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Symptoms of sexual dimorphism in judoists

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Summary

Introductoin. Sexual dimorphism is the difference in form between male and female individuals of the same species in the world of plants, animals and humans. This difference in form manifests itself in various spheres of life.

The phenomenon of sexual dimorphism is a factor particularly important in physical education and sports. Functional differences between men and women provide different opportunities for athletic performance or may be the reason why it is virtually impossible for women to practise some sports.

Access for women to almost each sport becomes a fact. Many countries, which are the leaders in international sports competition including Olympic Games, owe their position mainly to women's achievements. In Poland participation in sports among women is too limited. It seems impossible to maintain or improve the position of Polish sports in international rankings without their participation.

The purpose of this study was to determine dimorphic differences in male and female judoists, regarding body composition as well as aerobic and anaerobic physiological factors.

Material and methods. The research covered male and female judoists of KS AZS Sports Club at the Academy of Physical Education in Gdańsk. The research was conducted after the end of a preparatory period of an annual training cycle.

The 30-second Wingate test version was used to assess the anaerobic power. The tests were conducted using a "Monark" cycle ergometer. The aerobic power test was conducted on a Jaeger cycle ergometer with the load being increased until refusal to continue effort. The effort started from the 1.5 W/kg body mass load. After 5 minutes of work the load was increased by 25 Watts every minute.

Results and Conclusions. The observed significant statistical differences in body composition between male and female judoists proved that the training loads applied within the same group revealed the traits of sexual dimorphism. Manifestations of sexual dimorphism were also found in physiological indices.

Introduction

„The thesis that sport is a male domain is the commonest cliché of contemporary sports sociology, and to a lesser extent – sports psychology. Nevertheless, it is regularly confirmed by research results. Despite the fact that the development of civilisation of the end of the 20th century relatively quickly bridged the gulf between male and female athletes, sport still remains a male domain, where a certain number of females is allowed, provided they readily observe the rules established by males" [1].

Nowadays however, the growing interest in endurance sports among the female population has resulted in equal amount of time devoted to training by men and women. Parallel to increasingly frequent participation of women in various sport disciplines, an increased interest is observed in physiological effects of intensive and sustained effort on the female body. Undoubtedly, the gender-related differences in capability of adaptation to exercise performance result from multiple biological, morphological and physiological traits underlying physical capacity [2].

Sexual dimorphism is the difference in form between male and female members of the same species of plants, animals and humans. The gender-related differences in body constitution are manifested in various fields including sport. With similar fitness levels, males obtain better results than females in all measurable sports disciplines. Among both training and non-training females, there are some who run faster, throw farther and jump farther or higher than their male counterparts of similar age. The supremacy of female athletes may be due either to their unquestionable talent or rather male than female body constitution. The phenomenon of sexual dimorphism is of particular importance in physical education and sports.

The gender-related functional differences provide unequal opportunities for men and women to obtain high scores, or sometimes make it impossible for the females to participate in some sports disciplines. Sexual dimorphism in humans is defined as a series of differences in body constitution, size and proportions of different somatic features, occurring within male and female individuals belonging to the same species [3].

Such gender-related differences in body constitution and function, growth speed, maturation, as well as hobbies related to mentality, are different at consecutive life stages. These differences contribute to formation of a specific motor traits, typical for male and female individuals.

Dimorphism also refers to genetically conditioned differences in male and female bodies as for morphological, physiological and mental traits. Morphologically, sexual dimorphism is manifested by differences in body proportions. There are two types of body constitution: extremely female and extremely male [4].

The body constitution of female athletes, especially those who successfully perform, is markedly different from an ideal female constitution. The desired body constitution of a female athlete resembles a male one as for anthropometric and tissue sizes and proportions. Generally, sexual dimorphism of somatic traits in male and female athletes in a given sport discipline diminishes with training. Body constitution of male and female athletes doing the same sport becomes increasingly similar as female athletes are characterised by rather male silhouettes. Training contributes to the development of the male type of body constitution in both genders, through adipose tissue reduction and muscular development. The biggest differences between the body constitution of training individuals and that of non-training individuals are observed in the amount of adipose tissue. Piechaczek [5] and Krawczyk [6] have found that the percentage of adipose tissue in high class female athletes is lower than the average values of non-training males.

The gender-related differences in adaptation to physical exertion result from many important factors, such as biological, morphological and physiological body traits, directly related to physical capacity.

According to Kozłowski et al. [7], the factors determining gender-related differences in oxygen supply include: body mass (fat and muscle mass), functions responsible for oxygen transport within the body (respiratory volume, maximal heart rate, stroke volume (SV), the content of oxygen transporting hemoglobin and muscle oxygenation.

Heart volume, exercise SV and pulmonary vital capacity are lower in women, therefore their physical capacity is lower compared to that of males. The increase in oxygen uptake by working muscles, exposed to physical exertion is due to the increased muscular blood flow and cardiac output (Q), which depends on the heart rate (HR) and SV.

Especially due to smaller bodies, smaller hearts and lower amounts of the circulating blood, SV values are lower in females than in males. Higher HR values are also noted in females compared to males during physical exertion in exposure to the same load. Conversely, there are only slight gender-related differences in maximal heart rate (HR max) values, occurring in exposure to maximal physical exertion and diminishing with age. The gender-related differences in maximal cardiac output (Q max) with maximal exercise loads amount to about 30% in favour of males. Such differences are due to larger hearts and the resultant higher values of SV in males [2].

Respiration consists in the release of energy cumulated within the body. It is divided into external and internal respiration. External respiration consists in tissue supply with atmospheric oxygen particles. Internal breathing is the process involving chemical reactions within cells. Ventilation of the lungs is dependent on respiratory movements of the thorax.

Judo is a sport discipline characterised by a variable effort intensity and frequent changes in fight conditions. Exertion in judo competition is of short duration yet of changeable intensity. In order to supply muscles with a proper amount of energy so as they could sustain such effort, it is necessary to activate glycolytic transformation process, that is anaerobic metabolism. This exertion consists in repeated activities with a different extent of static and dynamic effort engagement. The fight is performed in a standing and kneeling position, or the competitors change the position from standing to kneeling. With acyclic movements and active performance of the opposing fighter, effort is characterised by a variable intensity and alternant engagement of aerobic and anaerobic processes.

Energy expenditure is directly related to potential physical effort performance, which depends both on effort intensity and effort duration.

A full time fight lasts 5 minutes, although in most cases it is finished earlier, and sometimes the fight lasts no longer than several seconds [8].

It is also necessary for the fighters to be able to continue fight under conditions of intensifying muscle acidification. Maintaining a high exercise capacity during the entire fight period and the necessity of starting the next fight after a short rest also requires aerobic fitness above the average norm. Mickiewicz-Zawadzka [9] in her paper suggests that judoists utilise over 90% of their oxygen threshold. The biggest effort is required during thrusts, leverage, choking and grasping. These require a high phosphate transformation capacity to achieve such a high anaerobic power. During each supramaximal effort, energy is derived mainly from phosphagen substrates [adenosine triphosphate (ATP) and phosphocreatine] which, due to their limited amount, enable a few-second performance only, like for example thrust.

According to Laskowski [8] and Mickewicz [9], judo requires comprehensive physical training, based both on aerobic and anaerobic transformation, determining the level of the fighter's special performance, conditioned by multiple factors including: sport class, age, body mass and the kind of discipline.

The aim of the study was to determine gender-related dimorphic differences in male and female judoists. The following research questions were posed:

1. What are the differences in body composition between male and female judoists belonging to the same training group?
2. What are the differences in aerobic and anaerobic physiological indices between male and female judoists belonging to the same training group?

Material and methods

The sample consisted of judoists from student sports clubs in Gdańsk. Table 1 presents sample characteristics. The study was conducted on completion of the preparatory stage of the yearly training cycle. The subjects were first class athletes.

The method of anaerobic fitness measurement

Anaerobic fitness was evaluated (using a laboratory method) by the test developed by Bar-Ora, named Wingate test (WAT-Wingate Anaerobic Test) [10].

A 30-second version of Wingate test was applied with a full flywheel resistance from the beginning of exercise. The subjects had their lower limbs tested with the load applied, corresponding to their body mass: 75g/kg.

A „Monark" cycloergometer (made in Sweden) with a mechanically regulated flywheel resistance was used for the study.

Basic mechanical test parameters were calculated, namely:

– maximal power (W/kg),
– the time of obtaining maximal power (s)
– the time of maintaining maximal power (s)
– the total amount of work performed during 30- second exertion [J/kg],
– power decrease index, expressing the difference between the highest and the lowest power value in 3-second intervals, divided by the time of power decrease.

All mechanical parameters of the Wingate test were calculated using a software. All mechanical WAnT parameters were calculated using MCE V 2.0 (11) software.

The method of aerobic fitness measurement

A computerized Oxycon gas analyser (made by Jaeger) and a cycloergometer were used to determine aerobic fitness. The test was conducted in seated subjects with an increasing load applied till their refusal to continue effort. The initial load was 1.5 W/kg with pedalling frequency of 55 rpm. After five minutes the load was increased by 25 W in one minute increments till the subjects refused to continue effort. After the test, the subjects remained seated on the cycloergometer for five minutes.

The values recorded during the maximal and submaximal effort and at rest included:

– ECG monitoring of the HR
– relative [ml/kg/min] and absolute [l/min] values of oxygen consumption and carbon dioxide elimination using a direct method (VO2),
– minute ventilation (VE),
– breathing frequency (BF).

Moreover, the total exercise power was determined in absolute [W] and relative [W/kg] values.

The measurement of basic body composition was performed using the TANITA BODY COMPOSITION ANALYZER TBF-300.

Statistic analysis was carried out using the ANOVA methods of variability comparison, regarding different variability-affecting factors.

Arithmetic means and standard deviation (SD) of the analysed traits were calculated. The significance of differences was calculated between the arithmetic means of different traits in the group of female judoists.

Tab. 1. Anthropometric characteristics of the studied male and female judoists

	women (n=10)	men (n=10)
Age (years)	23.8 ± 2.3	23.2 ± 2.5
Body height (cm)	166.1 ± 4,2	176.5 ± 6.2
Body mass (kg)	60.9 ± 5.7	79.6 ± 13.3

Tab. 2. Characteristics of selected body composition indices in the studied female and male judoists

	women (n=10)	men (n=10)
BMI (body mass index)	22.07 ± 1.3	24.9 ± 2.7
FAT% (percentage of adipose tissue)	18.08 ± 2.5 ***	9.07 ± 3.1
FAT Mass (kg) (fat body mess)	11.07 ± 2,1**	7.35 ± 3,5
FFM (kg) (fat free –mass)	49.9 ± 4,6**	36.52 ± 3,3
TBW (kg) (total body water)	69.84 ± 8.4**	51.12 ± 6,1

$p<0.05$*, $p<0.01$**, $p<0.001$***

Results

Statistically significant changes were recorded for the percentage of body adipose tissue (p<0.001), fat body mass (p<0.01), lean bodAs for oxygen consumption, a statistically significant difference was noted between the maximum oxygen uptake (VO_{2max}) at p<0.01 (Fig. 1). A statistically significant difference was also observed between the VE value in exposure to submaximal (p<0.05) and maximal (p<0.01) exertion (Fig. 3). The respiratory rhythm was significantly higher (p<0.05) in exposure to maximal exertion (Fig. 4). Significant differences were also found in maximal aerobic and anaerobic power values (Fig. 5, 7) and energy expenditure (J/kg) in anaerobic effort (Fig. 6).

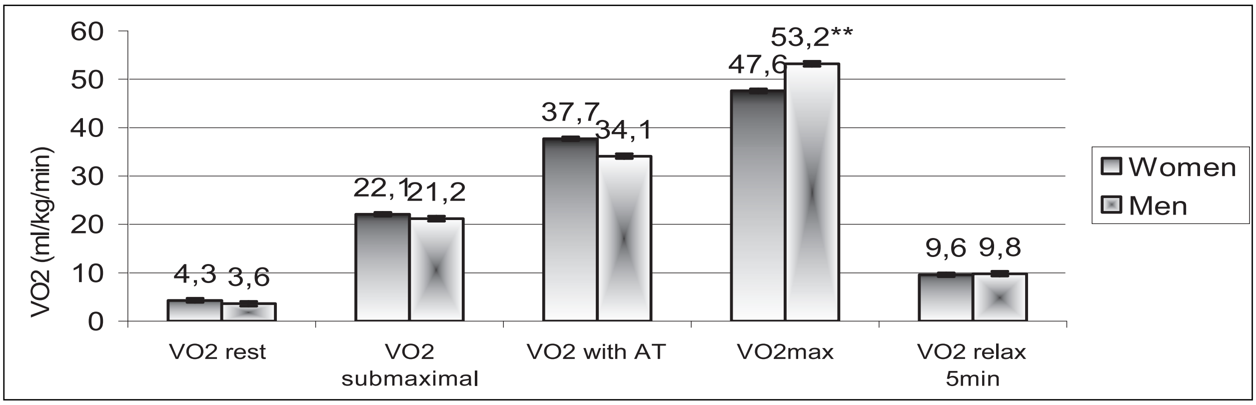

*Fig.1. Oxygen uptake chart (VO_2 ml/kg/min) in male and female judoists in exposure to aerobic exertion (p<0.001**)*

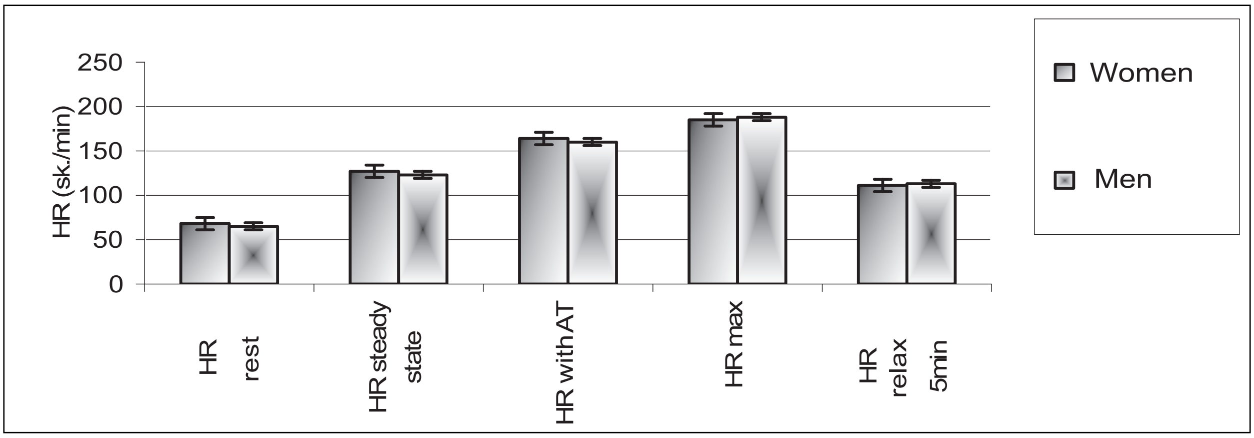

Fig.2. Heart rote (HR sk./min) in male and female judoist in test exertion

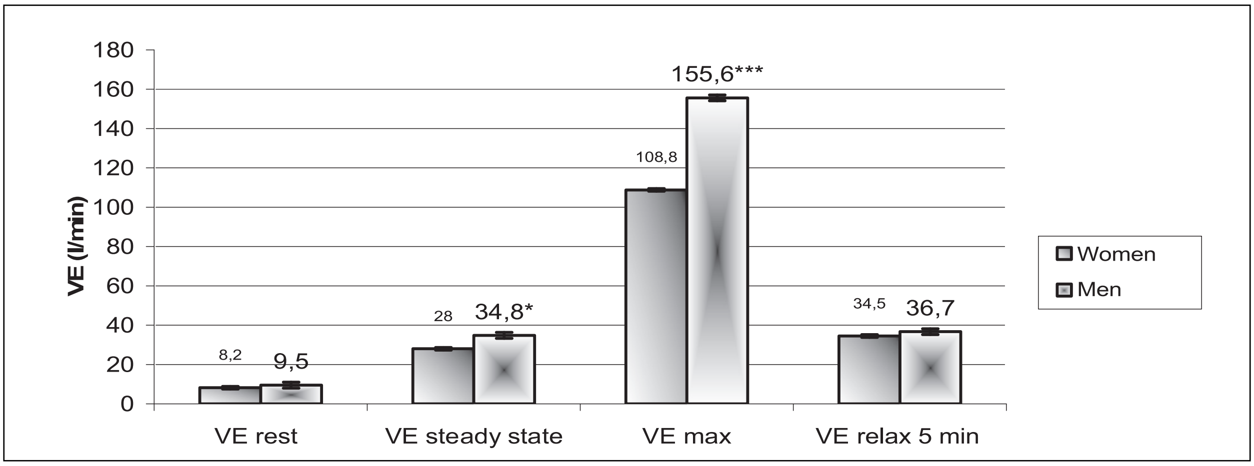

*Fig.3. Minute ventilation (VE l/min) in the sample of female and male judoists in test exertion (p<0.05, * p<0.001***)*

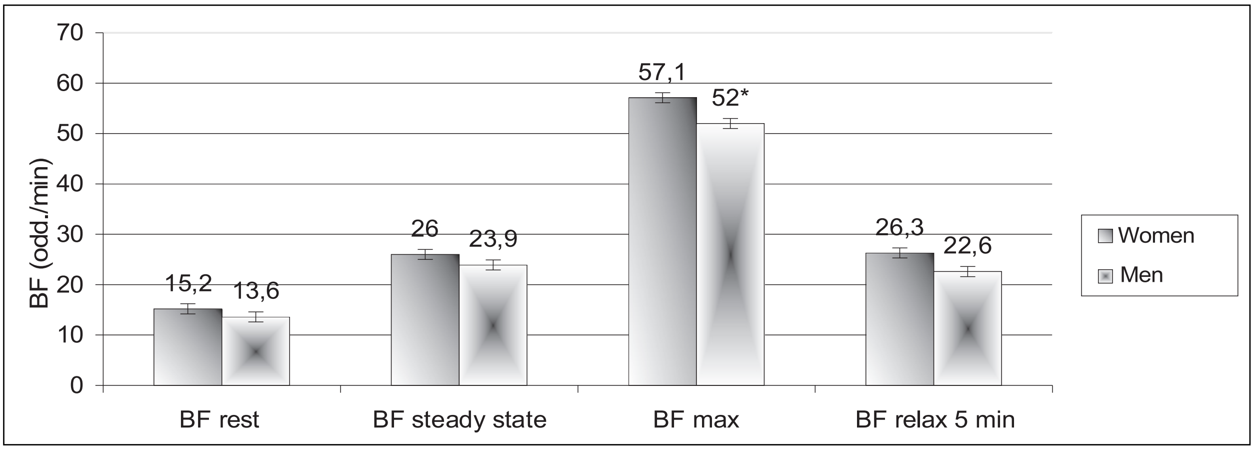

Fig.4. Breathing frequency(BF odd./min) in the studied female and male judoists in test exertion (p<0.05)*

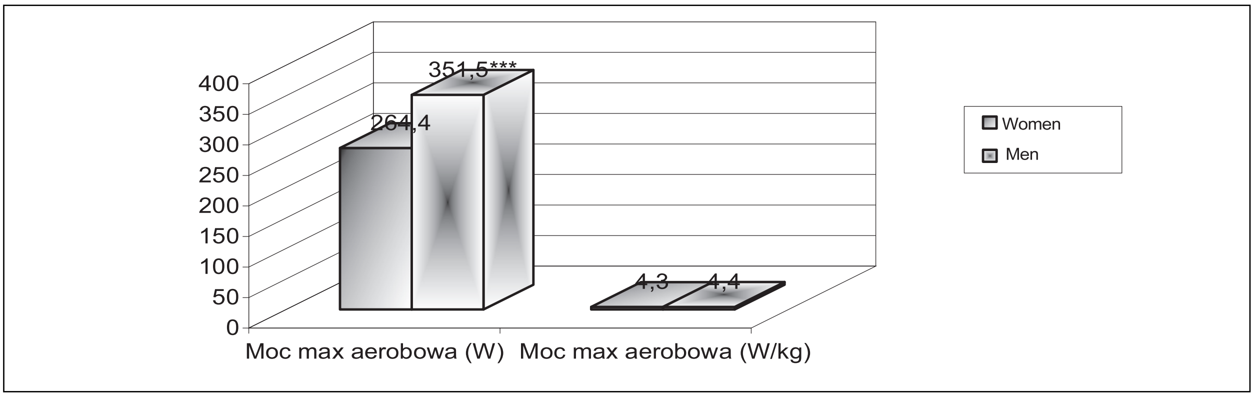

*Fig. 5. Maximal aerobic power (W, W/kg) in female and male judoists in test exertion (p<0.001***)*

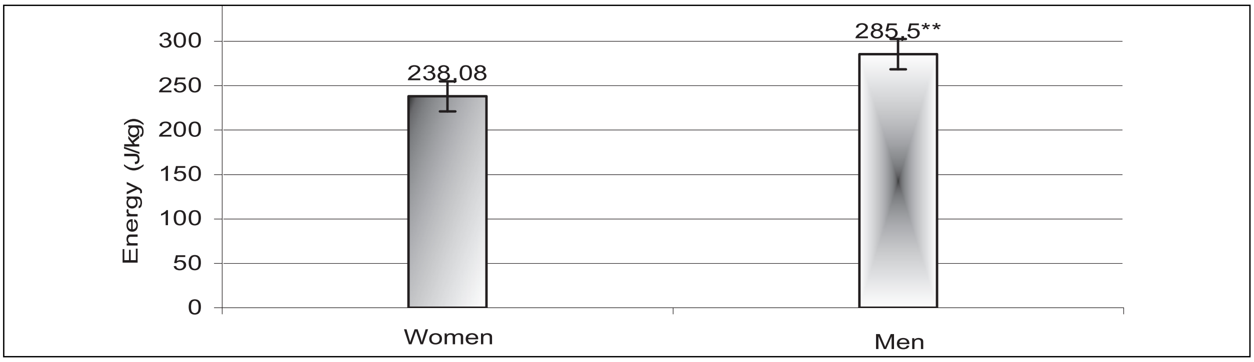

*Fig. 6. Mean values of energy (J/kg) in the studied female and male judoists in Wingate test (p<0.01**)*

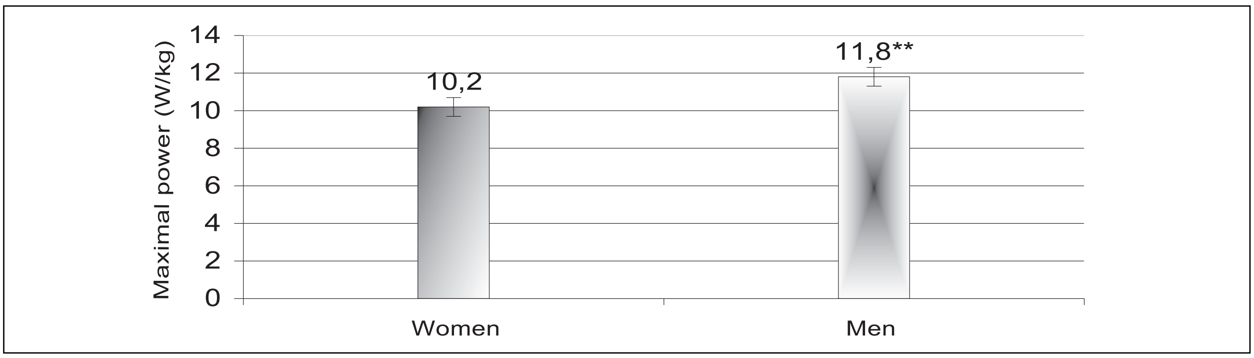

*Fig. 7. Mean values of maximal power (W/kg) in the studied female and male judoists obtained during Wingate test (p<0.01**)*

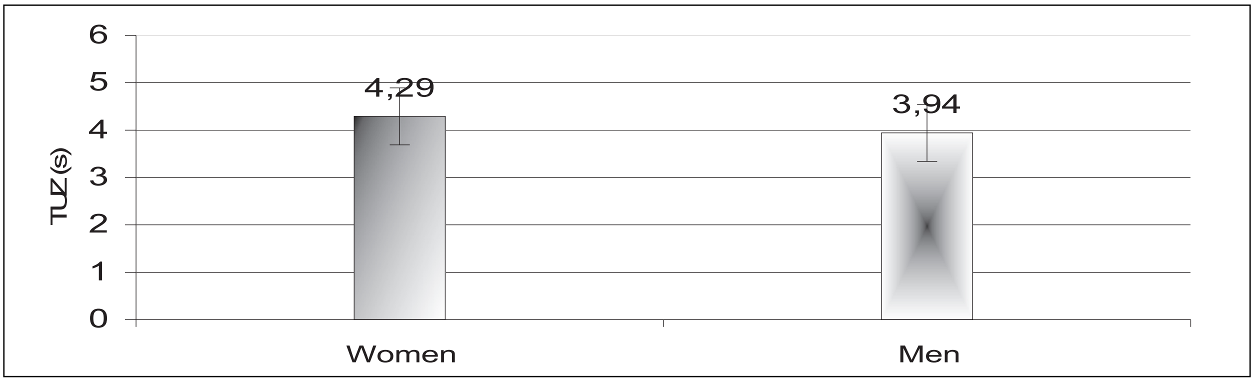

Fig. 8. Mean values of the time of obtaining maximal power [TUZ(s)] in the studied female and male judoists obtained during Wingate test

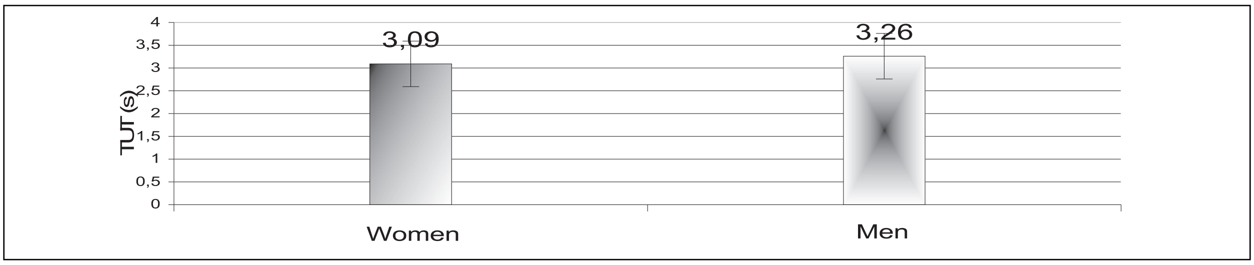

Fig. 9. Mean values of the time of maintaining maximal power [TUT(s)] in the studied female and male judoists obtained during Wingate test

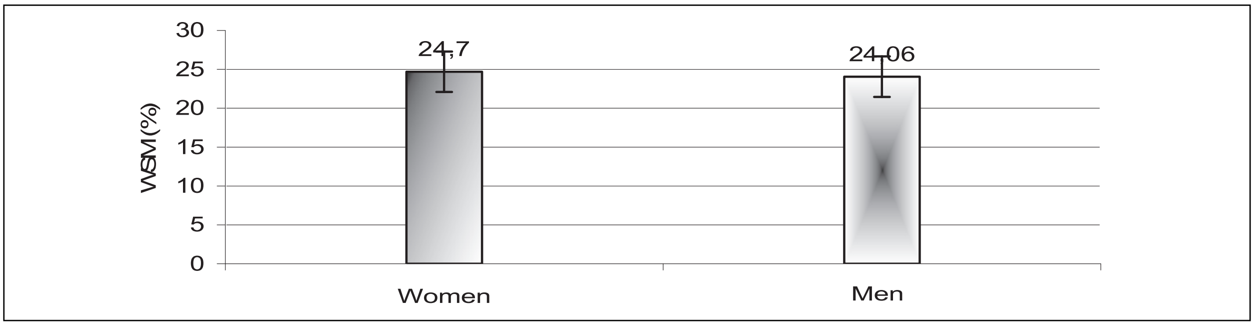

Fig. 10. Mean values of the power decrease index (WSM %) in the studied female and male judoists obtained during Wingate test

Discussion

Since the very beginning of its development, modern judo has become martial art requiring many years training and technique mastering, based on a number of repetitions as well as on strength and speed training [12].

The strength result is the effect of multiple factors, understood as general capability and predispositions of fighters. They include fitness, mental resistance and such physical traits as strength, speed, endurance, as well as generally understood physical performance [13].

Maximal oxygen uptake (VO2max) is a general index for physical capacity assessment. Physical capacity measurement is an integral part of training system and its result indicates whether the training goals have been achieved or not. Laskowski [8,14] indicates the importance of aerobic fitness based on study results, suggesting that aerobic capacity in judoists is the baseline parameter determining specific exertion. VO_{2max} values in the judoists studied by Ronikier [15] are approximately at similar levels (55 -60 ml/kg/min) compared to the results obtained in this study (53,2 ml/kg/min). Conversely, in the previous study the VO_{2max} values were within 48-52 ml/kg/min [15], while in this study the average VO_{2max} value was 47.6 ml/kg/min (Fig. 1).

A similar study conducted by Szczepanowska [16] indicates a substantial difference in VO_{2max} values between the female and male participants.

The maximal ventilation of the lungs (VE_{max}) is the next factor affecting physical capacity, and thus emphasising the differences resulting from sexual dimorphism of the trainees. The values of this parameter in the studied judoists are 108.8 (l/min) and 155.6 (l/min) for the female and male participants respectively. Markedly higher VE_{max} values were obtained in the female and male runners, who ran the distance of 100m, in the study by Chwalbińska-Moneta [17]. The average values in this study were 125 l/min 250 l/min for the females and males respectively.

The study carried out by Wojcieszak [18] at the beginning of the preparatory and the start period of the competition showed that the training conducted during this period contributed to the increase in the amount of energy expenditure and maximal anaerobic power. The energy expenditure due to exertion increased while performing Wingate test, both in the female and male participants, in each case however, markedly higher values were obtained by the males.

Gabryś [19] in his paper confirms that significantly higher values of the maximal power and total energy expenditure are obtained by males in various sport disciplines. His study programme included male and female sprinters, running the distances of 100m and 400m. Women, although they were able to maintain maximal power for a longer period of time [on average – 1.41 sec. (26%)], obtained significantly lower values for maximal power and total energy expenditure.

Dimorphic differences are manifested by different traits and properties of the human body. They are expressed by different sizes, shapes as well as different body components.

The differences between body size and composition between girls and boys are insignificant before the period of puberty. After reaching this stage, various differences are developed. The rapid growth of muscle mass and bony frame occurs due to hormonal changes. This is manifested by a significant increase in fat free body mass. In girls, the content of adipose tissue increases, particularly in the areas of hips and thighs.

Skibińska [20] and Chudecka [21] made an attempt to assess the dimorphic changes in fatty layer distribution in the II league female basketball players. They divided fatty layer distribution into three main types: male, female and mixed. They presented the characteristic of each type prevalence in a form of tables. Their results suggest that the male type is predominant in the studied groups and is characterised by thicker skin fat folds under the lower scapular angle rather than in the abdominal region, reaching the mean value of 55,3%. These results confirm the disorders in dimorphic body properties.

High class athletes are characterised by a significant adipose tissue reduction and well developed active tissue.

It is of note that female gymnasts are characterised by an extremely low fat tissue body content (12%), which in lower than in non-training males.

Łaska [22] studied the percentage of adipose tissue in fencers and shot putters. With the difference in body mass of almost 30kg, the competitors doing both disciplines were characterised by a very similar body fat content, amounting to 12.5% and 13.4% respectively.

The comparison of fat free body mass values, obtained in male and female training individuals in our study and the studies of other authors including Szczepanowska [16], did not reveal significant differences. The increase in fat free body mass due to training is generally lower in females than in males.

Szczepanowska [16] also studied the gender-related differences in total body water (TBW). She claims that in physically active females the tolerance to physical exertion and high ambient temperature is similar to that of physically active males, although the former are characterised by a low level of perspiration. This is due to a lower body water content and the resultant lower water-electrolyte metabolism.

To what extent are the achievements and results of female athletes due to inter-gender differences? It has been proven that genetically, the differences between genders amount to 1% only. They include multiple functional differences. Homeostatic processes in females are not as stable as they are in males. Women are less sensitive to the effect of environmental factors. The male organism is more prone to it, and therefore easier to be trained. Effort adaptation thresholds are genetically conditioned. Males and females are able to perform different kinds of exertion: females are capable of long lasting low intensity effort of and males – of a more intensive effort of different duration [17].

The similarities and, on the other hand, differences in body build and composition, as well as physiological and mental traits, cause that it is easier for both genders to function according to their social and biological roles.

Conclusions

1. The observed statistically significant differences in body composition between the female and male judoists indicate that the training loads applied in the same group members revealed sexual dimorphism.
2. Sexual dimorphism was also manifested in physiological indices despite the applied training load in the studied group of female and male judoists.

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