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Anaerobic capacity of upper and lower limbs muscles in combat sports contestants

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Summary

Introduction. The aim of the present research study was to compare the evaluation of peak anaerobic power generated by the lower and upper limbs muscles in wrestlers and boxers from the Polish national team, based on maximum and average power obtained in the Wingate test.

Material and methods. Classical style wrestlers (n=30) and boxers (n=34), representatives of the Polish national team in these sports, took part in the study. All experimental subjects performed 30-seconds Wingate test for the lower limbs and then upper limbs. The load was individually selected in proportion to the body weight and was 0.075 kp/kg for the lower limbs test and 0.055 kp/kg for the upper limbs test. During the two tests, maximum power (Pmax) and mean power (Pmean) were recorded and expressed in relative terms (per unit body weight or kg of FFM). Blood samples were taken from the ear lobe after each test, for determination of lactate concentration (LA).

Results. Maximum power and average power of the lower and upper limbs muscles, per kg of body mass (BM), was statistically significantly higher in wrestlers when compared with the boxers. Calculation of maximum and average power registered by the experimental contestants in both power tests per kg of FFM confirmed existence of differences between the anaerobic capacity of the lower and upper limbs muscles of wrestlers and boxers. Lactate threshold level (LApeak), upon completion of power tests was similar, regardless of the sport and the type of test.

Conclusions. In summary, from the obtained data it can be concluded that wrestlers, compared with boxers, are characterized by higher relative maximum power and relative average power (W/kg BW) generated by both the upper and lower limbs in the Wingate test. These differences remained after conversion of maximum and average power into kg of Fat Free Mass (W/kg FFM), despite significant difference in body fat in athletes of these two sports. The highest concentration of lactate in the blood after both power tests in wrestlers and boxers was similar, which indicates that the upper limb muscles produce more lactate per unit of work done during maximum power.

Introduction

Wrestling and boxing are sports associated with acyclic movement pattern and wide variety of tactical and technical elements [3,4]. In both of these disciplines, sport contest requires frequent high and even maximum intensity actions, during which re-synthesis of ATP for muscle contraction comes from anaerobic changes, involving increased lactate production [4,18]. This is confirmed by the results of measurements of blood lactate after a wrestling and boxing match. Kraemer and colleagues [9], after studying free-style wrestlers during contests, found that after a 5-minute match, concentration of lactate in the blood jumped to 20 mmol/l. Even after a boxing match lactate concentration in the blood for some time remained high, reaching an average of 17.1 mmol/l [6]. These data show that in wrestling as well as boxing, contestants should be characterized by considerable anaerobic capacity of the muscles. Horswill [4] is of the opinion that wrestlers anaerobic capacity is a factor that decides on a contestant's sport level.

The aim of the present research was to compare anaerobic capacity of lower and upper limbs muscles of wrestlers and boxers from the Polish national team, based on maximum power and average power generated in the Wingate test.

Material and methods

In classical style wrestlers (n=30) and boxers (n=34), representatives of the national team in these sports, participated in the study. After reviewing the tests protocol approved by the local ethical committee, all the contestants gave oral consent to participate in power tests and the taking of blood from the earlobe.

All the experimental subjects were weighed and measured, allowing for calculation of BMI. The fat content was determined on the basis of thickness of four skin folds (biceps,

triceps, spina iliaca anterior superior and under the shoulder blade), according to the method described by Durnin et al [1]. Thickness measurements of skin folds were performed on the left side of the body, in an upright position.

All experimental subjects performed 30-seconds Wingate tests for the lower limbs and upper limbs, on a ergometer bicycle (Monark, Germany) and manual ergometer (Lode BV, Netherlands) respectively. Each test was preceded by a 5-minute warm-up. The load was individually selected, proportionally to the body weight and was 0.075 kp/ kg for the test performed on the lower limbs, and 0.055 kp/kg for test on the upper limbs. During both the tests, maximum power (Pmax) and mean power (Pmean) were registered and expressed in relative values (per unit body weight or kg of FFM). At the end of each test, after 7, 9 and 13 minutes, blood samples were taken from the earlobe for later determination of lactate concentration (LA). Lactate concentration was determined using ready set and photometer from Dr. Lange (Germany) and expressed in mmol/l.

Statistical analysis was performed using Statistica v. 6 (StatSoft, USA) program. But in order to compare the differences between wrestlers and boxers, Student t test was used for independent variables, and $p<0.05$ was taken to be statistically significant level.

Results

The tested contestants were of similar age and had similar length of training. There was no significant difference in height and Fat Free Mass (FFM), however, the wrestlers were characterized by significantly higher body weight, higher fat content (expressed in kg and %) and higher BMI compared to the boxers (Table 1).

Table 2 shows maximum power and average power generated by the experimental contestants in both power tests. As is clear from these data, wrestlers generated statistically significantly higher maximum and average power of lower and upper limbs muscles, per unit body weight (W/BM) than boxers. Conversion of maximum and average power of tested contestants in both power tests per kg FFM confirmed existence of differences between anaerobic capacity, of the upper and lower limbs muscles, of wrestlers and boxers. The highest concentration of lactate (LApeak), after completion of power tests was similar, independent of the type of sport or exercise test.

Discussion

It is a well-known fact that muscle anaerobic capacity plays a significant role both in wrestling and boxing, the reason being that for these sports startup effort is defined by significant intensity and causes high muscle and blood acidity [11, 14]. Horswill [4] believes that the anaerobic capacity winner wrestlers is higher than in loser wrestlers, therefore, it is a factor determining competition level of a contestant.

Anaerobic capacity of the muscles is often evaluated on the basis of results obtained in a 30 s Wingate test, which may be carried out using either lower or upper limbs [2]. Maximum power and average power (work) are determined in this test. Maximum power reflects the potential of obtaining energy for the work of the muscles with the use of ATP and phosphocreatine located in the muscles, while the average power level depends mainly on the potential of resynthesis of ATP through glycolytic transformation.

Evaluation of anaerobic capacity of the upper limb muscles is rarely carried out than of the lower limbs muscles, while data on this subject are sparse, particularly in relation to the boxers. Hübner-Wozniak and colleagues [6], studying wrestlers and boxers representing the Polish national team, who performed a Wingate test of upper limbs and lower limbs obtained relative maximum power of 9.7 and 8.0 W/kg respectively, and the average power of 7.0 and 6.2 W/kg respectively. Values comparable to the maximum and average power obtained under this study were obtained in tests on free style wrestlers, these were 9.6 and 6.9 W/kg respectively [7]. However, Horswill et al [5], studying senior wrestlers representing the U.S. national team, obtained values for maximum power lower than the above (7.8 W/kg), but similar average power. Lutosławska et al [10], testing freestyle wrestlers obtained similar values as published data, that is, maximum power 9.7 W/kg, and average power – 6.9 W/kg.

Table 1. General characteristics of tested wrestlers and boxers (x ± SD)

Variable	Wrestlers (n=30)	Boxers (n=34)
Age (years)	24.5 ± 3.9	22.8 ± 2.1
Body height (cm)	177.9 ±7.7	178.1 ± 8.6
Body mass (g)	84.4 ± 13.2	71.8 ± 15.1*
BMI	26.8 ± 3.7	22.4 ± 3.0**
Fat content (%)	16.3 ± 4.4	9.4 ± 5.2**
Fat content (kg)	13.8 ± 3.2	6.7 ± 4.6***
Fat free mass (kg)	70.6 ± 11.3	65.1 ± 10.2
Training experience (years)	10.1 ± 4.2	8.5 ± 2.5

Statistically significantly lower compared with the wrestlers at: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 2. Maximum and average power of the lower and upper limbs of wrestlers and boxers (x ± SD)

Variable	Upper limbs		Lower limbs	
	Wrestlers (n=30)	Boxers (n=34)	Wrestlers (n=30)	Boxers (n=34)
Peak power (Pmax) W/kg BM W/kg FFM	 9.3 ± 1.9 11.1 ± 1.3	 8.4 ± 0.9*** 9.3 ± 0.7***	 11.4 ± 0.6 13.6 ± 0.5	 9.8 ± 0.5*** 10.8 ± 0.3***
Mean power (Pmean) W/kg BM W/kg FFM	 7.9 ± 0.6 9.4 ± 0.4	 6.3 ± 0.5*** 6.9 ± 0.4***	 9.2 ± 0.8 11.9 ± 0.6	 8.6 ± 0.6*** 9.5 ± 0.4***
LA_{peak} (mmol/l)	12.1 ±2.0	12.0 ± 2.4	12.5 ± 1.8	12.3 ± 2.4

*** Statistically significantly lower compared with the wrestlers at (p <0.001)

Data on relative (per unit body weight, kg) maximum power and average power of the lower limbs muscles in wrestlers (11.4 and 7.9 W/kg respectively) obtained in the present study are similar to those registered by Hübner-Wozniak et al [7], who studied Polish national team wrestlers and arrived at 11.4 W/kg relative maximum power and 8.7 W/kg average relative power.

Likewise, Lutosławska et al [10], in a 30 s Wingate test carried out with the lower limbs, arrived at a relative maximum power of wrestlers of 11.3 W/kg, and relative average power 8.6 W/kg. Yet again, data presented by Yoon [17], for Korean wrestlers show that they too registered, in the Wingate test, results similar to present results, for maximum power (11.2 W/kg), however, they obtained average relative power lower than the present, (6.7 W/kg). Popadic Gacesa et al [12] demonstrated, for wrestlers aged 21 years, that the relative maximum power of the players surveyed was 9.8 W/kg, while the average power was 6.6 W/kg, and for the boxers – 9.3 and 6,7W/kg respectively. Horswill et al [5], studying senior wrestlers perform a 30s Wingate test of the lower limbs, found them to have an average rate of relative maximum power of 10.9 W/kg and mean relative power of 9.4 W/kg.

Zupan et al [19], studying a group of 457 athletes practicing sports that require short-lasting high-energy efforts, such as football, sprint cycling, basketball, boxing and wrestling, in the evaluation of maximum power and average power obtained in a 30 s Wingate test generated by the lower limbs obtained results, 11.7 and 8.5 W/kg respectively, similar to that found for wrestlers in the present study. Both these indexes were clearly higher compared with the maximum power and average power obtained by boxers under the present study.

Results of many studies indicate a positive correlation between maximum power and fat free mass (FFM) [13,15]. Conversion of maximum and average power generated by the contestants under the present study, in both power tests per kg FFM, has confirmed existence of differences between wrestlers and boxers in their anaerobic capacity of upper and lower limbs muscles.

Peak concentration of lactate in the blood (LApeak) after a 30 s Wingate test involving the lower limbs of wrestlers (12.9 mmol/l) and boxers (12.1 mmol/l) obtained in the present study indicates a significant participation of glycolytic changes in providing energy for muscles work during this effort and is a confirmation of earlier studies [7]. Lutosławska et al [10], who examined 33 wrestlers representing both styles, registered peak LA concentrations identical (13.3 mmol / l) to those registered in the present study. After Wingate test carried out on the upper limbs, peak concentration of lactate in the blood of wrestlers and boxers was 12.1 and 12.0 mmol/l respectively. Similar results have been presented by Hübner-Wozniak and colleagues [8], who registered peak, 13.0 mmol/l, LA concentration in the blood of wrestlers and 11.6 mmol/l for boxers. It should be noted that in contestants of both the studied sports, the peak concentration of lactate in the blood upon completion of Wingate test on the lower and upper limbs was similar, although in the test involving upper limbs work done during exercise was lower in comparison with test involving lower limbs. Lutosławska et al [10] have arrived at similar results, and have proposed that the lack of differences between lactate concentration in blood after Wingate test involving upper and lower limbs results from greater percentage of fast contracting fibers in the arm muscles compared with leg muscles. This implies that the muscles of the upper limbs get higher work energy from glycolytic changes than lower limbs muscles. This is consistent with results obtained by Yasudy and colleagues [16] who have showed that the arm muscles are more dependent on carbohydrate metabolism than the leg muscles.

Conclusions

In summary, from data obtained, it be stated that in Wingate tests on the upper as well as lower limbs wrestlers were characterized by higher relative maximum power and relative average power (W/kg BW) compared with boxers. These differences remained even after conversion of maximum and average power into Fat Tree Mass (W/kg FFM), despite significant difference in body fat content in athletes of these two sports. The highest concentration of lactate in the blood of wrestlers and boxers was similar, upon completion of both power tests, which shows that the upper limb muscles, during maximum effort, produce more lactate per unit work done.

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