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The Influence of Clothes Made from Natural and Synthetic Fibres on the Activity of the Motor Units in Selected Muscles in the Forearm - Preliminary Studies

Abstract

The present paper deals with new health aspects of clothing. These research studies were undertaken to determine the influence of natural and synthetic fibres which temporarily cover the forearm muscles on the activity of the motor units in these muscles. The electrophysiological parameters of motor units were measured with electromyographical methods. The results of the tests showed that temporarily covering the examined muscles in the forearm with synthetic clothing changed the pattern of the motor units' activity. Covering the forearm with natural clothing evoked no such effect.

Key words: *clothing, comfort, muscle activity, electrostatic charges, thermal insulation, linen, polyester.*

Introduction

Natural raw materials, including flax, are human friendly in every respect. They are environmentally friendly and guarantee optimal comfort in use. From the very beginning of human history, they have served to protect man from unfavourable elements of the environment in perfect comfort. The synthetic fibres introduced at the end of the 20th century were uncritically accepted as being easier to maintain, despite being unable to match natural fibres in respect of comfort.

The present studies were undertaken to determine the influence of natural and synthetic fibres which temporarily cover the forearm muscles on the activity of the motor units of these muscles. The motor units of the tested muscles were studied both at rest and during voluntary movements. Additionally, the motor fibre transmission within the nerves supplying the investigated muscles was assessed.

Among many factors which may influence the activity of muscle motor units, especially after their being covered with synthetic fibres, temperature changes were taken into account, as was the possibility of electrostatic field emission over the surface of the muscles examined. It was assumed that one of the determinants causing this phenomenon was changes in the transmission of the motor fibres which innervate the muscles investigated. The circadian cycle of the muscles' efficiency originating from the fatigue-relaxation rhythm was also considered in these studies [7]. It is commonly known that in a typically healthy human the motor units after relaxation during sleep (between 1.00 a.m. and 7 a.m.) show fluctuating activity up to the period of their maximal efficiency in the pre- and post-midday hours (more or less between 11.00 a.m. and 1.00 p.m.) as well as later. Furthermore, about 6.0 p.m. - 10.00 p.m., the efficiency of the motor units undergoes exhaustion because of their natural fatigue, reaching a peak in the late evening hours (about 11.00 p.m.) [6]. Therefore, the period of the day when tests were performed (between 2.00 p.m. and 9.00 p.m.) was chosen to adjust changeable activity to the optimal period of muscle motor unit efficiency in a healthy human. The circadian cycle of the temperature rhythm is, in general, the same as above. The variability in motor unit efficiency

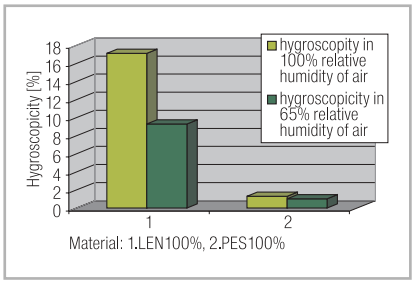

Figure 1. Hygroscopicity of linen and polyester fabrics in different humidity conditions (Polish Standard PN-80/P-04635).

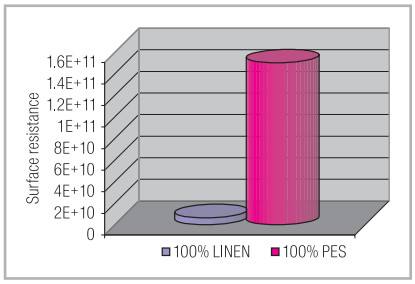

Figure 2. Surface resistance of linen and polyester fabrics [Ω].

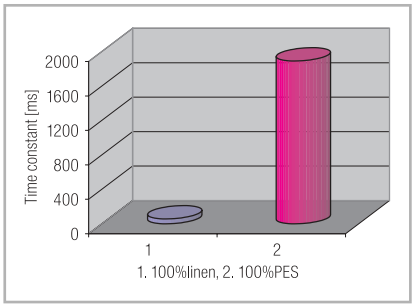

Figure 3. Electrostatic discharge time constant for cloth of 100% linen and 100% PES.

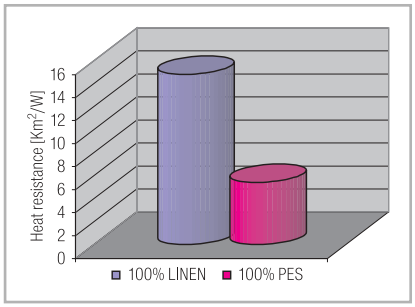

Figure 4. Heat resistance for linen and polyester fabrics.

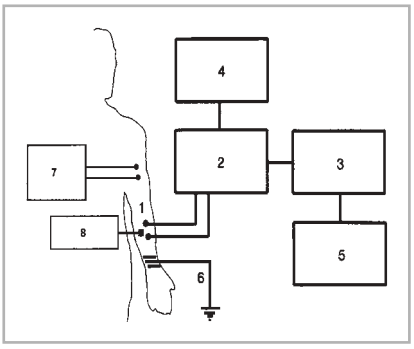

Figure 5. Experimental arrangement used during the electrophysiological tests performed in this study; 1 - surface bipolar recording electrodes, 2 - AC amplifier, 3 - personal computer, 4 - loudspeaker connected to the amplifier, 5 - printer, 6 - reference electrode, 7 - stimulating bipolar electrode, 8 - thermometer measuring temperature over the skin [3].

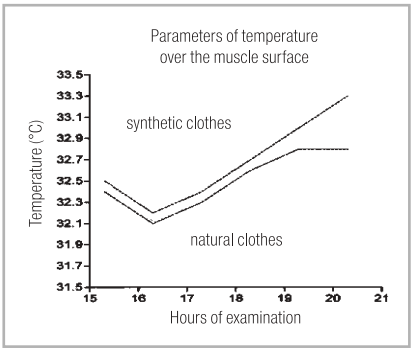

Figure 6. Time-dependent changes in the temperature measured over the skin of the tested muscle groups in two subjects dressed with shirts made of different fibres (the tests were performed every hour between 3pm to 9pm).

depends on the sex of the individuals, although it is necessary to state that only male volunteers were examined in this study. The influence of fabric structure parameters on the phenomena investigated will be the topic of future research programmes and independent publications.

Materials and Methods

Natural and synthetic fibre fabrics were used as test material. The choice of linen as the representative of the natural fibres was because of the Polish origin of this fibre. The choice of polyester to represent synthetic fibres was made because this is the most common fibre in clothing.

The tests were carried out on men's shirts made of the above-mentioned fibres, with the same model (long sleeves) and the same construction. Only the size varied, due to the differences in the volunteers who had signed up for the trails. The characteristics of the clothes used's textile metrology parameters are shown in Figures 1-6. The tests were conducted in accordance with Polish Standards.

The time constant (measured in ms) is defined as the time for a 67% discharge of electrostatic charges gathered on the cloth's surface. The conditions for the measurement of the time constant were as follows:

- upper limit of time constant potential - 150 V
- lower limit of time constant potential - 50 V
- air humidity - 65%
- air temperature - 20°C

From the lower values of surface resistance, and the time constant of electrostatic discharge for linen fabric compared to values measured for the polyester shirt, it may be concluded that linen cloth does not allow electrostatic charges to gather on its surface. A person wearing a polyester garment is exposed to the danger of a constant influence from electrostatic fields, and consequent rapid discharges when in contact with conducting materials. This is a consequence of polyester's ability to gather electrostatic charges. The higher level of heat resistance of linen cloth demonstrates its better thermal protection against cold than is the case with polyester cloth.

The preliminary studies were performed in mid-April 2001 (the environmental temperature was about 20°C) with12 healthy male volunteers aged

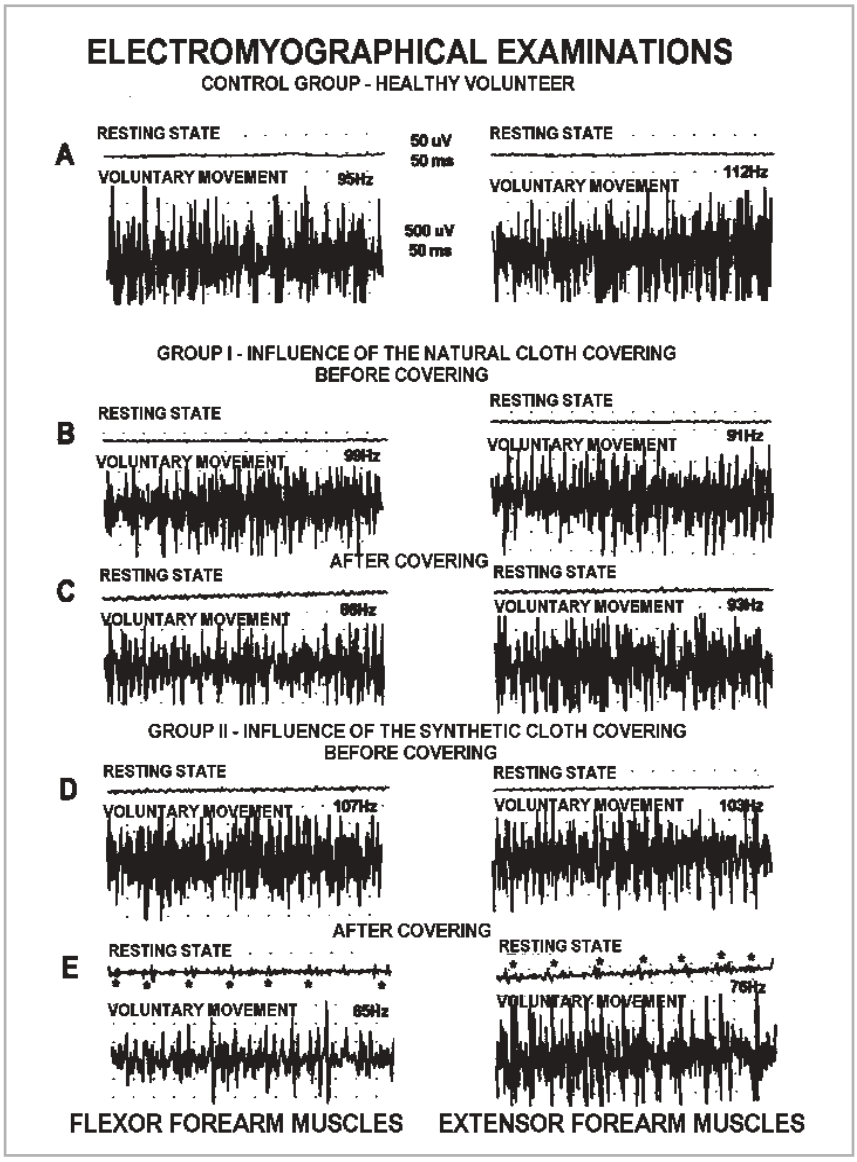

Figure 7. Examples of EMG recordings obtained in a healthy volunteer (A) and two subjects of group I (B, C) and group II (D,E) before and after covering the forearm with two kinds of cloth. Upper records - recordings at the state of rest; lower records - recordings during the voluntary movements. Stars show the presence of spontaneous discharges. Numbers in the upper right corner show the frequency of the action potentials appearing in each record during voluntary movements.

Table 1. Number of subjects in the control group and both subject groups wearing natural and synthetic shirts. The results of the temperature measurements (means) in the control group and group I and II subjects before and five hours after covering the forearm muscles. The other abbreviations are the same as in Table 2 (the grey areas indicate changes).

Group kind	Examined muscles Extensors of the forearm	
Control group N=50	n=50 32.2 (SD=0.14)	
Group I Natural Cloth N=6	Before covering n=12 32.3 (SD=0.11)	5 hours after covering n=12 32.8↑ (SD=0.12)
Group II Synthetic Cloth N=6	Before covering n=12 32.4 (SD=0,13)	5 hours after covering n=12 33.2↑* (SD=0,17)

Table 2. Results of electromyographical (EMG) and electroneurographical (ENG) studies and temperatures over the surface of the investigated muscles recorded in subjects of groups I and II. The symbols ⇑ and ⇓ show subsequently increases and decreases of the values in the measured parameters. The symbol ⇒ shows that the parameters were unchanged. Stars (*) indicate statistically significant changes (p<0.05) in recorded parameters comparing to controls. N - number of subjects; n - number of test; (SD - standard deviation), the grey areas indicate changes.

Recording->extensor forearm muscles
Recording->flexor forearm muscles
EMG
⇓ ⇓

radial nerve stimulation
recording->extensor forearm muscles
ENG - M-Wave
⇓ ⇓

	Resting state		Voluntary Movement					
	Muscle Tension Amplitude (µV)	**Sponta-neous activity**	**Amplitude (µV)**	**Frequency (Hz)**	**Amplitude (µV)**	**Conducti on velocity of motor fibres (m/s)**	**Temperature (°C)**	**Examined parameter**
Before covering	n=24 5.6 SD=0.17	n=24 not recorded	n=24 850 SD=55	n=24 110 SD=10	n=12 3.9 SD=0.2	n=12 47.8 SD=2.5	n=12 32.3 SD=0.11	Group I Natural cloth N=6
After covering	n=24 n=4↑ 6.2 SD =0.12 n=20→ 5.7 SD=0.15	n=24 not recorded	n=24 → 900 SD=65	n=24 → 100 SD=12	n=12 → 3.6 SD=0.1	n=12 → 46.2 SD=2.0	n=12 n=9↑* 32.8 (SD=0.12) n=3→ 32.4 SD=0.15	
Before covering	n=24 5.7 SD=0.11	n=24 not recorded	n=24 → 950 SD=75	n=24 → 92 SD=15	n=12 → 4.3 SD=0.2	n=12 → 57.2 SD=2.7	n=12 → 32.4 SD=0.13	Group II Synthetic cloth N=6
After covering	n=24 n=17↑* 14.5 SD= 0.15 n=7→ 6.0 SD=0.12	n=24 n=15*	n=24 n=13↑* 1800 SD=25 n=8↓* 700 SD=55 n=3→ 900 SD=85	n=24 n=19↓* 68 SD=9 n=5→ 91 SD=12	n=12 n=8↓* 2.9 SD=0.2 n=4→ 4.0 SD=0.15	n=12 → 5.6 SD=3.0	n=12 n=11↑* 33.2 SD=0.17 n=1→ 32.1 SD=0.12	

24-27 years, weighing from 69 to 78 kg. In the preliminary report before the examination was performed, none of them reported any movement or neurological disorders, and were not undergoing any treatment with drugs or other medication. None of them reported any chronic or inherited diseases.

The volunteers were dressed with long shirts made of linen and subsequently polyester shirts, which were buckled on the collars. The long shirts were buckled at the wrist of both hands; the time of covering was about 5 hours. The examinations were performed in an air-conditioned chamber at temperature of 20°C and a relative humidity (RH) of 55 %.

The volunteers were not engaged in effortful movements; they were usually asked to reading, use a computer (they chose the computer games), or they simply conversed. They were all previously informed about the aim of the examination and gave signed consent. They could drink mineral water or eat fruit as necessary.

The measurements of the skin's surface temperature over the muscles were performed in the flexors and extensors of the forearm with a standard contact thermometer (Figure 6), both before and after the subjects dressed in the shirts tested. Examinations with surface electrodes of the muscle activity in a state of rest (time base 50ms, sensitivity 50 µV), and of the bioelectrical activity of the flexor and extensor muscles in both forearms during the subjects' maximal efforts (time base 50 ms, sensitivity 500 µV) (Figure 5) were performed in a similar way using a NeuroRapid RunTime 10/20 electromyograph (connected to a PC, making possible the acquisition, processing and storage of the data). Following the electrical stimulation of the radial nerves (single pulses with duration of 0.1-0.2 ms, frequency at 1-2 Hz) with the recordings of evoked potentials over the forearm extensor muscles (M wave, time base 2 ms, sensitivity 1 mV), the conduction velocity of the motor fibres was examined.

During the analysis of the electrophysiological data taken from the tests performed in the state of rest, the parameters of amplitude and frequency of the spontaneously firing motor units (Figure 7E, shown with stars) were estimated, as was the general muscle tension. During the voluntary movements, the recruitments of motor units were analysed by amplitude and fre-

quency in the records of the single-action potentials.

In the electroneurographical studies of the evoked potentials (M wave), parameters of amplitude and latency from the stimuli onset (see examples in Figure 4, shown with cursors) to the onset of waves were analysed. Considering the conduction distance and latency of the potentials (in milliseconds), the conduction velocities of the motor fibres were ascertained.

The results of studies performed on people wearing shirts made of natural (group I, N=6) or synthetic fibres (group II, N=6) were compared with the controls available in the Department of Pathophysiology of Locomotor Organs. These control parameters are studied in volunteers from the healthy population every 2 years (N=50, control group). Details of these electrophysiological studies are given elsewhere [2].

In this study, the mean values and their standard deviations (SD) were calculated and values of given parameters were compared between the two groups of subjects, together with those of the control group before and after covering the forearms, using the t-Student test.

Results

Examinations of the surface temperature

The results of the temperature measurement in studies performed before and after the 5-hour tests are shown in Table 1. Figure 6 shows the distribution of the temperature recorded during the whole test in 2 subjects wearing shirts made of synthetic and natural fibres. In both cases, covering the surface of the forearm caused the temperature to increase, significantly in the subject dressed with the synthetic clothing.

Examinations of the muscles during voluntary movements and during the resting state

The muscle tension measurements during the state of rest showed variation in only 4 cases out of 24 trials (Table 2). An increase in the parameters of the amplitudes was observed only in group I subjects while recording the flexors of the forearm. On the other hand, a significant increase in the referring parameters of the amplitudes was observed in most cases (17/24) in the group II subjects while recording both muscle types. Furthermore, in most of the cases mentioned they were related to the presence of spontaneous potentials (15/24) in the recordings at rest (see also part E of Figure 7, shown with stars) at the frequency of 5-15 Hz. Also, in most cases in group II (but not in group I), during the electromyographical recordings with voluntary movements, significant changes in both the amplitudes (21/24) and the frequency (19/24) of the action potentials (19/24) were observed in the investigated motor units. However, these were within the ranges of normal physiological parameters.

Examinations of the transmission in motor fibres of the radial nerves

Data on the results of the evoked potential study are shown in Table 2. This data shows that covering the arm and the forearm with any type of clothhas no significant influence on the conduction velocity of the motor fibres within the nerve branches. However, in half of the subjects in group II, the recorded potentials had a slightly lower amplitude, as can be seen in the lower right example of Figure 8. It should be mentioned here that the parameters of the amplitudes of the evoked potential were in every case within the physiological range.

Conclusions

The presented preliminary studies allow us to draw the following conclusions:

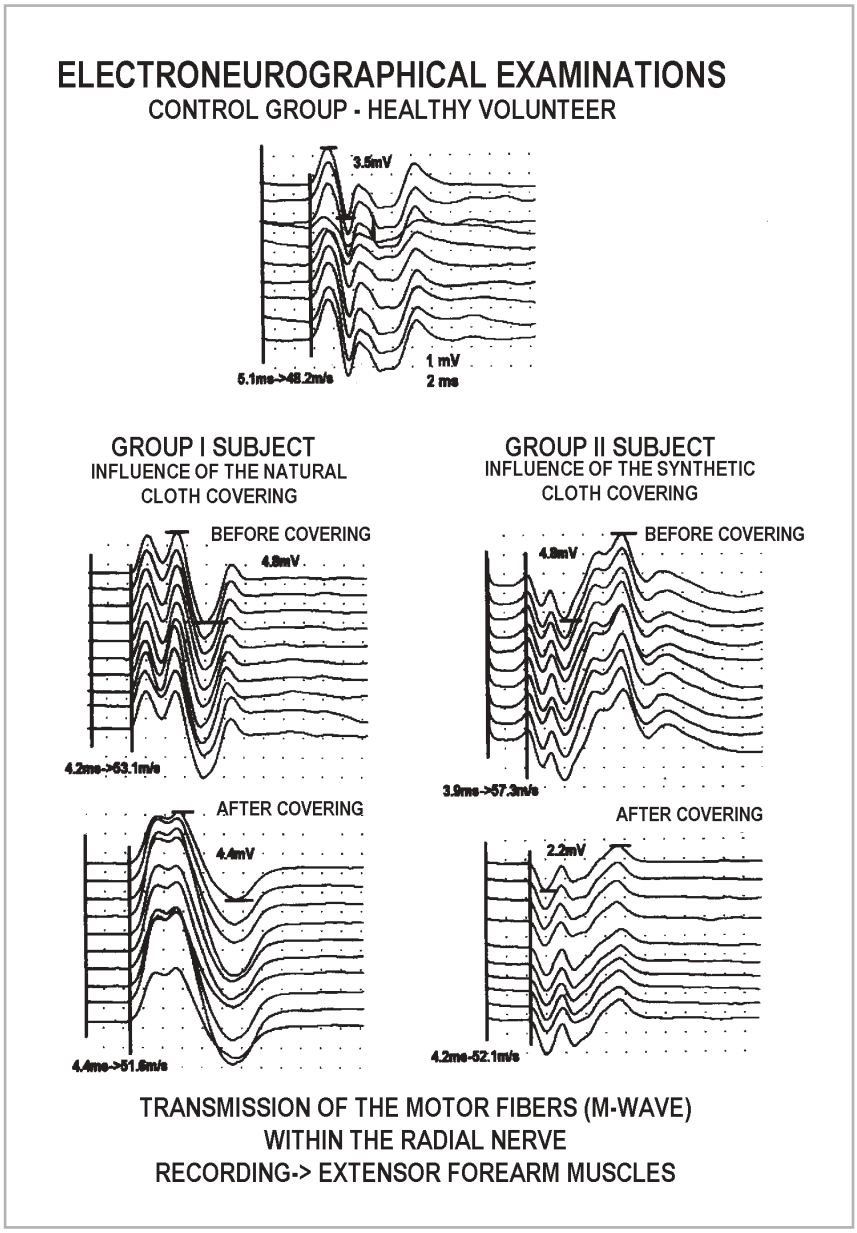

Figure 8. Examples of ENG recordings obtained in a healthy volunteer (control group), and in two subjects of groups I and II. Vertical markers indicate the latencies of M waves in the recorded potentials. Horizontal markers indicate the ranges of amplitudes. Numbers refer to the amplitude parameters (in mV) and the latencies related to the motor conduction velocities (in subsequent ms->m/s).

- Temporarily covering the tested forearm muscles with synthetic clothing changes the pattern of motor unit activity. This is expressed by the low-frequency spontaneous activity of the muscle fibres during the state of rest, or by diminished high-frequency activity of the motor units during the voluntary movements. These phenomena are correlated to the slight changes in the motor conduction velocities of the nerve fibres supplying the muscles.
- Covering the forearm with the natural clothing evokes none of the phenomena described in conclusion 1.
- A comparison of the results obtained in both groups of subjects with the controls leads to the conclusion that slight changes in the activity of the muscle motor units observed in group II are not pathological.
- Fluctuations are the reason for the desynchronisation in muscle motor units that may lead to a greater tendency to fatigue while wearing the synthetic garments.
- The electric charges gathered on the polyester cloth surface which cause an electrostatic field on the skin-cloth zone, together with an increase in the skin temperature in the polyester cloth, may be the cause for the observed changes.
- Due to the interesting results described above and the lack of possible explanation compared to other studies and literature, further research will be carried out aimed at identifying and analysing the phenomena caused by the influence of clothes made of natural (mainly linen and hemp) and synthetic fibres on the human body.

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