day as the average number for the whole head then each tress-equivalent (3000 hairs) on a head would receive just 0.4 comb strokes (~150 comb strokes/year) indicating that not all of the head, or any fibre, is combed all of the time. Again, it is evident that one cannot assume all fibres in an array experience frequent and repeated loads.

Conclusion:

The data from this initial work indicates that typical combing and wear experiments give only an indication of what might occur on head and only on very long hair. During combing, individual fibres may not experience any significant load and are unlikely to experience repetitive loads >10g

The low number of comb strokes combined with the low 'event' probability is in keeping with consumers growing their hair long and in good condition.

The data and claimed magnitude of product effect from prolonged laboratory combing studies needs to be treated with caution as it may not be at all consumer relevant. Multi-cycle fatigue experiments at higher loads e.g. >10g, may reflect fibre engineering properties but probably have little direct consumer relevance to product or ingredient performance on heads beyond a few tens of cycles. Further, these data now call in to question claims stating a magnitude of change based on very high number repeat cycle methods. Consequently, the data indicates the need for a significant rethink of methods used for hair care product evaluation and claim substantiation.

Acknowledgements

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Figures

Figure 1. Combing set up showing position of the load cell attached to a single fibre placed at the front of the tress.

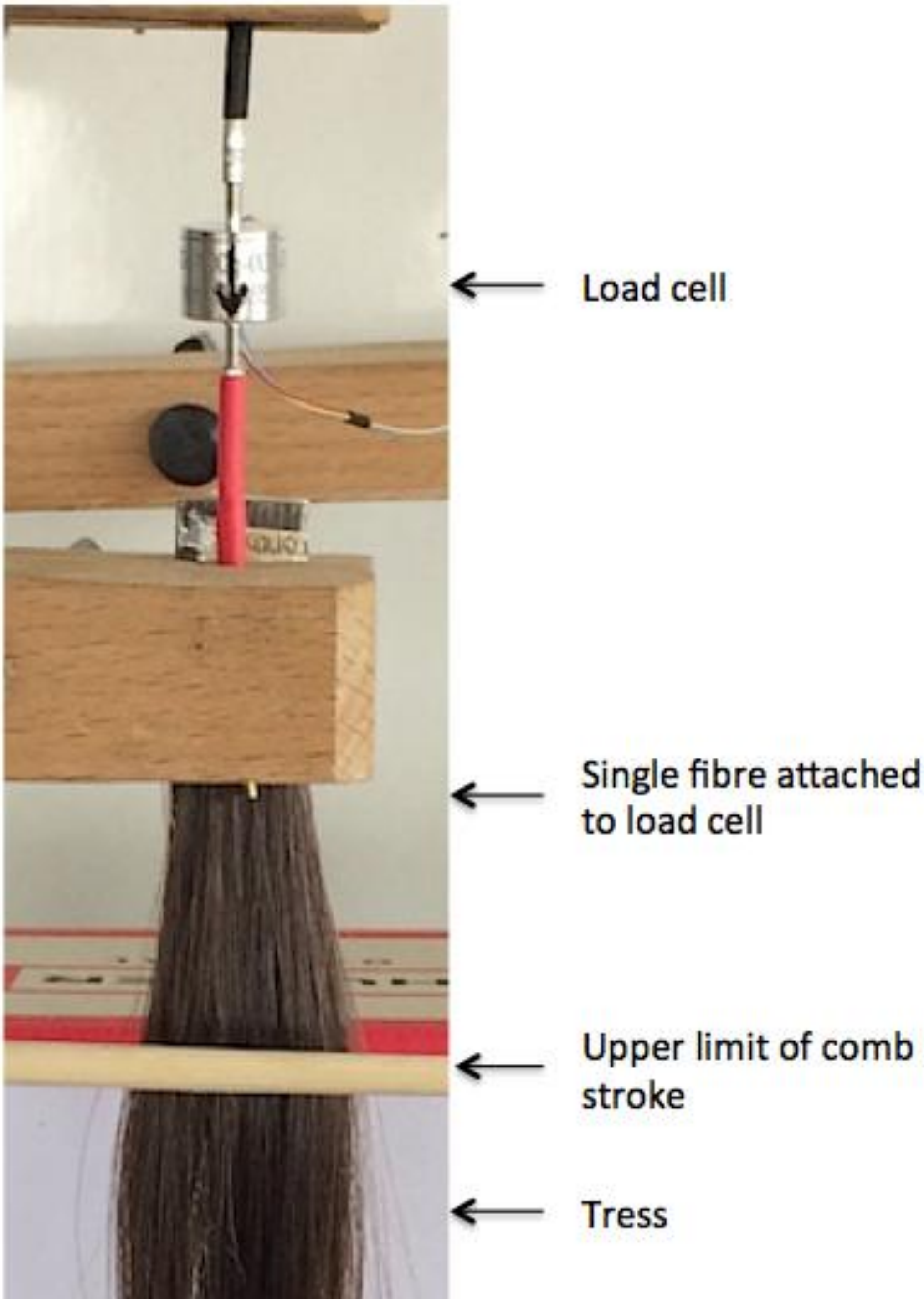
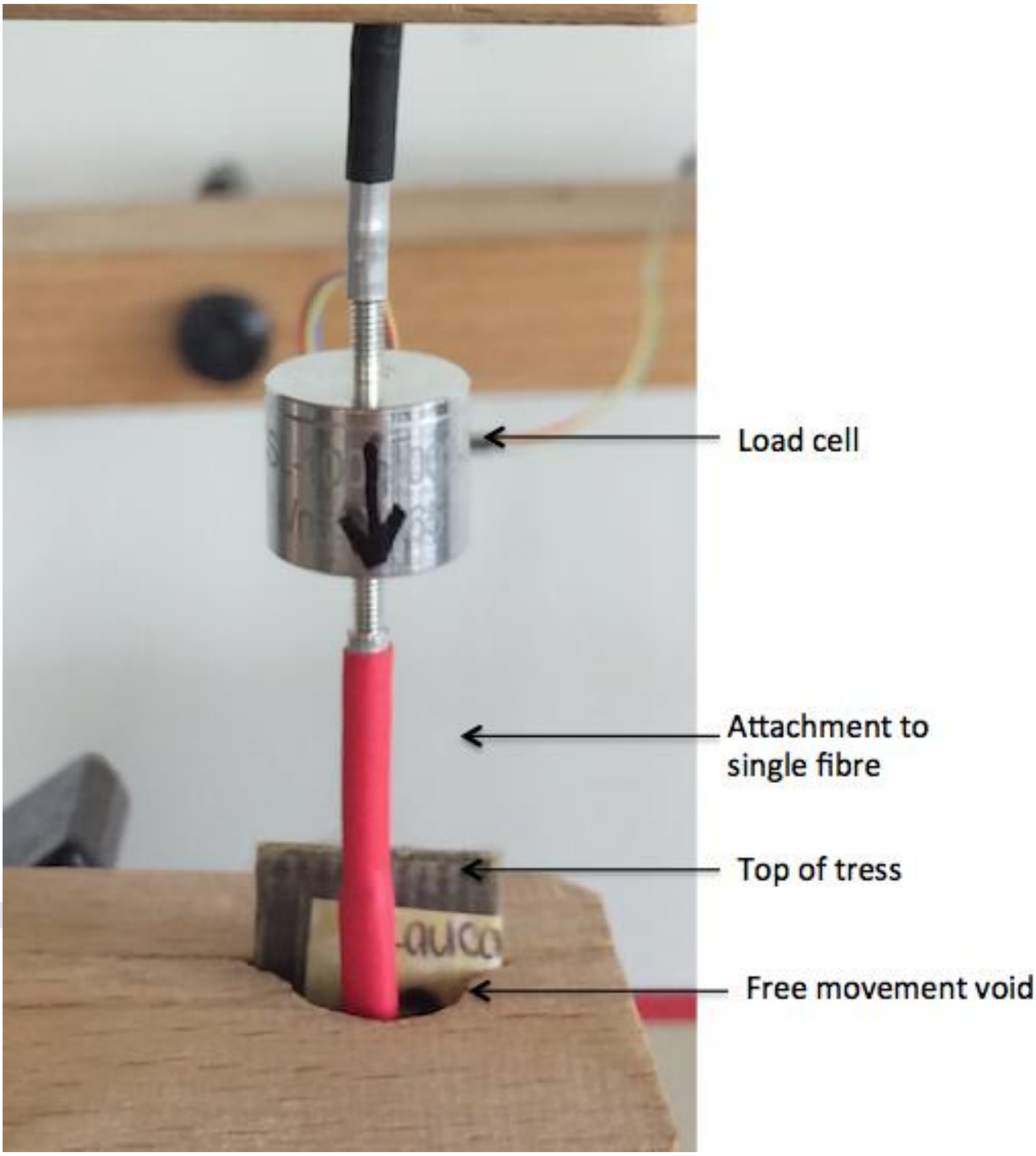


Figure 2. The load cell attachment to a single fibre passes freely through the tress clamp allowing a full range force measurement fro 0-100g



Tables

Table I: Estimating the number of comb strokes and frequency of combing throughout the day.

Responses		Number of combing strokes used (strokes)					
		1 – 7	8 – 14	15 – 21	>21	0	total
Daily combing frequency (no. of times)	0 – 1 (mid: 0.5)	45	22	12	14	9	102
	2 – 3 (mid: 2.5)	61	35	11	12	0	119
	4 – 5 (mid: 4.5)	2	4	0	1	0	7
	>5 (mid: 5.0)	0	2	0	1	0	3
	total	108	63	23	28	9	231
Average no of comb strokes							16 ±2.3(95 %CI)
Average daily combing frequency	1.7						

Table 2a. In-vivo combing speeds of Caucasian women (≥ shoulder length)

Subject	Stroke 1 (cm/s)	Stroke 2 (cm/s)	Stroke 3 (cm/s)	Stroke 4 (cm/s)	Stroke 5 (cm/s)	Average (cm/s)
A	17.5	21.4	22.6	27.4	22.3	22.2±3.5
B	25.0	26.3	27.0	21.8	24.8	24.9±2.0
C	25.1	21.9	21.0	30.2	25.8	24.8±3.6
D	22.0	19.4	23.9	19.9	26.5	22.3±2.9
E	31.1	30.2	27.9	31.0	28.1	29.6±1.5

Table 2b. In-vivo combing speeds of Asian women (≥ shoulder length)

Subject	Stroke 1 (cm/s)	Stroke 2 (cm/s)	Stroke 3 (cm/s)	Stroke 4 (cm/s)	Stroke 5 (cm/s)	Average (cm/s)
A	26.1	20.4	28.5	27.1	27.6	25.9± 3.2
B	23.0	22.1	22.3	20.5	30.4	23.6 ±3.8
C	36.0	29.7	30.0	18.4	23.3	27.4± 6.7
D	20.9	30.5	26.3	33.5	39.3	30.1± 6.9
E	30.7	39.6	33.0	29.2	41.7	34.8± 5.5

Table 3. Combing speed ex-vivo based on in-vivo measurements.

Hair Type	State	Stroke 1	Stroke 2	Stroke 3	Stroke 4	Stroke 5	
Asian	Dry	5.31	5.5	11.0	22.7	26.3	
	Wet	7.6	12.9	13.9	26.0	24.6	
Caucasian	Dry	7.3	25.6	27.8	27.7	24.4	
	Wet	10.9	20.9	25.1	26.0	28.8	
		Stroke 6	Stroke 7	Stroke 8	Stroke 9	Stroke 10	Mean (cm/s)
Asian	Dry	24.8	29.3	29.3	32.4	37.8	22.4± 11.3
	Wet	27.9	23.6	25.6	27.2	27.5	21.6± 7.3
Caucasian	Dry	26.4	29.7	32.3	31.6	33.6	26.6± 7.4
	Wet	29.7	27.1	29.5	26.7	29.3	25.4± 5.7

Table IV: load cell data. U=unbleached, B=bleached, C=conditioned. 'Event' = a recorded load ≥1g. 'Comb set' = 1 tangled tress combed 10 times.

	Hair type	Treat	N (Comb set)	No. of comb sets in which an event occurred	Total events in 30 comb sets	Min. count in 1 comb set	Max. count in 1 comb set	Min. load (g)	Max. load (g)	Avg. load (g)	Probability based on 30 comb sets
Dry	Asian	UB	30	6	6	0	1	1.20	5.77	1.78	0.20
		B	30	7	7	0	1	1.12	4.53	1.38	0.23
	Caucasian	UB	30	6	17	0	9	1.16	4.03	1.77	0.20
		B	30	9	14	0	3	1.11	12.3	1.79	0.30
Wet	Asian	UB	30	3	3	0	1	1.14	1.16	1.08	0.10
		B	30	30	508	3	31	1.80	12.3	2.06	1.00
		B+C	30	0	0	0	0	0.00	0.00	0.00	0.00
	Caucasian	UB	30	14	17	0	2	1.07	3.04	1.37	0.47
		B	30	30	365	5	28	1.90	7.61	2.04	1.00
		B+C	30	2	2	0	1	1.17	1.60	1.26	0.07