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HAIR QUALITY IN GRAVID VERSUS NON-GRAVID WOMEN

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SUMMARY

The article deals with search for the material parameters that would be suitable for specification of human hair viscoelactic properties. These parameters have simultaneously satisfied an unambiguous differentiation between gravid and non-gravid women. Microscope was used to determine the hair thickness, a pull-test deformation device then to establish both the tearing resistance and relaxation curves, taken as a basis to determine values of Young's modulus, relaxation time, shear yield point, breaking point, maximum elongation. Taken from the region around occipital condyla, ninety samples of uncolored female hair were placed under measurement. This study has shown that at least the parameters of yield point, diameter, and the second relaxation time are significantly affected by gravidity.

Key words: human hairs, viscoelastic model of hairs, Youngs modul hairs, relaxation time of hairs

INTRODUCTION

As a non-live part of human body a hair undergoes various changes in quality throughout its life cycle, not only during the female gravidity. This is why this paper is focused on its research just during the period of gravidity when the changes, once arisen, could be easiest identifiable. Even the sample-taking phase posed a problem already, as it was uneasy to find a gravid woman with uncolored hair. Despite all the complications and due to a good cooperation with the Faculty Hospital in Ostrava and its personnel we succeeded.

Relaxation, elasticity, extensibility rank themselves among the basic properties of hair, being also measurements within this paper. Further the limit values, such as yield points, breaking points, were measured.

Several computer programs, such as ScopePhoto, GIMP, Gnuplot were used within the study, moreover the instrumentation, such as the Deform pull-test machine (Type 2) with its TRHEY! control software.

Hair

Human hair is a nanocomposite fiber with its physical look and mechanical strength being influenced by a variety of factors, such as ethnic origin, hygiene, chemical treatment, or living environment (Zhenxing et al., 2009). There are two basic functions of human hair, cosmetic and protective. It serves the purpose of heat insulation, protecting the skin mainly against burns, and works as a mechanical protection against abrasions (Robbins, 2002). Hair thickness, length, and quality depend on hair positioning (head/body), on hereditary predispositions, and age (Pröckl, 2005). Hair thickness changes along its length. A hair is complete near head, with its cuticula mostly missing at hair ends as a result of mechanical wear (Guohua et al., 2005). Structure of hair and its parts is depicted e.g. in (Bartošová et al., 1982), (Pröckl, 2005). For chemical structure of hair see e.g. (Pröckl, 2005).

Mechanical Properties of Hair

Mechanical properties of hair – strength, elasticity, ductility – are subject to hair structure and molecular arrangement of hair keratin. They are mainly dependant on hair cortex ultrastructure that ranks itself, in terms of its structure, among the mechanically anisotropic materials as it consists of elastically extensible fibers and of hygroscopic and relatively rigid matrix. When exposed to moisture, a hair becomes more elastic, as less stable hydrogen bonds tend to break within the matrix and its volume grows by action of matrix hydration. Strength of moist hair is less that the bearing capacity of a dry hair. Other layers of hair – medula and cuticula – are less important in view of mechanical characteristics. Mechanical properties of hair shank may be primarily changed by action of various internal influences: genetic, nutritive, metabolic in their nature. Secondary influences are ascribable to external factors: aggressive chemicals (thioglycolates, concentrated peroxides, ammonia). Adverse action of these substances may result in reduced resistance to mechanical loads, which may cause the hair break or tear (Bartošová et al., 1982). Strength and elasticity of the hair that has been colored or otherwise damaged is strongly reduced compared to the hair that has never experienced chemical treatment (Guohua et al., 2005). Hair strength is measured as the maximum weight a hair withstands before getting ruptured. Hair ductility is the length by which the hair gets prolonged by action of the above maximum weight. Elasticity is the most important characteristic of hair, being the ability to be prolonged by action of tensile force and deformed by action of rotation, and restore its original length and shape, once these forces stop acting. Mechanical characteristics of hair, other than hair length and thickness, are also depending on the extent to which the keratin molecules are saturated with water, and thus also on the relative humidity and temperature at which the sample hair is examined (Bartošová et al., 1982).

Hair Changes During Gravidity

Hair is one of the body parts the quality of which is influenced by changes in hormone levels, mainly the growing level of estrogenes as the pregrancy progresses (APA, 2007).

A variety of women has experienced quicker growth, thickening of hair, and overall increase in hair volume. This conditions lasts until the childbirth only. Increased hair density is the result of the fact that daily loss of hair is less than during a non-pergnancy of a woman. Equally, some of the pregnant women observe growing density of hairs across the body, mainly around their arms, legs, and above upper lip. It results by action of andergenes, sexual hormones, whose level starts increasing at utmost rate during the first trimester of pregnancy (March of Dimes, 2009), (Babyleuter, 2012). After the childbirth, on the contrary, the hair quality deteriorates strikingly and more and more hair fall out (Pröckl, 2005).

OBJECTIVE

Objective of this study was to demonstrate or disprove the influence of female gravidity on quality of hair. It is alleged in the specialized articles that hair quality improves during pregnancy. The scientists see the reason behind this phenomenon in a relic from the evolution era when there was a need of plentiful hair (fur) to maintain proper bodily temperature and/or heat up a cub.

Hypothesis of this study: Hair quality improves during gravidity, in qualitative and quantitative terms.

METHODS

It was necessary before commencement of the work to collect the samples in accordance with the given requirements. The hair ought to be uncolored, cut just at the head skin. Sample hair from ten women were available for our measurements. The first five women (index 1–5) were non-gravid, other five of them (index 6–10) were gravid. 9 pieces of hair from every woman went under measurement.

At the beginning, hair diameters were measured, using a microscope connected to a computer with the GIMP program (Fig. 1).

For every piece of hair, its diameters was measured 5-times at various points of its length. Total diameters was determined thereafter (Tab. 1). Measurements were taken in pixels, to be then converted to micrometers. These (diameter) values were compared

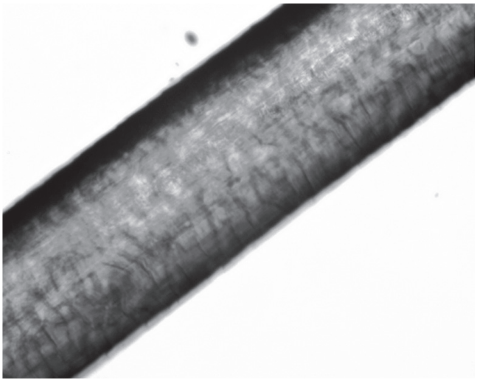

Figure 1. Photography of hair in microskop

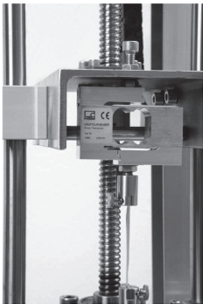

Figure 2. Detail of jaws breaker Deform 2

(Graph 1, 2). The scale was calibrated by means of a glass with decimal marks, inserted under the microscope lense.

As for other inputs, they were ambient air temperature and humidity. These parameters may strongly effect the hair properties. The measurements were entered into the TRHEY! program used to control the pull-test machine of the Type Deform 2 (Fig. 2).

The work with the pull-test mechine of the Type Deform 2 followed. At this point the hair was clamped between the machine's jaws. For easier handling and to avoid hair being slipped out and crushed a piece of paper was wrapped around the hair before its clamping. Inition length of hair was also measured at this point. Value of relaxation, slow or quick tearing were selected by means of the TRHEY! program. Speed and maximum spacing of the pull-test machine jaws were then set for the given quantities. Tearing or tensioning time was set as constant. Given the relaxation, the speed was set to 10 mm per minute, maximum jaw spacing to 5 mm, and time to 300 seconds. The values of 10 mm per minute, maximum spacing to 70 mm and time of 300 seconds were used for slow tearing. For quick tearing, the values were adjusted to 100 mm per minute, maximum spacing to 70 mm, and time to 300 seconds. Three reiterations were used to measure the samples for every quantity monitored.

The following formula was applied to relaxation:

$$F(t) = a + b \cdot e^{\frac{-t}{\tau_1}} + d \cdot e^{\frac{-t}{\tau_2}}$$

where F – hair-exerted force, t – time, a – final elastic member, b – elasticity of Maxwell member with short time of relaxation, τ_1, τ_2 – relaxation times of Maxwell elements, d – elasticity of Maxwell member with long time of relaxation.

To clarify your overall image a chart reflecting the relaxation curve is attached among the results.

Young's modulus was used for the slow and quick tearing process calculations:

$$E = \frac{l_0}{S} \cdot K \qquad S = \frac{\pi \cdot D^2}{4}$$

where l_0 – initial hair length, K – hair rigidness equal to slope of the tearing test curve's linear section, S – hair cross-section, D – diameter.

Extensibility was among other characteristics being assessed, determined from the chart.

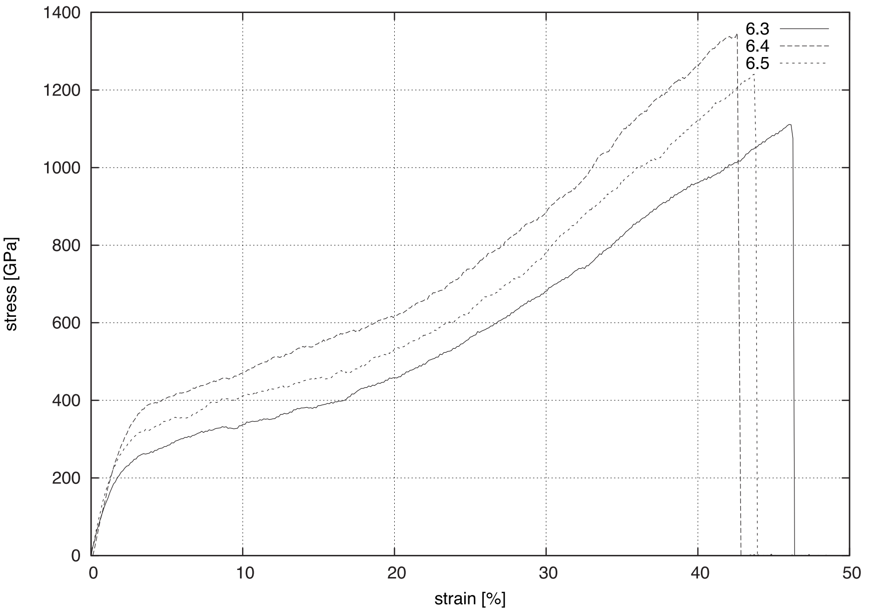

Figure 3. Comparisons of rearing test curves for three pieces of hair from a gravid woman

RESULTS

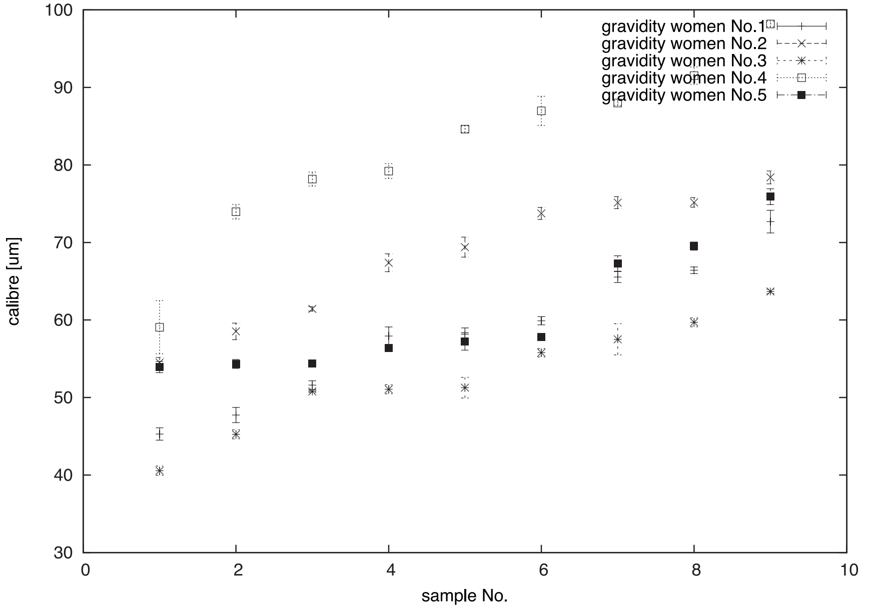

Figure 4. The calibre hairs in gravidity women

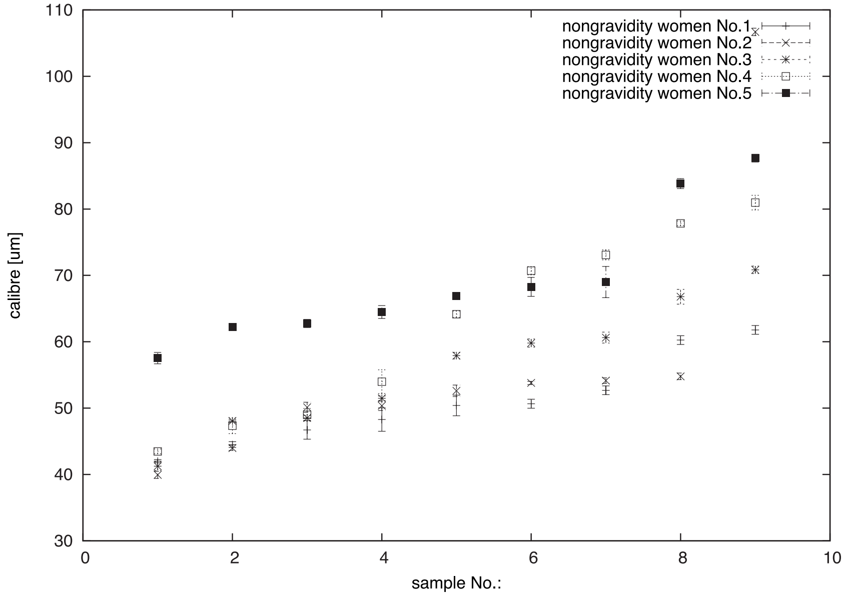

Figure 5. The calibre hairs in nongravidity women

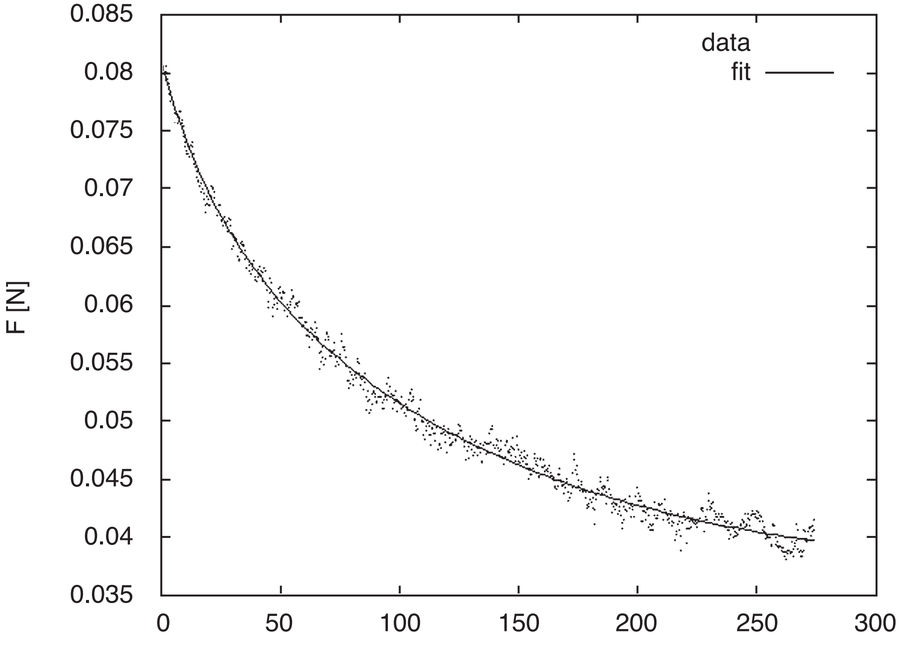

Figure 6. The curve of relaxation

Table 1. Total calibre of hairs

NONGRAVIDITY		
Sample	**Calibre [μm]**	**Standard deviation**
1	50.81	6.38
2	56.27	18.61
3	56.23	9.04
4	62.27	13.49
5	69.34	9.43
GRAVIDITY		
	Calibre [μm]	**Standard deviation**
6	58.36	8.62
7	68.18	7.99
8	52.84	6.87
9	82.01	11.24
10	60.75	7.67

Table 2. Young's modul for slow and fast tear in nongravidity women

NONGRAVIDITY		
Sample	**E_S [GPa]**	**E_F [GPa]**
1	2.26	2.99
	2.38	0.32
	1.23	6.85
2	2.41	6.01
	2.60	3.47
	2.70	2.70
3	4.47	4.75
	2.78	2.11
	4.95	4.82
4	1.72	2.30
	1.52	1.73
	1.31	1.63
5	2.48	2.18
	3.85	1.76
	1.90	1.66

Table 3. Young's modul for slow and fast tear in gravidity women

GRAVIDITY		
Sample	**E_P [GPa]**	**E_R [GPa]**
6	50.81	6.38
	1.72	1.82
	2.38	2.40
	2.03	3.13
7	1.74	2.73
	2.27	2.83
	2.51	3.81
8	2.36	2.03
	2.52	1.79
	2.55	1.25
9	0.94	1.16
	1.19	1.36
	1.35	1.69
10	3.74	2.94
	1.90	1.85
	4.23	2.20

DISCUSSION AND CONCLUSION

Values of hair diameter were determined on five samples from gravid women and on five samples from non-gravid women. In respect of the fact that the hair width is not equal along the entire hair length, desreasing from the hair base on (Guohua et al., 2005), the measurements had to be taken at several points. For the purpose hereof five different points were selected with subsequent averaging of partial results. Non-gravid hair diameter was found about 5.5% less than its counterpart for gravid women.

Yield point was found as higher (2.7%) for non-gravid women than for the gravid ones (2.3%). It can be deduced from the above that the gravid women's hair show lower capacity as for its elesticity. Here, the results differ from the original hypothesis. There can be several reasons, such as a defect of a particular piece of hair or unequal hair sections being measured. The pieces of hair differ in their thickness from one section to another due to the cuticula presence or absence which finds major reflection in their properties (Guohua et al., 2005). In both cases, regardless of whether subject to slow or quick tearing process, Young's modulus was found higher for non-gravid women. Slow tearing process gave the value of 2.57%, quick process the 3.02%. For assessment of these values see Table 2 and 3. It was moreover found that the hair extensibility ranged around 40%.

In this studies are magnitude no all throws for characteristic changes mechanical properties, because their natural diffusion on individuals is greater than change accompanied pregnancy. During pregnancy hair happen soft and thin (about 3%). At straining and after break to the original condition return less and slower than hair women nongravidity. The hairs of pregnancy women are less adapt tension. Further was place, do you hair pregnant women relaxed slower. A at slow tear these hair break faster, therefore support smaller stress. The limit elasticity is nongravidity women higher (2.7%) than in gravidity women (2.3%).

Our hypothesis has been confirmed for the thickness parameter. As demonstrated, a change in these parameters may also evoke the above described perception of gravid women.

REFERENCES

APA. (2007). Pregnancy and Hair Loss. www.americanpregnancy.org [online]. American Pregnancy Association, March 2007 [visited 8. 3. 2012]. Available from http://www.americanpregnancy.org/pregnancyhealth /hairloss.html

BabyCenter, LLC. (2012). Hair and nail changes during pregnancy. www.babycenter.com [online]. Babycenter, LLC, [visited 8. 3. 2012]. Available from http://www.babycenter.com/0_hair-and-nail-changes-during-pregnancy_1456563.bc.

BARTOŠOVÁ L., JORDA V., ŠŤÁVA Z. (1982). Choroby vlasů a ovlasené kůže. Avicenum zdravotnické nakladatelství, 1st edition, 256 p.

GUOHUA W., BHUSHAN B., TORGERSON P. M. (2005). Nnomechanical characterization of human hair using nanoindenttion and SEM. Ultramcroscopy, 105, 1–4, pp. 248–266.

March of Dimes (2009). Hair changes. www.marchofdimes.com [online]. March of Dimes Foundation, June 2009 [visited 8. 3. 2012]. Available from http://www.marchofdimes.com/pregnancy/yourbody_hair.html.

PRÖCKL, J. (2005). Příručka o vlasech. www.studioamadeus.cz [online]. 30. 12. 2005 [visited 8. 3. 2012]. Available from http://www.studioamadeus.cz/o-vlasech.

ROBBINS, R. C. (2002). Chemical and Physical Behavior of Human Hair (4th ed.).

ZHENXING, H., GAOSHENG, L. (2009). Measurement of Young's modulus and Poisson's ratio of Human Hair using Optical techniques. Proceedings of SPIE, the International Society for Optical Engineering 7522(3), p. 21.

SROVNÁNÍ KVALITY VLASŮ U GRAVIDNÍCH A NEGRAVIDNÍCH ŽEN

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SOUHRN

Článek se zabývá hledáním materiálových parametrů, které by byly vhodné pro specifikaci viskoelastických vlastností lidských vlasů. Tyto parametry současně vyhovovaly jednoznačné diferenci u gravidních žen proti ženám negravidním. U vlasů byla mikroskopicky stanovována jejich tloušťka a na deformačním trhacím zařízení pak během několika testů studovány jak trhací tak relaxační křivky. Z nich byly určeny Youngovy moduly, relaxační časy, meze skluzu, meze pevnosti, maximální prodloužení. Měření proběhlo na 90 vzorcích ženských nebarvených vlasů odebíraných z oblasti týlního hrbolu. Tato práce ukazuje, že minimálně parametry hranice skluzu, průměr a druhý relaxační čas jsou těhotenstvím signifikantně ovlivněny.

Klíčová slova: lidské vlasy, viskoelastický model vlasů, Youngův modul, relaxační čas

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