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A COMPARATIVE ANALYSIS OF CHANGES IN TACTILE SENSITIVITY IN MEN AND WOMEN PRACTICING SELECTED SPORTS

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ABSTRACT
Purpose. The aim of the study was to identify the relations between sports activity and threshold tactile sensitivity in athletes practicing selected sports: team games, water sports, swimming, martial arts, track and field and soccer. **Basic procedures.** The study was conducted between 2000 and 2002. 673 subjects took part in the study, including 346 men and 327 women. The age of the subjects ranged from 19 to 23. Threshold tactile sensitivity was measured with the use of Touch-Test™ Sensory Evaluator (Semmes-Weinstein Monofilaments) on the tip of the index finger of the dominant hand. Identifying the tactile threshold involved using an aesthesiometer filament of the smallest pressure force that the subject was able to feel. The collected data was processed separately for males and females. The following nonparametric tests were used in the statistical analysis: the Kruskal-Wallis test and the Mann-Whitney U test. **Main findings.** In general, athletes representing selected sports showed lower tactile sensitivity than subjects practicing no competitive sports. A detailed comparative analysis of various sports yielded differences between groups of subjects in terms of variability in the athletes' tactile sensitivity. In the groups of athletes, as well as in the control groups, women displayed a higher level of tactile sensitivity than men in the threshold pressure test. **Conclusions.** Physical activity, specific to individual sports, is a reason for a variability of threshold tactile sensitivity. Among the studied athletes, swimmers displayed the highest tactile sensitivity, and the lowest tactile sensitivity was observed in athletes practicing water sports, regardless of sex.

Key words: touch, sensory thresholds, sport, physical activity, perception

Introduction

Long-term sports training is conducive to an athlete's full adjustment to the requirements of his or her sport of choice. The resulting functional and structural changes in the athlete's body constitute the physiological basis for training. Apart from the athlete's motor function, kinesthetic sensations accompanying the body movements, e.g. visual, aural, tactual sensations specific to individual physical exercises, also become adapted. A high level of kinesthetic sensations and perceptions conditions the development of co-ordination motor abilities necessary for each type of motor activity. To a great extent, these abilities determine the effectiveness of the athletes' actions and patterns of motor behavior [1].

The skin is the largest sensory area of the body. The structural basis for its tactile function is determined by the activity of tactual receptors. The skin surface tactile sense is complemented with deep sensibility (bathyesthesia). The surface and deep senses in terms of their structure and function cannot, however, be clearly discriminated. Almost all tactile sensations result from the cooperation between the receptors of superficial and deep sensibility. Deep sensibility and its significance for sports activity have been subject to numerous studies [2–4]. Unfortunately, studies on athletes' superficial sensibility cannot be found in professional literature. It seems, therefore, necessary to attempt an analysis of the relations between athletes' superficial sensibility and the type of sport practiced. Researchers studying skin receptors distinguish various aspects of tactile sensitivity; however, the number of studies on its functioning, variability and adaptability is still not sufficient.

The aim of this study was to identify relations between sports activity and threshold tactile sensitivity in athletes in selected sports. The research hypothesis was that physical activity specific to a given sport is a cause of variability of the threshold tactile sensitivity in athletes.

Material and methods

The study was conducted between 2000 and 2002. 673 subjects participated in the study, including 346 men and 327 women, aged 19–23. The subjects were

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Table 1. Study groups and number of subjects

Group	Number of subjects	
	men	women
1. Team games players (basketball, volleyball, team handball)	48	56
2. Water sports athletes (kayaking, rowing)	47	30
3. Swimmers	25	32
4. Martial arts competitors (judo, taekwondo, karate)	35	31
5. Track and field athletes (runners)	30	36
6. Soccer players	41	n.a.
7. Control group	120	142
Total	346	327

n.a. – not applicable

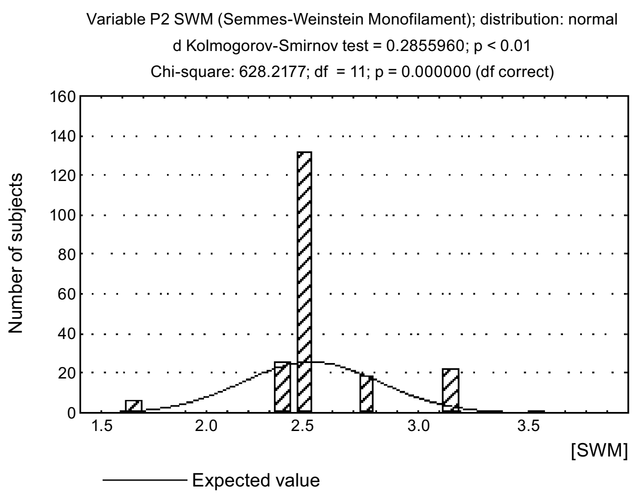

Figure 1. Distribution of TTS (threshold tactile sensitivity) mean values on the tip of the index finger – men practicing competitive sports (n = 226)

students of the University School of Physical Education in Poznań who practiced selected sports: team games, water sports, swimming, martial arts, track and field (running) and soccer. The control groups consisted of students who did not practice competitive sports (Tab. 1).

The dependent variable in the study was the threshold tactile sensitivity (TTS) measured on the tip of the index finger of the subject's dominant hand (1.04% of subjects were left-handed).

The measurements were performed with the use of Touch-Test™ Sensory Evaluator (Semmes-Weinstein Monofilaments), being a set of 20 nylon filaments with plastic grips. The filaments were of equal length and different width; each filament featured a different value of the least-bending pressure force (in grams and grams/mm^2). Owing to the differences in pressure force of particular filaments and in order to normalize the distribution of the dependent variable, the aesthesiometer's designer, Sidney Weinstein, found the logarithm for the numerical value of pressure force as $\mathrm{Log}_{10\ F(mg)}$ = Semmes-Weinstein Monofilament (SWM). The obtained numerical values from 1.65 to 6.65 were marked on the plastic grips of the filaments [5]. For the purpose of the present study these numerical values were accepted as measurement units (SWMs) for statistical analysis.

The TTS was the aesthesiometer filament of the least pressure force causing the least strain of the skin by stimulating the subject's tactual mechanoreceptors and producing the sense of touch.

While measuring the TTS, the subject remained sitting with his or her arms on the knees. Each subject was instructed about the method of measurement and undertook a pre-test to experience a supraliminal stimulus (with a thick, easily perceptible filament) and subliminal stimulus (with a thin, imperceptible filament). The subject was then asked to close his or her eyes and exposed to the pressure of other aesthesiometer filaments until the threshold filament was found. The test was repeated to confirm the TTS value. The results were recorded in a table along with the subject's age and practiced sport. All measurements were always taken by the same person in the morning and in the afternoon.

The collected data was then processed for statistical analysis with an Excel spreadsheet and STATISTICA software. To assess the conformity of mean values distribution of the dependent variable with the model distribution, the Kolomogorov-Smirnov test was used. The hypothesis about the conformity of distributions of the dependent variable with the normal distribution was rejected as the obtained distributions differed significantly from the model distribution (Fig. 1). In the statistical analysis two nonparametric tests were used: the Kruskal-Wallis test and the Mann-Whitney U test. The relations between the subjects' age and the TTS were evaluated using Spearman's rank correlation coefficient.

Results

The sense of touch and subjects' age

Having taken into consideration the results of other studies indicating relations between the TTS and age

Table 2. The subjects' age range

Age range (years)	Accurate age range	Number of subjects	
		men	women
19	18.50–19.49	49	51
20	19.50–20.49	141	135
21	20.50–21.49	96	104
22	21.50–22.49	43	28
23	22.50–23.49	17	9
Total		346	327

[5–7], and a rather short age range of subjects of both sexes (max. 5 years), age was excluded as a discriminating factor for the experimental groups. Tab. 2 shows that the majority of subjects – 237 men (68%) and 239 women (73%) – were aged 20–21 at the time of the study.

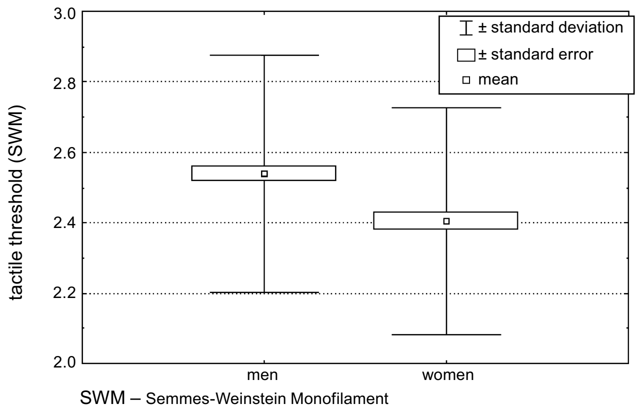

Figure 2. Comparison of TTS (threshold tactile sensitivity) values on the tip of the index finger in male and female athletes practicing competitive sports (n = 427)

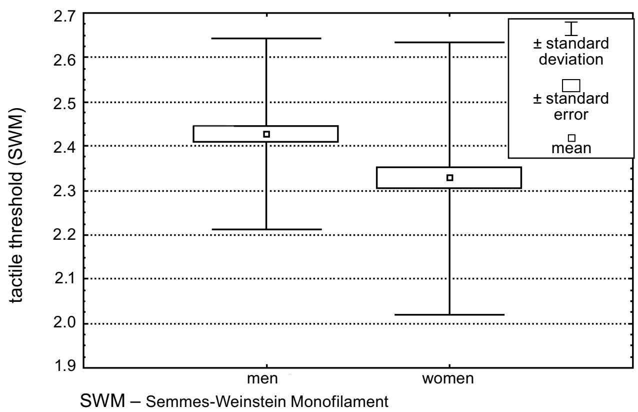

Figure 3. Comparison of TTS (threshold tactile sensitivity) values on the tip of the index finger in male and female athletes practicing no competitive sports (n = 262)

With regard to the specific conditions of particular sports practiced by the athletes under study, possible relations between the subjects' age and aesthesiometric measurement results were sought. No statistically significant correlations between the parameters under study were observed in the men's and women's groups. For example, Spearman's rank correlation coefficient between age and the TTS on the tip of the index finger in the water sports male athletes amounted to R = –0.10.

The sense of touch and subjects' sex

The statistical analyses were made separately for men and women (Fig. 2, 3). Tab. 3 presents the results obtained by the male and female subjects. The male subjects displayed higher TTS than the female subjects. In the groups of athletes and control groups sex was a significant discriminating factor for TTS values. Female subjects displayed lower TTS than men in the threshold pressure test.

Table 3. Differences in TTS (threshold tactile sensitivity) variability on the tip of the index finger in men and women practicing and not practicing competitive sports

Groups of subjects compared	Mann-Whitney U test results (Z)
Male athletes/female athletes	Z = –3.73*
Men/women (control group)	Z = –3.56*

* p = 0.01

Table 4. Differences in TTS (threshold tactile sensitivity) variability on the tip of the index finger in subjects practicing and not practicing competitive sports: comparison of sex groups

Groups of subjects compared	Mann-Whitney U test results (Z)
Male athletes/male subjects (control group)	Z = –2.83*
Female athletes/female subjects (control group)	Z = –2.85*

* p = 0.01

The sense of touch and the type of competitive sport

In order to assess the effect of sport activity on tactile sensitivity, the TTS values on the tip of the index finger in the athletes and control groups (both sexes) were compared. Higher TTS was observed as a result of practicing competitive sports. The athletes displayed lower tactile sensitivity than the non-athletes. The differences observed were statistically significant (Tab. 4). Fig. 4 and 5 present diagrams for the groups of men and women, respectively.

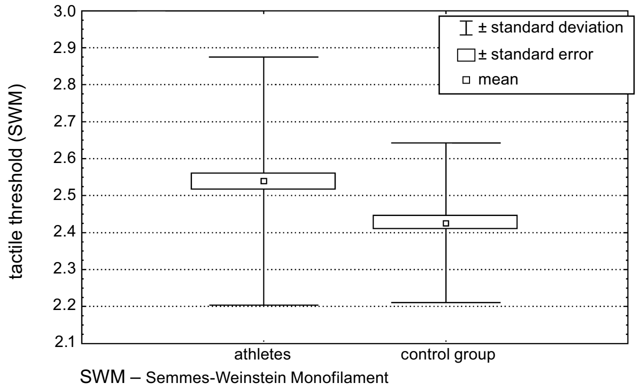

Figure 4. Comparison of TTS (threshold tactile sensitivity) values on the tip of the index finger in male athletes practicing and not practicing competitive sports (n = 346)

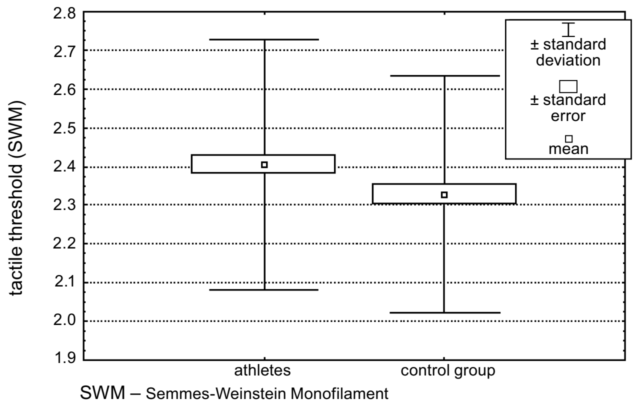

Figure 5. Comparison of TTS (threshold tactile sensitivity) values on the tip of the index finger in female athletes practicing and not practicing competitive sports (n = 327)

The effect of the type of sport on the sense of touch

The effect of the type of sport on the TTS was assessed using the Kruskal-Wallis test. The obtained test results (H = 37.58 in men; H = 25.69 in women) allowed us to reject the null hypothesis, suggesting no TTS differences between the subject groups. The analysis revealed statistically significant differences (p = 0.01) between athletes practicing selected sports, which led to a more detailed comparative study between the groups, with the use of Mann-Whitney U test.

In the male groups, the highest TTS was displayed by water sports athletes followed by team games players, soccer players, track and field athletes, martial arts competitors and swimmers (Fig. 6). The subjects from the control group displayed lower tactile sensitivity than the martial arts competitors and swimmers.

The differences between the groups with regard to the TTS variability are the following (Tab. 5):

- water sports athletes displayed the lowest statistically significant values of tactile sensitivity of all groups of athletes under study; only in comparison with the team sports players, the difference was statistically insignificant;
- team sports players displayed lower statistically significant tactile sensitivity than soccer players, martial arts competitors and swimmers; in comparison with the track and field athletes, the difference was statistically insignificant; team sports players showed higher tactile sensitivity than water sports athletes (statistically insignificant);
- soccer players featured higher statistically significant tactile sensitivity than the water sports athletes and team games players, and lower tactile sensitivity than track and field athletes, martial arts competitors and swimmers (statistically insignificant);
- track and field athletes displayed higher tactile sensitivity than water sports athletes (statistically significant), team games players, and soccer players (statistically insignificant), and lower tactile sensitivity than martial arts competitors and swimmers (statistically insignificant);
- martial arts competitors featured higher tactile sensitivity than water sports athletes, team games players (statistically significant), soccer players and track and field athletes (statistically insignificant), and lower tactile sensitivity than swimmers (statistically insignificant);
- swimmers displayed higher tactile sensitivity than water sports athletes, team games players (statistically significant), soccer players, track and field athletes, and martial arts competitors (statistically insignificant);
- the control group featured higher tactile sensitivity than water sports athletes, team games players (statistically significant), soccer players, and track and field athletes (statistically insignificant), and lower tactile sensitivity than martial arts competitors and swimmers (statistically insignificant).

Table 5. Differences in TTS (threshold tactile sensitivity) variability on the tip of the index finger between groups: men (n = 346)

Study group	Track and field athletes	Team games players	Martial arts competitors	Water sports athletes	Swimmers	Soccer players
Team games players	Z = –1.02					
Martial arts competitors	Z = 0.7	Z = 1.78*				
Water sports athletes	Z = –2.51**	Z = –1.6	Z = –3.22**			
Swimmers	Z = 1.36	Z = 1.89*	Z = 1.06	Z = 2.28**		
Soccer players	Z = 0.58	Z = 1.76*	Z = –0.16	Z = 3.15**	Z = –1.22	
Control group	Z = –1.2	Z = –2.72**	Z = –0.32	Z = –4.53**	Z = 1.09	Z = –0.49

Z – Mann-Whitney U test result, * p = 0.05, ** p = 0.01

Table 6. Differences in TTS (threshold tactile sensitivity) variability on the tip of the index finger between groups: women (n = 327)

Study group	Track and field athletes	Team games players	Martial arts competitors	Water sports athletes	Swimmers
Team games players	Z = –0.2				
Martial arts competitors	Z = 0.58	Z = 0.82			
Water sports athletes	Z = –1.71*	Z = –1.7*	Z = –1.97*		
Swimmers	Z = 2.18*	Z = 2.58**	Z = 1.54	Z = 2.94**	
Control group	Z = –2.2*	Z = –2.91**	Z = –1.31	Z = –2.99**	Z = 0.72

Z – Mann-Whitney U test result, * p = 0.05, ** p = 0.01

In the groups of female subjects, the highest TTS, i.e. the lowest tactile sensitivity, was displayed by water sports athletes, followed by track and field athletes, team games players, martial arts competitors and swimmers (Fig. 7). The control group featured lower tactile sensitivity than the group of swimmers.

The differences between groups in terms of their threshold tactile sensitivity are as follows (Tab. 6):

- water sports athletes featured the lowest statistically significant tactile sensitivity out of all groups of female athletes under study;
- track and field athletes displayed higher tactile sensitivity than water sports athletes (statistically significant), and lower tactile sensitivity than team games players, martial arts competitors (statistically insignificant) and swimmers (statistically significant);
- team games players featured lower tactile sensitivity than water sports athletes (statistically significant), and lower tactile sensitivity than martial arts competitors (statistically insignificant) and swimmers (statistically significant);
- martial arts competitors displayed higher tactile sensitivity than water sports athletes (statistically significant), track and field athletes, and team players (statistically insignificant), and lower tactile sensivity than swimmers (statistically insignificant);
- female swimmers featured higher tactile sensitivity than water sports athletes, track and field athletes, team games players (statistically significant) and martial arts competitors (statistically insignificant);
- subjects from the control group displayed higher tactile sensitivity than water sports athletes, track and field athletes, team games players (statistically significant) and martial arts competitors (statistically insignificant), and lower tactile sensitivity than swimmers.

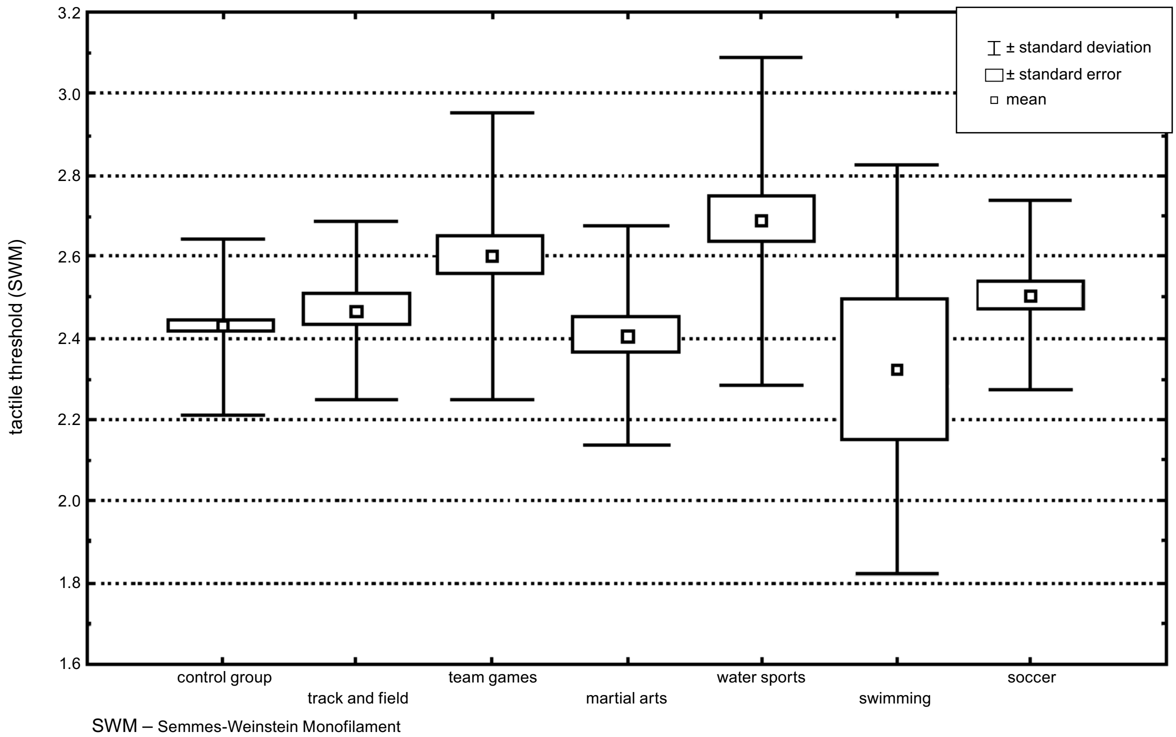

Figure 6. TTS (threshold tactile sensitivity) variability on the tip of the index finger in male athletes practicing selected sports as compared with the control group (n = 346)

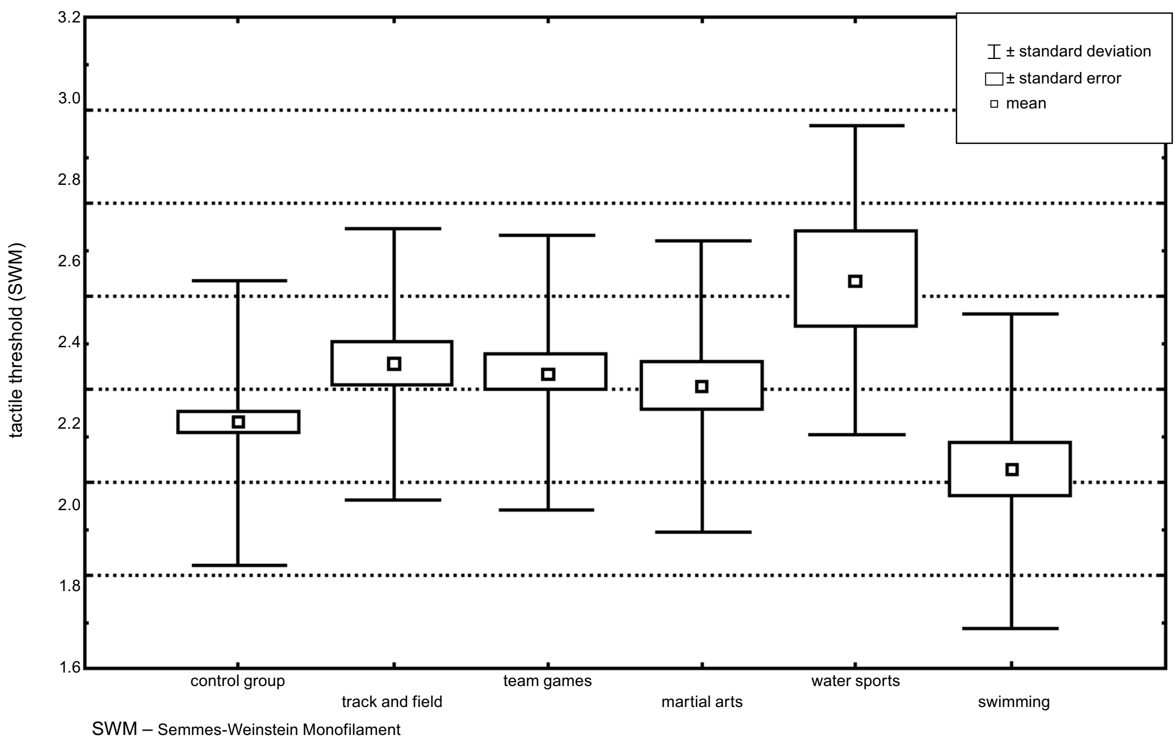

Figure 7. TTS (threshold tactile sensitivity) variability on the tip of the index finger in female athletes practicing selected sports as compared with the control group (n = 327)

Discussion

Since the study was merely an attempt to examine relatively new issues, not all of its results can be compared with those from other studies. Some results were interpreted with reference to the general variability conditions of tactile sensitivity.

Since the sense of touch is most significant in manual location, handling and identification of objects, the variability of tactile sensitivity as a function of age has been an interesting research subject [8, 9]. Population studies show that tactile sensitivity in subjects of both sexes is weaker with age, beginning with pubescence [10]. This is linked to several biological properties of the skin, such as thickness of the epidermis or the quantity of collagen and elastin, which can change with age.

Changes in morphology, quantity, density and location of tactual receptors are also likely to appear [11]. The present study fails to confirm the effect of age on tactile sensitivity, which is understandable taking into account the subjects' short age range.

Weinstein [12] studied different aspects of tactile sensitivity as a function of body part, sex and laterality. In the 1950s he designed the Semmes-Weinstein aesthesiometer, to examine war veterans and distinguish between those with damage to the peripheral nervous system and those with damage to the central nervous system. Weinstein's calibrated nylon filaments replaced the earlier Von Frey's bristles (in the late 19^{th} century Von Frey developed a sensory measurement method using calibrated human hairs and animal bristles). Since the 1950s Weinstein's aesthesiometer has been used by a number of clinicians and researchers. It allowed for a distinction of the various aspects of the sense of touch. Weinstein examined 24 men and 24 women by measuring their tactile threshold and assessing two-point discrimination. In the tactile threshold examination he noticed that the face was the most sensitive part of the body in men and women, followed by the trunk, fingers and upper extremities. The least sensitive were the lower extremities. In his evaluation of two-point sensory discrimination, Weinstein noted the greatest density of tactual receptors in men and women in the fingers, face and feet. The more distal the body part is, the higher its sensitivity. Weinstein also observed that women displayed higher tactile sensitivity on individual body parts than men, but only during examination of threshold pressure. More recent population studies [10] also show that sex significantly differentiates the sense of touch. The results of threshold examination revealed that women were indeed more sensitive than men. In all groups of subjects in the present study, sex is a discriminating factor for TTS mean values. The female subjects have all displayed generally higher tactile sensitivity than men. Although male and female athletes feature higher TTS than the subjects from the control groups, the intersexual differences between the measuring points are similar in both the athletes' and control groups.

The TTS changes in the competitive athletes under study were compared with the results obtained by the subjects from control groups. It was observed that physical activity, specific to individual sports, affected the athletes' sense of touch. In some athletes sports training can enhance the tactile neural basis, in others tactile sensitivity may decrease.

Sports training is a specific, long-term process aimed at developing the athlete's physical skills necessary for the sport being practiced. Already during the first stage of sports training, guided exercises specific to the athlete's chosen sport are strongly emphasized [13]. According to Czabański [14], specially selected motor exercises can equip the athlete's motor function with kinesthetic sensations. While performing movements, owing to the activation of skin and myo-arthral receptors, potentials generated in tactile neurons provide information about movement accuracy, range and force. The mechanoreceptors affect motor orders for the hand and finger muscles [15]. The hand's tactile sensitivity is the highest in the fingertips which feature high density of tactual receptors. The fingertips are the most exposed to the environmental impact and remain the preferred spot for tactile examination [16–18]. In the present study, the TTS was measured on the tip of the index finger as a spot particularly stimulated during sports activity.

The stimulus in team games (basketball, volleyball, team handball) is the fingers' contact with the ball. During hitting or passing the ball the fingertips are most susceptible to frictions, pressures and strokes. In kayaking or rowing, the stimulus is the contact with an oar. For example, during rowing both rower's hands are placed on the oar, and movements are performed with wrists and fingers. Swimming requires physical activity in the water environment, which is conducive to the body's adaptation to the physical features of this environment. A swimmer receives stimuli from the water environment via his or her tactual receptors, which affects the propulsive movements and leads to an improvement of the tactile analyzer. In martial arts, the stimulus is the contact with the opponent's body. Mastering sensory skills in constantly changing situations is crucial to all martial arts competitors. Soccer players and runners represent sports in which training and competitions generally lack factors explicitly affecting their tactile sensitivity. However, these are athletes whose high level of physical activity, due to intensive efficiency training and development of motor traits, is very likely to affect their general level of tactile sensitivity. Also the atmospheric conditions which soccer players and runners are exposed to during training and competitions can affect their sense of touch.

The significance of the sense of touch in various sports cannot be refuted. The tactual receptors, receiving stimuli from contacts with the ground, outfit or a sports apparatus, provide the athlete's body with information about its immediate surroundings. While handling an object, the pressure force between the fingertips and the thumb is automatically balanced out to prevent the object from breaking or slipping out. This precise force control requires information from the tactile units about the intensity of friction between the skin and the object. It can be concluded that systematic training enhances the tactile analyzer since it leads to correct identification of stimuli, i.e. athletes develop higher tactile sensitivity to the outside stimuli and display much greater abilities to discriminate their movements in various conditions.

However, the results of the present study show that in groups of male athletes only, swimmers and martial arts competitors featured statistically insignificantly higher tactile sensitivity than the control group. All other athletes displayed lower tactile sensitivity, while statistically significant differences were only noted between water sports athletes, team games players and subjects from the control group.

The female subjects produced similar results. The female swimmers and martial arts competitors showed statistically insignificantly higher tactile sensitivity than subjects from the control group. The other athletes featured lower tactile sensitivity, but statistically significant differences were only observed between the water sports athletes, track and field athletes, team games players and the control group.

Tactile sensitivity is a genetically conditioned trait. However, it can be greatly modified by different environmental factors, among which are varied physical activities characteristic of different sports. The outermost layer of the epidermis, called *stratum corneum*, is composed of dead, exfoliated cells. The number of layers of these cells, determining the thickness of the cuticle, varies (100 to 200 in thick skin; 2 to 5 in thin skin) and depends on mechanical pressure forces and frictions the skin is exposed to. Thus the type of sports activity can modify the thickness of the epidermis. On the basis of the results of the present study it can be concluded that changes in the epidermis thickness can be a cause of variability in threshold tactile sensitivity observed in athletes practicing different sports. Moreover, Osiński [19] puts emphasis on intentional actions in sports training aimed at relieving the body of numerous unpleasant sensations, primarily caused by mechanical factors such as feelings of touching, pressing, stroking, scratching or tapping. Highly significant in effective training are frequent showers, rubbing the body with wet and dry towels and various massages.

Conclusions

1. Physical activity in various sports is a cause of variability in athletes' threshold tactile sensitivity.
2. The highest tactile sensitivity in the groups of subjects under study, regardless of sex, was displayed by swimmers, and the lowest by water sports athletes.
3. Athletes whose fingertips are constantly exposed to mechanical pressures and frictions feature lower tactile sensitivity than the subjects from the control group.
4. Swimmers show a tendency towards higher tactile sensitivity than the subjects from the control group.

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