

# A STUDY ON THE STRENGTHS OF HAIR: RELAXED AND NATURAL HAIR STRENGTHS AMONG UNIVERSITY OF ILORIN STUDENTS, ILORIN, KWARA STATE

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Hair strength determines hair health and length, and this is an important property that varies in all races. This study was conducted to determine the relationship between natural and relaxed hair strengths, and to determine the relationship between hair strength and age among female students. A total of 210 female subjects aged 17-35 years (100 with Relaxed hair and 110 with Natural hair) selected from the University of Ilorin were used for this study. Three hair strands were taken from the vertices of participants, and their lengths were measured using a ruler. Hair Breakage Weight (HBW) (the amount of suspended weight (in grammes) that breaks hair strand) was measured and recorded using a digital weighing scale. Data were analysed using SPSS (IBM®, ARMONK, NEW YORK, USA) and results were computed using Pearson's Chi-square analysis. Independent Samples T-test was used to compare the HBW of two strands to one strand. P-values less than 0.05 were considered to be significant. Results showed that the mean HBWs of one strand and two strands for Natural hair were higher than those of Relaxed hair ( $p \leq 0.001$ ). Natural hair had a higher HBW value than Relaxed hair. There was no significant statistical relationship between hair breakage weight and age in both Natural ( $p = 0.437$ ) and Relaxed hair ( $p = 0.551$ ). There was a significant difference between HBW of one strand and HBW of two strands ( $p \leq 0.001$ ). Average Hair Breakage Weight range for Relaxed and Natural hairs were 40.00-64.00(g) and 52.50-76.50(g) respectively. This study shows that Natural hair has a higher strength than Relaxed hair, which implies that Natural hair is much better for females wanting longer, healthier and more beautiful hair. It also gives information about hair strengths in individuals, pointing out why some individuals experience more hair breakage than others, which is clinically important for health and aesthetic reasons.

**KEYWORDS:** Hair Breakage Weight, Natural Hair, Relaxed Hair.

## INTRODUCTION

African hairs are reputable for not growing long unlike other races' hair types. This does not imply that Africans' hairs do not grow, but a lot of breakage and shrinkage occur because of the kinkier, coarser, and curlier characteristics of African hairs. Another contributor to this could be the slower growth rate of African hairs compared to other races. Afro-ethnic hair was found to grow more slowly at a rate of 0.9

cm/month compared to Caucasian hair, with a rate of about 1.3 cm/month (1). Dr. Neil Persadsingh compared African, Asian, and Caucasian hairs removed during combing and came to the conclusion that African hairs had more knots, partial breakages, trichoptilosis (longitudinal division of the distal shaft), and breakage in his book, The hair in black women (2).

The cross-section of a hair strand comprises a cuticle, cortex and a medulla, which are arranged in layers

with the cuticle being the hair's outer layer. The cortical layer has the bulk of the hair fibre and it serves an important role in the physical and chemical properties determination of the hair, such as strength, colour and texture (3).

Apparently, strong hair has a higher tendency to withstand all the various hair styling (especially in people of African descent) and harsh weather conditions.

In Nigeria today, the differences between the strengths of relaxed and natural hairs have not been properly studied. Although genetics play a major role in the type of hair one inherits, the use of various hair products also play an equally important role, most especially the use of products like relaxers and texturizers that permanently straighten and, as the name suggests, "relax" hairs. This relaxing is as a result of the altering of the chemical composition of hair. In a study titled "Relaxers' damage hair: Evidence from amino acid analysis," 'relaxers' are associated with decreased cystine, which is consistent with fragile damaged hair (4). A decrease in levels of glutamine and citrulline have also been linked to inflammation (4). Chemically, hair is made up of keratin, lipids, minerals and pigments. Keratin is a protein found in the cortex and is composed of 18 amino acids, the most abundant of these amino acids are cysteine, cystine, serine, glutamic acid, threonine, arginine, leucine, isoleucine and valine. L-cystine has a role in the protection of hair against oxidative stress (5).

The study to determine if there is a wide difference between the strengths of relaxed and natural hair is crucial for health and aesthetic purposes. In addition to this, there is little literature on the strengths of hair in relation to weight that can be carried by a hair strand before it breaks. This study has been able to assess the various strengths of hair among female students with relaxed and natural hair in University of Ilorin, Nigeria.

## **MATERIALS AND METHODS**

### **STUDY DESIGN**

Two hundred and ten University of Ilorin female students (comprising one hundred and ten females with Natural hairs and one hundred females with Relaxed hairs) were used for this research. All measurements were taken by the same examiner (to reduce inter-observer error). Participants were healthy and within the age range of 17-35 years. Participants with low-cuts, dyed hairs, infectious skin diseases and hair disorders like alopecia, hair shedding and developmental disorders were excluded.

Hairs obtained were from participants with Relaxed and Natural hair statuses. Relaxed hair is hair that has

been treated with Hair relaxer to chemically straighten it, while Natural hair is hair that has not been treated with Hair relaxer.

### **ETHICAL APPROVAL**

Ethical approval was obtained from the ethical review committee of the Department of Anatomy, University of Ilorin, Kwara state, Nigeria. All participants consented to participate in this research experiment.

### **DATA COLLECTION METHODS**

Questionnaires were administered to collect information about demographic details (nationality, age, sex and educational background) and hair statuses.

Hair strands were extracted at the vertex, generally where hair density is the highest. Hairs were cut at or close to the root at this point. Hairs' lengths (cm) were measured to be at least 6 cm long (to maintain consistency) and recorded.

The technique explained by Science Buddies and Svenja Lohner was used to measure Hair Breakage Weight (6). One end of a hair strand was attached around the middle of a pen with paper tape. The other end was attached to a paperclip with tape, and this was hooked through the top of one side of a small plastic bag. Books were stacked into two places to the same height, next to each other, while leaving space wide enough to accommodate the pen and plastic bag that suspended the hair. Beads were placed into the plastic bag, one after the other, and observed to see if the suspended hair broke. This was repeated until hair eventually broke. The plastic bag, including the beads that were inside it, were placed on the weighing scale for hair breakage weight (g) measurement. The measured weight (g) was then recorded. These steps were also repeated for two hair strands tied parallel to each other.

### **STATISTICAL ANALYSIS**

The statistical package for social sciences (IBM, version 27, New York, USA) was used. Results were computed using Pearson's Chi-square analysis. Independent Samples T-test was used to compare the hair breakage weight of two strands to one strand. P-values less than 0.05 were considered to be significant.

## **RESULTS**

### **DATA PRESENTATION**

The measurements of human subjects (hair length, hair breakage weight) were presented as mean, median, range, minimum and maximum values of the age, hair length, hair breakage weight of one strand (g) and hair breakage weight of two strands (g) of both Natural hair and Relaxed hair.

| NATURAL<br>N=110 |             |                  |  |   | RELAXED<br>N=100 |                  |  |   |
|------------------|-------------|------------------|--|---|------------------|------------------|--|---|
|                  | Age (Years) | Hair length (cm) | Hair breakage weight of one strand (g) | Hair breakage weight of two strands (g) | Age (Years)      | Hair length (cm) | Hair breakage weight of one strand (g) | Hair breakage weight of two strands (g) |
| Mean             | 21.00       | 6.96             | 68.25                                  | 113.63                                  | 21.57            | 6.83             | 53.08                                  | 91.27                                   |
| Median           | 21.00       | 7.00             | 67.50                                  | 112.00                                  | 21.00            | 7.00             | 52.50                                  | 87.00                                   |
| Range            | 18          | 3.00             | 87.00                                  | 132.00                                  | 18               | 3.00             | 91.00                                  | 137.00                                  |
| Minimum          | 17          | 6.00             | 31.00                                  | 62.00                                   | 17               | 6.00             | 21.00                                  | 40.00                                   |
| Maximum          | 35          | 9.00             | 118.00                                 | 194.00                                  | 35               | 9.00             | 112.00                                 | 177.00                                  |

**Table 1: Descriptives of all Measured Parameters**

Table 1 shows the mean of the hair breakage weights of one and two hair strands of Natural hair 68.25g and 113.63g, respectively, were greater than the mean of the hair breakage weights of one and two hair strands of Relaxed hair 53.08g and 91.27g, respectively.

| VARIABLE=Hair breakage weight of one strand |             | T-TEST       |         |      |
|---|-------------|--------------|---------|------|
| Hair status                                 | Mean±S.D    | t-test value | p-value | Inf. |
| Natural hair                                | 68.25±18.54 | 38.603       | <0.001  | S    |
| Relaxed hair                                | 53.08±17.15 | 30.958       | <0.001  | S    |

Note: S.D= Standard deviation, Inf= inference, S=Significant

**Table 2: Evaluation of Hair Strength**

Hair breakage weight directly measured the mechanical strength of individual hair strands (7). According to Table 2 above, using the One sample t-test to compare the strengths between Natural hair & Relaxed hair, Natural hair (t= 38.603) has higher strength than Relaxed hair (t=30.958). The above also shows that there's a significant mean difference between Relaxed hair and Natural hair (p<0.001).

| VARIABLES    | X <sup>2</sup>       | df  | P- value | Inf. |
|--------------|----------------------|-----|----------|------|
| Natural Hair | 524.422 <sup>a</sup> | 520 | 0.437    | NS   |
| Relaxed Hair | 547.125 <sup>a</sup> | 552 | 0.551    | NS   |

Note: df= Degree of freedom, X<sup>2</sup>= Chi-square, Inf= Inference, S= Significant

**Table 3: Determination of the Association between Hair Strength and Age**

In Table 3 above, using the Chi-square test to determine the association between Hair strength and Age, the P-values for Natural hair and Relaxed hair are 0.437 and 0.551 respectively, which are both greater than 0.05, implying that this relationship is not statistically significant.

| VARIABLES                              | T-TEST       |         |      |
|--|--------------|---------|------|
|  | t-test value | p-value | Inf. |
| Hair breakage weight of one strand (g) | 6.138        | <0.001  | S    |
| Hair breakage weight of two strands(g) | 5.960        | <0.001  | S    |

Note: Inf= inference, S=Significant

**Table 4: Comparison between the Hair Breakage Weight of Two Strands and One Strand**

In Table 4 above, Using the Independent Samples t-test, there's a significant difference between the hair breakage weight of one strand (t-value = 6.138) and hair breakage weight of two strands (t-value = 5.960), depicting that two hair strands will not carry double the weight (g) of one hair strand before they break. The P-value <0.001 for the hair breakage weight of both one strand and two strands implies that it is significant, which supports the above inference.+

**THRESHOLD DEFINITIONS (CRITERIA DEFINITIONS) BASED ON PERCENTILES**

These criteria will be used in defining the hair strength based on one strand hair breakage weight.

Strong hair will be defined as having a breakage weight above 75th percentile while Weak hair will be defined as having a breakage weight below 25th percentile. From the statistical analysis, Average hair is defined as having a breakage weight within the

|   | Median | Variance | Std. dev | Min   | Max    | Range | IQR   |
|---|--------|----------|----------|-------|--------|-------|-------|
| Naturalist hair breakage weight of one strand | 67.00  | 349.402  | 18.69    | 31.00 | 118.00 | 87.00 | 24.50 |
| Relaxed hair breakage weight of one strand    | 52.50  | 293.973  | 17.15    | 21.00 | 112.00 | 91.00 | 24.00 |

N.B: Std. dev= Standard deviation, Min= Minimum, Max= Maximum, IQR= Interquartile range

**Table 5: Hair Strength Range**

range of 52.50 and 76.50 for Natural hair and between 40.00 and 64.00 for Relaxed hair as seen in Table 4.5 above. Therefore, any measured hair breakage weight value that falls below 52.50 (g) denotes weak hair strength for natural hair, according to the statistical analysis. Any measured hair breakage weight value that falls above 76.50 (g) denotes strong hair strength for natural hair. In the same vein, any measured hair breakage weight value that falls below 40.00 (g) denotes weak hair strength for relaxed hair. Any measured hair breakage weight value that falls above 64.00 (g) denotes strong hair strength for relaxed hair.

|   | 25 <sup>th</sup> percentile | 50 <sup>th</sup> percentile | 75 <sup>th</sup> percentile |
|---|-----------------------------|-----------------------------|-----------------------------|
| Naturalist hair breakage weight of one strand | 52.50                       | 67.00                       | 76.50                       |
| Relaxed hair breakage weight of one strand    | 40.00                       | 52.50                       | 64.00                       |

**Table 6: Hair Strength Percentile**

**DISCUSSION**

The study of the hair strengths of both Natural and Relaxed hairs is crucial for identifying the implications in individuals (especially females) for health, decision making and aesthetic purposes. The variations in the strength of hair of individuals, in terms of hair breakage weight, can be attributed to factors that are genetic and environmental, in addition to hair products applied to hair and increasing age.

Hair mechanics is commonly evaluated by conducting tensile strength tests, and the results yield data in the form of stress-strain curves (8), but in this study, Hair mechanics was evaluated by carrying out Hair breakage weight tests on both Relaxed and Natural hairs.

In this study, Natural hair had a higher hair breakage weight than Relaxed hair in female individuals. This is similar to the results of the study on tensile hair strengths, carried out in South Korea, on virgin and bleached hair. Virgin hair was reported to have a higher tensile strength than bleached hair, and tensile strength continually decreased as more bleaching trials were done. Virgin hair had a Peak stress of 146.64g, tensile energy of 108.00erg/cm<sup>2</sup> and tensile strength of 14.66g/cm<sup>2</sup>, which were all higher than those of Bleached hairs 1, 2 and 3 (9).

Hair breakage weight in this study for natural hair was between 31 and 118 grams, and hair breakage weight for relaxed hair was between 21 and 112 grams, which are lower than that of the study carried out in Tokyo, Japan, on 81 Japanese males with ages between 2 and 91 years. Hair breaking strength was reported to be between 40 and 190 grams (10).

In the study conducted in Turkey, it was reported that the use of hair dyes, gender, and drug use did not significantly affect the break force of hairs; however, there was a statistically significant difference in the break forces of hairs when compared based on strain and diameter (11).

Caucasian or Asian hairs have been reported to have a higher tensile strength, the tensile strength being the maximum stress that each single fibre was able to withstand, than African hairs, like in the study, where the breaking strength in African hair was 101 MPa, which was lower than that of Asian 139 MPa and Caucasian 117 MPa (12).

In a study to quantify hair shape and hair damage induced during reshaping of hair, untreated hair's tensile strength 1.21N.m was higher than that of hair treated with NaOH hair relaxer 0.78N.m, that of hair treated with guanidine hair relaxer 0.70N.m, and that of hair treated with hair bleach 0.48N.m (13). And this is consistent with the results obtained in this study.

In this study, association between hair strength and age

in the female students of the University of Ilorin, Nigeria, was found to not be statistically significant in both natural and relaxed hairs. In a study conducted in the Czech republic, it was concluded that hair's tendency to grow persists up to 30 years of age, then slowly decreases and then achieves a steady state around 60 years of age. Hair, in the Czech republic study, was obtained only at the nape area and studied. Hair of women older than 35 years had lower yield and ultimate strength compared to that of women younger than 35 years. It was concluded in this study that people younger than 35 years have both weak and strong hairs, while people older than this age only have weak hairs (14).

In the study carried out in Tokyo, Japan, the breaking strength of hair in 81 Japanese males showed a significant rectilinear rise up to the age of 20 years and was followed by a significant linear fall with increasing age. Young's modulus followed a second-power function of a gradual fall up to age 15, followed by a gradual rise with advancing age. The hair's diameter showed a peak at age 15, followed by a gradual decrease with advancing age. The percentage extension at breaking and the amount of energy required until breaking also increased until age 15, and then gradually declined (10).

In a study to determine the association of age, lifestyle habits and the self-perception of hair condition with the objectively measured physical properties of hair in Caucasian females with brown hair, there were no significant differences among the four age groups studied in the research for break stress. It was speculated in the study that since absolute break stress decreases with decreasing hair fibre diameters, the age-dependent differences may not have been statistically significant if inherent break stress-which is independent of hair fibre diameter changes-was determined. However, the break stress data in this study were not normalised to the hair fibre diameters (15).

In another study conducted in South Korea, it was concluded that the breaking force of hair is strongly related to hair diameter, and from their results, it was concluded that the decrease of hair diameter was responsible for the tensile strength reduction of aged hair. The mean hair tensile strength did not change significantly up to those in their 40s, then decreased significantly from the 50s onwards. This implies that the required force for hair breakage began to decrease significantly in Korean women in their 50s, meaning that their hair became weaker with ageing and could be broken more easily (16).

Another study conducted to explore the break force of anagen hair by forming criteria according to the diameter of hair, gender, age, strain, use of drugs and

hair dyes and how these criteria affect the mechanical resistance of hair reported that the break force in hairs studied did not show any dependency on age (11).

In another study carried out to determine the physical and mechanical properties of hair in Tunisian women, the load required to break hair strand increased until the age of 40 years and then decreased. Statistical analysis showed that there was a significant difference only between the break load of children's hair and adult's hair (21-40 years) (17).

Many participants with relaxed hair expressed that their reason for opting for relaxed hair was because of the ease at which relaxed hair can be managed, as compared to natural hair, which was complained of being very hard and expensive to manage and style. These reports are similar to those in a questionnaire-based study conducted in South-West Nigeria. Olasode reported that relaxer use was for beautification, social acceptability and ease of management of the relaxed hair. What is interesting about this is that participants with natural hair in this study didn't complain of difficulty in managing their hair and many of them were very content with their hair, except for wanting it to be much longer (18).

This study shows that Natural hair has a higher strength than Relaxed hair, which implies that Natural hair is much better for females wanting longer, healthier and more beautiful hair. It also gives information about hair strengths in individuals, pointing out why some individuals experience more hair breakage than others, which is clinically important for health and aesthetic reasons.

## CONCLUSION

Hair breakage weights in Natural and Relaxed hair statuses point out hair strengths and are attributed to both genetic and environmental factors. The mean hair breakage weight of Natural hair was higher than that of Relaxed hair. Two hair strands did not carry double the weight of one hair strand. Association between hair breakage weight and age in both Natural and Relaxed hairs was not significant. Average hair was defined as having a breakage weight within the range of 52.50 and 76.50 for Natural hair and within the range 40.00 and 64.00 for Relaxed hair.

## RECOMMENDATIONS

For more research work, studies should be conducted to determine the relationship between body mass index and hair breakage weight in subjects in the major ethnic groups, both on relaxed and natural hairs.

## CONTRIBUTIONS TO KNOWLEDGE

This study has provided insights to the strengths of both

natural and relaxed hairs in terms of hair breakage weight, measured in grammes. It is useful in determining if an individual has weak hair, average strength hair or strong hair. It also gives insights to the effects of relaxer application on the breakage weight of hair.

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