

# Natural or man-made fibers – the question of our health

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## ABSTRACT

*Materials manufactured from natural fibers and materials used in textiles, are in all aspects people friendly. They are environmentally friendly and guarantee optimal comfort when worn. From the beginning of mankind they protected man against the unfavorable elements of the environment providing perfect comfort. Synthetic fibers, which were introduced during the 20<sup>th</sup> century are easier to maintain and have had been accepted without much criticism despite the fact that they cannot match natural fibers in respect to comfort. The 21<sup>st</sup> century seems to be the age of human protection. The protection of the environment and healthy food are already receiving attention. Now it is time to look closer at the clothing we wear. Modern apparel should not only give the highest comfort, but should also have a positive influence on the health of our bodies or at least not be harmful. This paper contains the latest results of research done on polyester and clothing from natural fibers. Amongst the tests that were done, were the protection of fabrics against UV. Tests were also done to see whether fiber origin had any influence on human body parameters, which are responsible for the state of the immune system. The next aim of this research was to ascertain whether wearing different kinds of clothing under certain conditions, whether resting or exercising may be the cause of oxidative stress and how the body's defense mechanisms change. One way of testing the ability of the body to defend itself against the reactive oxygen species is to determine the so-called total antioxidant status (TAS). This parameter shows the total ability of tissues to neutralize exactly determined amounts of reactive oxygen species.*

## Introduction

Natural fibers, including linen and hemp are people friendly in every way. They guarantee high comfort as well as environment protection. Since the beginning of time, they are a natural human protection against weather conditions giving comfort to man.

In the presence of increasing environment pollution and chemistry more and more entering our lives man has to make choices almost everyday. Often preferring healthy "green" food and to move to the suburbs instead of living in city centers.

Clothing comfort is a complex and hazy subject hard to define in a few simple words. Most of all this is

a result of the personal requirements of individuals. However, saying shortly we can call comfort all physiological human body reactions to the conditions related with the environment-cloth system. For the everyday consumer comfort embodies "freedom from pain and from discomfort; a neutral state" (Li, 2001). Comfort is very important for most users. This is illustrated in Figure 1. It shows some results from a study on the perceptions of the importance of various attributes of clothing worn at the work place, which covered a number of national groups from Europe, Asia and Australia. The main trends are similar for all the different national groups. From the nine dimensions listed, comfort, fit, style, color and quality were rated as more important than the rest, which suggests the need for an effective method for the evaluation of the overall wear performance of clothing. The "skin – clothing" system is the key one when considering about the comfort formula. We should consider it as an open system, which is always in a state of dynamic interaction with the surrounding environment in terms of physical, sensory, physiological and information factors.

Heat and moisture transport between the human body and its surroundings is a result of processes which take place on the surface of the skin and during breathing, processes which arise from conduction, convection, radiation and evaporation. The contribution of numerous processes to the whole system differs under various surrounding conditions (Figure 2).

Humans have a special set of nerves for experiencing pleasure, such as a mother's caress or lover's embrace. While the thick nerve fibers rapidly shoot electrical signals to the somatosensory cortex of the brain and convey information about contact and pressure, the thin slow ones connected to the insular cortex, convey the emotional context sensation (touching). The fast fibers indicate when we are touched and the extent of the touch. The slow fibers signal the finer sensations of touch (Figure 3).

In a similar way the sensory receptors in the skin transmit information to the brain concerning stimuli from our clothing. The nerve ends collect the stimuli from the skin exposed to the clothing and send the information to the brain. In this way they stimulate certain processes in the human body. Depending on the kind of stimulus from our clothing it may be pleasant or not. Apart from stimuli directly received by fast and slow fibers of the nerves in the skin, there are many other factors contributing to the complex impression of the wearer of the clothing. The aspects of comfort as well as the hygienic properties of clothing have been widely researched and there are a number of publications on the topic.

These days traditional tests on the physical-mechanical characteristics of textile products are not sufficient in terms of the objective evaluation of textile properties. In the tests described below we have tried to

extend the research. The aim was not comfort in itself, but the changes in human body caused by cloth. Under the term "changes" we mean the state of the immune system and allergic reactions. According to the results of research on clothing and the influence on plasma levels of immunoglobulin E and histamine, an increase in allergic reactions can be observed in people wearing synthetic clothing. The same effect does not occur when people wear natural fiber garments. Therefore, we have tested clothing that is commonly worn in our everyday life. Two groups of raw materials were distinguished; natural and synthetic fibers.

## Experimental procedure

### Sleep and natural fibers

At the Institute we have established a new laboratory - *Laboratory for physiological influence of cloth on human body*. This laboratory is fully air-conditioned guaranteeing stable temperatures and humidity levels for the experimental requirements. The experiments were done in co-operation with the Karol Marcinkowski University of Medical Sciences in Poznań under the agreement with its Commission of Bio-ethics. Experiments were done on the influence of bedding on sleep. A comparative test has been done on bedding made from natural (100% linen, 100% cotton) and synthetic (100% PES) fabrics. Some of the most important fabric features are shown in Table 1. During the experiment, the skin and internal body temperatures, as well as level of immunoglobulin A, were also measured. Young males slept for eight hours between linen bedding followed, by eight hours between bedding. The environmental conditions were strictly defined for each experiment to avoid any accidental differences of results. The temperature was 20 °C, humidity 50%, sleep duration 22.00 till 6.00 during spring. The men were of a similar age and constitutional condition. Temperature was measured at 10 minute intervals. The level of immunoglobulin A (IgA) (a class of antibodies, often formed as a dimer, i.e. two antibody molecules attached to each other end to end) that is secreted into bodily fluids such as saliva - IgA protects the body's mucosal surfaces from infections) was measured by analyzing their saliva.

### Sebaceous gland

Tokura *et al.* (2002) described different adaptability of sebaceous gland activity for two kinds of clothing with hydrophilic (cotton) and hydrophobic (polyester) properties (Figure 5). The human skin has evolved, being surrounded by clothing with hydrophilic properties. The sebaceous glands are located approximately 0.5 mm under the skin surface. They are distributed over almost the entire body with the exception of the palms of the hands and the soles of the feet. The number of glands per skin area and their size vary considerably. The most and of the largest sebaceous glands are to be found on the scalp, up to 800 per cm<sup>2</sup>. The secretions produced by the sebaceous glands thinly

cover the hair and the surface of the stratum corneum, which may spread up to the upper layers of the stratum corneum. Thus, water permeability is reduced and the resistance to acid, lye and bacterial contamination is increased (Figure 6). For a month ten female adults wore pajamas with hydrophilic properties and ten female adults wore pajamas with hydrophobic properties while sleeping at night. The pajamas were worn directly next to the skin and Sebum and blood samples for measurement of natural killer cell activity was collected two times from their back.

### Oxidative stress

Natural fibers including linen and hemp are human friendly in every way. They guarantee high comfort as well as environmental protection. For ages they have a natural protection for the human being against all weather conditions, giving comfort to the man. Natural and synthetic fiber clothing have been used as a test material, i.e. linen and polyester. Tests have been done on men's shirts made from the above-mentioned fibers, but using the same model, long sleeves and the same construction. Only the size varied due to the differences in the size of the volunteers who signed up for the trials. The characteristics of the textile metrology parameters of the clothes worn are shown in Table 2. The time constant of the ms unit is the time for 67% discharge of the electrostatic charges gathered on the clothing surface. Conditions for the measurement of time constant were as follows:

- Upper limit of time constant potential – 150V
- Lower limit of time constant potential – 50V
- Air humidity – 55%
- Air temperature – 20 °C

The lower values of the surface resistance and time constant of electrostatic discharge for linen fabrics compared to those for polyester fabrics indicate that linen clothing does not allow the building up of electrostatic charges on their surface. A person wearing polyester garments is exposed to the danger of a constant influence of an electrostatic field and rapid discharges when in contact with conducting materials. That is a consequence of the ability of polyester to gather electrostatic charge. The tests were conducted on six healthy, untrained, similarly built males ages 19 to 23. The control group was people wearing linen garments and the test group was the same people wearing polyester garments. They stayed in a specially adopted climatic chamber (Laboratory of Physiological Testing at the INF) at a temperature of 20 °C and relative humidity of 50 % with air movement below than 0.5 m/s. The tests were conducted during resting (8 hours), moderate physical exercise (20 min) and after post-exercise restitution (until blood pressure and pulse stabilized). The physical activity was on the level of 75 W according the cyclometer (Hellige) (Figure 11). During the period before resting, before exercising, after exercising and after recovery, the physiological parameters were tested and blood samples for biochemical assessment were taken. TAS (total antioxidant status) was

measured using a colorimetric method (Randox Laboratories Ltd. GB). The authors of this study received permission from the Bioethical Commission at the University of Medical Sciences in Poznań to conduct these tests.

### Natural fibers fabrics and UV protection

Apparels made from natural fibers not only influence some of the physiological factors of our body favorably, but also ensure safety during sunny days, protecting us against hazardous ultraviolet radiation. Ultraviolet rays emitted by the sun and the thinner ozone layer create high risks for humans. That is why clothing should guarantee protection to wearers against higher levels of UV radiation. The above-mentioned protection is largely a factor of the structural parameters of the fabric, such as density, thickness, cover factor as well as color. The fiber is important especially in cases of raw fabrics (untied). Natural fibers containing natural pigments and lignin absorb ultraviolet rays highly effectively. Linen and hemp fibers contain lignin as part of their structure and therefore can be classified as excellent protectors against UV rays. As it can be seen from the Figure 13, linen fabrics of a lower "openness", therefore fabrics of a more dense structure assure better protection against hazardous ultraviolet radiation – the UPF factor being higher. It is well known that linen and hemp fabrics are sometimes finished in liquid ammonia. This reduces creasing ability and results in better handle. Liquid ammonia gives a softer touch as well as increasing "easy-care" properties. This finishing process makes the fabric structure denser and so increases the UV protection factor (Figure 14). The more dense the structure of a fabric the user better the protection against ultraviolet radiation of the B type, which is responsible for skin burning, as well as A type which penetrates the skin deeper causing cancer. The media on the basis of medical reports, report that cosmetic creams and liquids with UV protection often live up to their promises. Therefore, clothing seems to be the most effective and important way to protect human beings against UV radiation. It provides very effective protection for individuals exposed to the sun. This is very important for military and special purpose dress.

## Results and Discussion

### Sleep and natural fibers

Results of experiments showed that temperature of body is lower during sleep in linen and cotton bedding. Also in that case level of immunoglobulin A content is higher than for polyester bedding (Figure 4). That means a deeper sleep when human body regenerates quicker and rests better. Human immune system grows stronger.

### Sebaceous gland

Squalene, waxester and triglyceride, derived from

the sebaceous glands, increases from start to finish of experiment significantly in cotton pajamas, but did not change significantly in polyester pajamas (Figure 7 to 9). Prof. Tokura maintained that Natural Killer cell activity increased significantly in PES (Figure 10). It indicated, that the subjects wearing polyester pajamas were more stressed during their sleep. Stress could decrease the level of androgens. The reduced levels could also suppress sebaceous gland activity. Constant skin cover by clothing with hydrophilic properties (cotton) could enhance sebaceous gland activity. It indicates that the skin as a defense barrier against attacks from surrounding agents could function more effectively. Synthetic clothing (with hydrophobic properties) would suppress natural and seasonal increases of sebaceous activity.

### Oxidative stress

The aim of the tests was to find the answer to the question, whether wearing different kinds of clothing during specific conditions, while resting or exercising may be the cause of oxidative stress and how the body's defense mechanisms change. One of the ways of testing the ability of the organism to defend itself against the reactive oxygen species is to determine the so-called total antioxidant status (TAS) (Witmanowski, 1997). This parameter shows the total ability of tissue to neutralize previously determined amounts of reactive oxygen. The results of the TAS level tests conducted on the people wearing linen and polyester clothing under controlled conditions are shown in Figure 12. The results showed that the TAS values are lower for individuals wearing PES for a period of eight hours as compared to those wearing linen. The difference is considerably larger after moderate exercise. Similarly, the TAS is higher for individuals wearing linen when recovering after doing exercise. The results may show that the antioxidative reserves are higher, resulting from increased amounts of ROS in the individuals wearing PES. It is presumed that the polyester clothing may cause a higher production of ROS, which reduces the antioxidative reserves of the body. A change of the parameters of the antioxidative system may reflect the oxidative stress, i.e. a disorder in the physiological defense mechanisms against the reactive oxygen species.

## Conclusions

1. According to the results of the research on garments made from cellulosic fibers such as cotton, linen and hemp, have a positive influence on the physiological parameters of the human body, i.e. the level of immunoglobulin A, histamine and sebaceous gland activity in comparison to polyester clothing.
2. The lower levels of total antioxidative status in individuals wearing polyester indicate that this probably is an effect of the increased production of reactive oxygen species, which are responsible for oxidative stress.

3. Linen and hemp garments provide safety to the wearer, even under conditions of high ultraviolet radiation, as well as ensuring good comfort and cool touch.
4. Garments made from natural fibers are environmentally friendly and assure at a time when chemical products are increasingly being used, healthy future living and protection of our environment.
5. The most important step of research will be the determination of optimal natural and synthetic fiber blends, which will provide the wearer on the one hand with good comfort and health typical of natural fibers, and on the other hand the easy care properties of synthetics.

The aim and reason for this study is clear to everyone. It is important to know everything about the relationship between clothing and our bodies and its influence on our health. In these days of high competitiveness in textile markets, consumers should be aware of the consequences when buying garments made from different fabrics and fibers.

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  - The Washington Post, July 30, 2002 (by Shankar Vedantam).

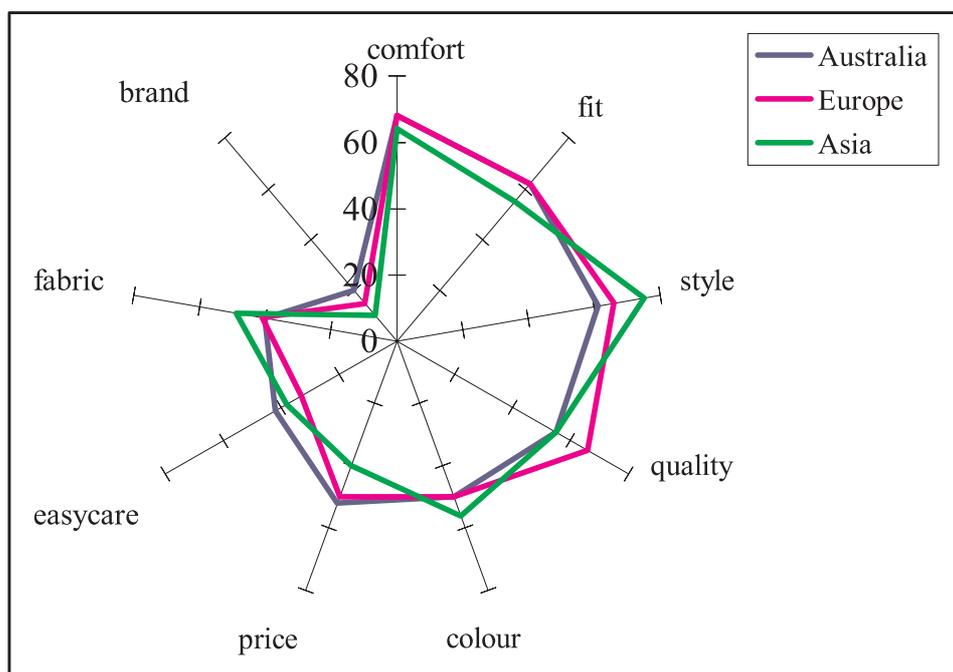
**Table 1.** Properties of bedding fabrics.

Fabric	Surface mass (g/m <sup>2</sup> )	Hygroscopicity at 65% humidity	Hygroscopicity at 100% humidity	Resistance (Ω)	Heat Resistance (Km <sup>2</sup> /W)
100%linen	152.3	7.0	16.2	5.5 x 10 <sup>9</sup>	12.2
100%cotton	141.4	6.4	15.1	1.2 x 10 <sup>9</sup>	10.6
100% PES	138.6	0.3	1.5	1 x 10 <sup>12</sup>	7.5

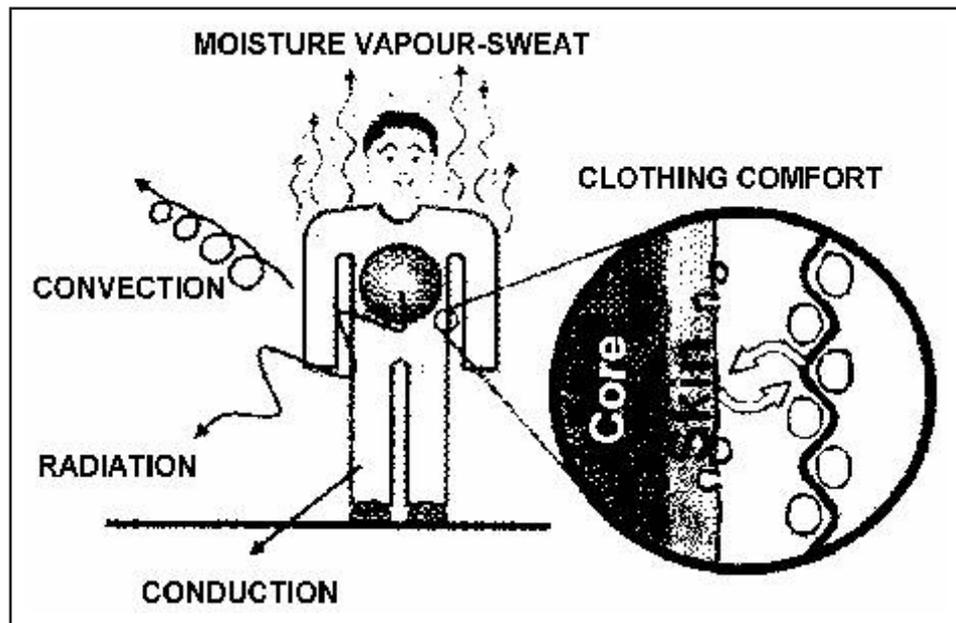
**Table 2.** Properties of clothing fabrics.

Material	Hygroscopicity		Surface resistance Ω[ms]	Electro-static discharge time constant	Heat resistance [Km <sup>2</sup> /W]
	65% air humidity	100% air humidity			
100% linen	9.3	17.1	1.5x10 <sup>9</sup>	56	14.8
100% PES	1.0	1.3	6.5x10 <sup>11</sup>	1891	5.4

**Figure 1.** Clothing requirements of consumers. (Source: Li, 1998).



**Figure 2.**  
The human-clothing-environment system.  
(Source: Li, 2001).



**Figure 3.**  
"TOUCH:  
Special nerves  
help babies and  
lovers feel  
pleasure, softy".  
(Source:  
Vedantam,  
2002).

### A mother's touch, a lover's caress

#### Study locates special nerves for gently transmitting love

**By Shashank Sankaran**  
The Washington Post

**WASHINGTON**—Neuroscientists have discovered what scientists have always known: The touch of a lover's hand is special.

Scientists announced Sunday a study that shows brains have a special set of nerves for feeling pleasure in a partner's caress or a lover's embrace.

These nerves, sensitive to the soft touch of fingers gliding over a cheek or a parent's soothing hand, but that are found in areas of the brain that scientists speculate that the nerves might be designed to make humans reward themselves and themselves — at least, that's what they believe by the fact that the nerves are wired to the same brain areas activated by cocaine and other social rewards.

Although these special nerves, which have thin fibers and send relatively slow signals to the brain, had been identified in animals and humans, their role had been unclear.

Scientists had wondered about their purpose, especially because they do not work as efficiently as other nerve fibers, which are also found in skin.

The research, published in the current issue of *Nature Neuroscience*, indicates that while the thick fibers rapidly shoot electrical signals to the brain, the thin fibers of the touch and

sets of nerves is that the slow fibers transmit from the surface layers of the skin, perhaps even to the wrist, while the fast fibers mostly carry other kinds.

Newborns might be able to feel the love in a parent's touch before they can feel the touch itself.

Researchers, just this morning, showing that both non-physical contact and touching, the group of scientists wrote.

"The profound importance of such a system for human well-being has long been appreciated, at least since the classical study of baby attachment and love addiction by a surgeon's mother in response to simple contact."

The nerve system continues to function throughout life, but decreasing the importance of such contact. While the thicker nerve fibers that transmit contact information are more densely packed, the slow nerves are found only in areas of the skin such as the forearm.

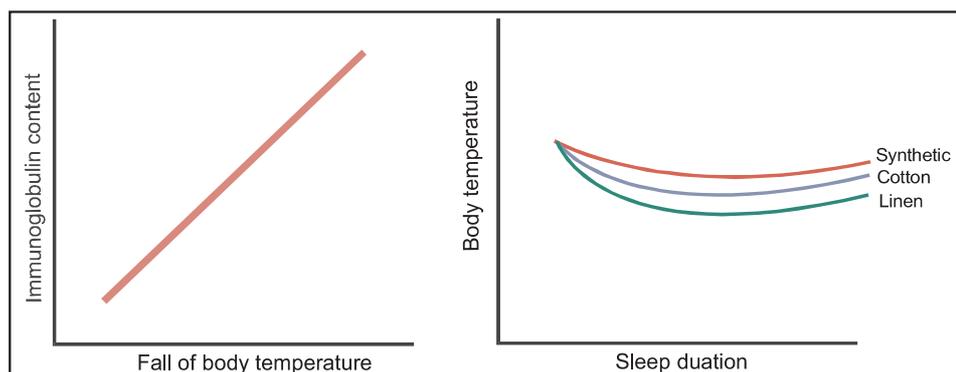
Their functional role is to help the level of consciousness and has to do

with the information about contact and pressure, the thin slow fibers connect to the insular cortex and control the emotional content of the touching. Both sets of fibers fire together, and the brain combines information about physical contact with information about emotional content, melding them into the richness of physical experiences.

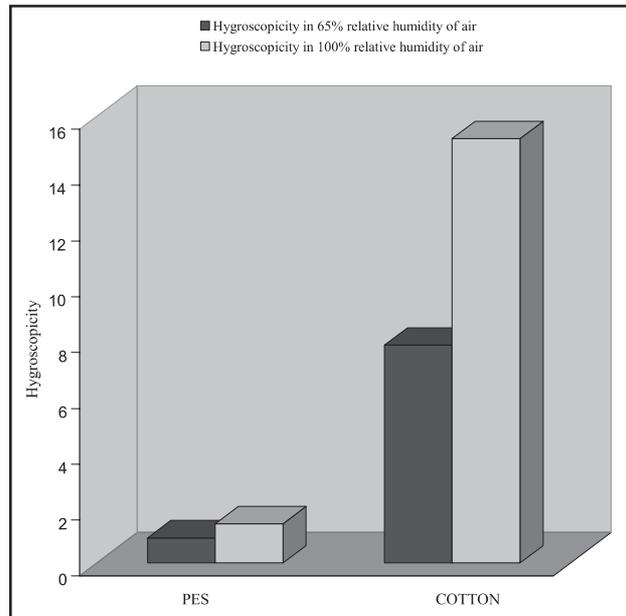
A special touch course might have evolved people with less different

See TOUCH, Page 7

**Figure 4.**  
Temperature and immunoglobulin content for cotton and polyester bedding.  
(Source: Vedantam, 2002).



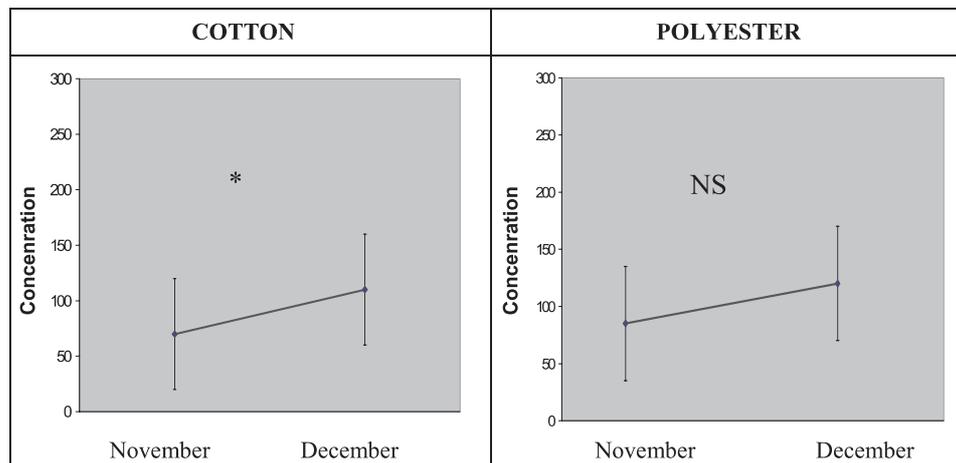
**Figure 5.**  
Hygroscopicity  
of cotton and  
polyester fabric.



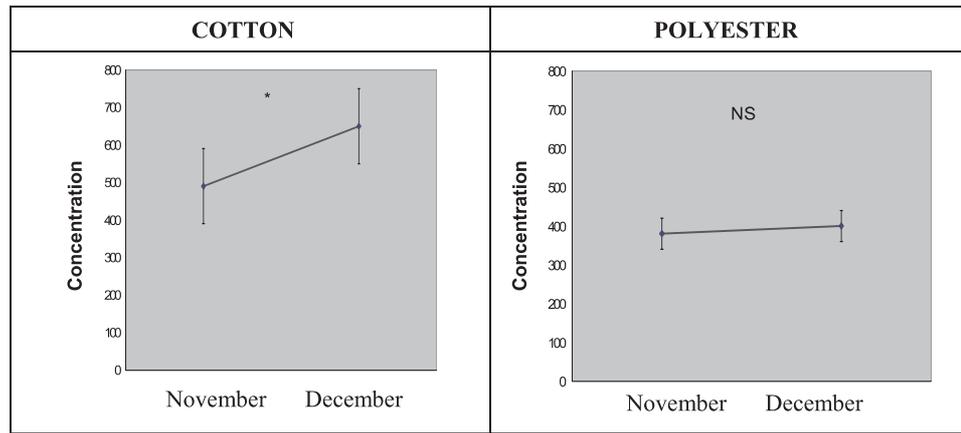
**Figure 6.**  
Sebaceous  
gland. (Copy-  
right © 2000 -  
2003 Skin Care  
Forum).



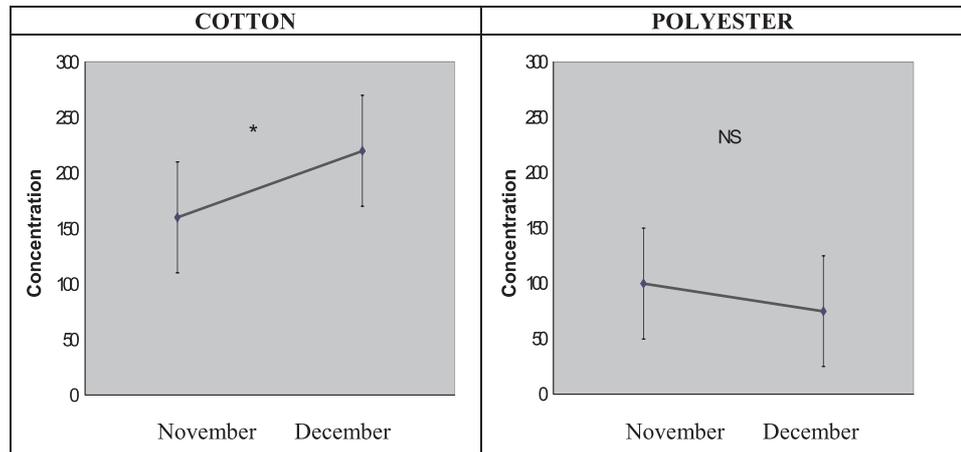
**Figure 7.**  
Average SQ  
(Squalene) in  
pajamas.



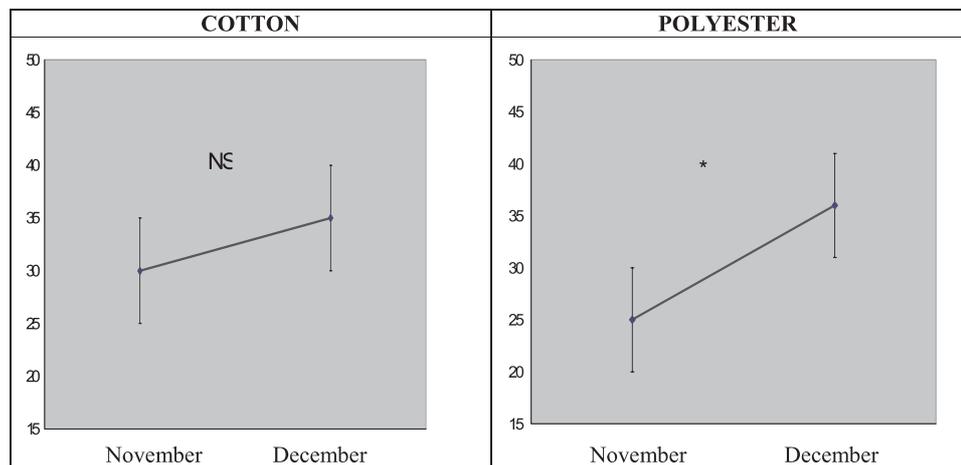
**Figure 8.**  
Average TG  
(triglyceride) in  
pajamas ( $\mu\text{g}/\text{ml}$ ).



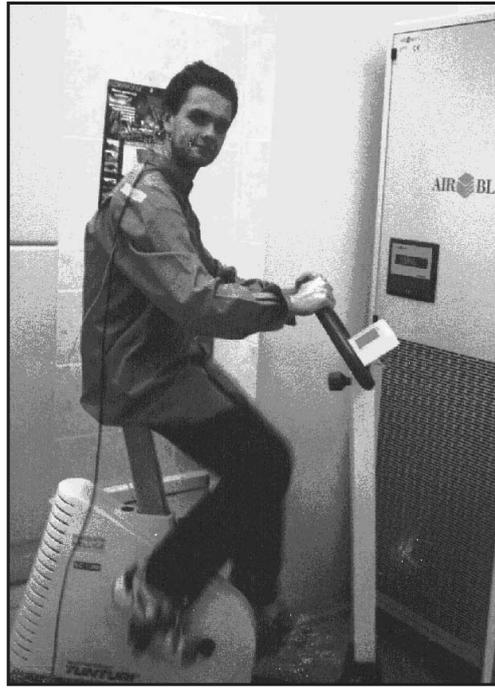
**Figure 9.**  
Average WE  
(waxester) in  
pajamas ( $\mu\text{g}/\text{ml}$ ).



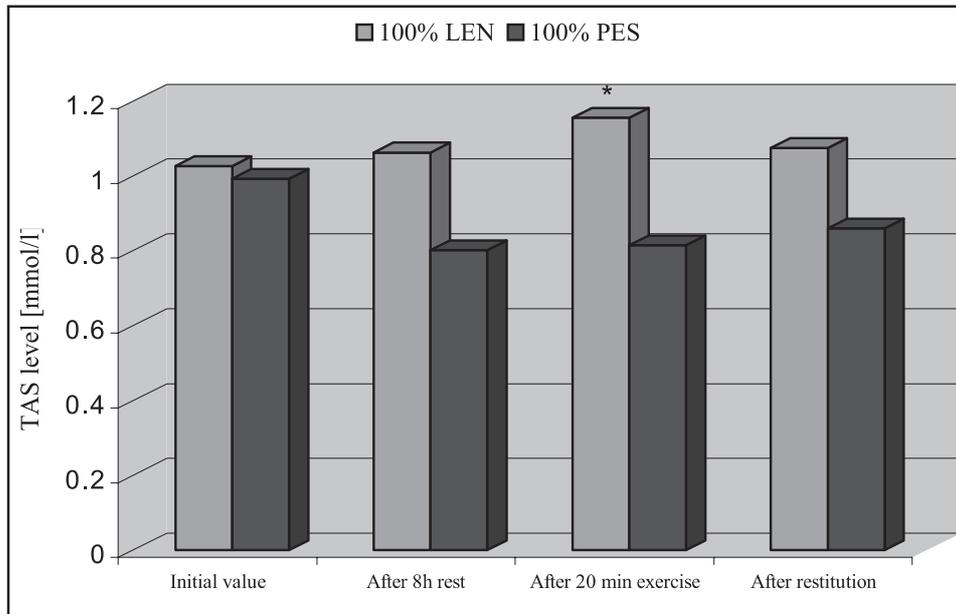
**Figure 10.**  
Average NK cell  
(natural killers)  
activity in  
pajamas (%).



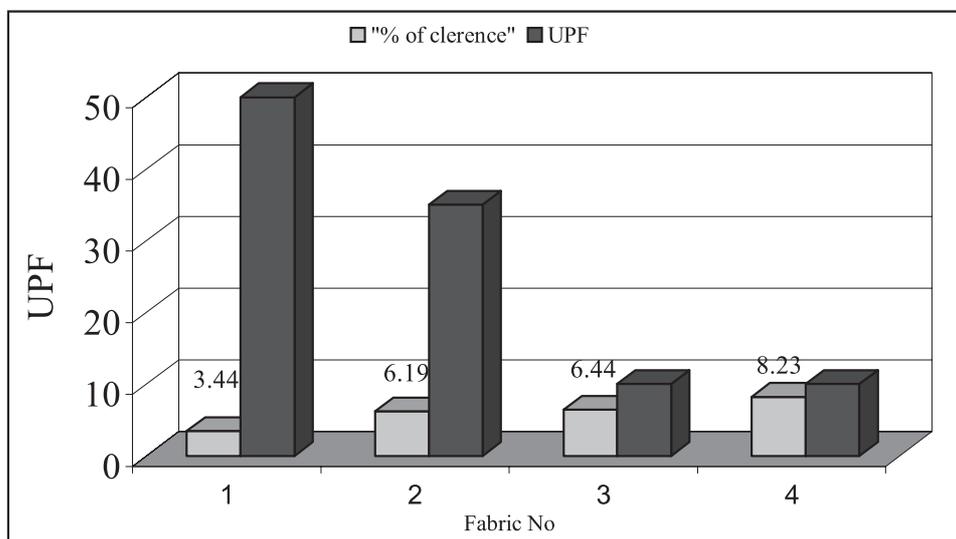
**Figure 11.**  
Moderate  
physical exer-  
cise.



**Figure 12.**  
The TAS level in  
people wearing  
linen and PES.



**Figure 13.**  
UPF and  
percentage of  
clearance for  
linen fabrics.



**Figure 14.**  
UV transmittance through hemp fabrics after different finishing processes.

