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INFLUENCE OF TRAINING ON ANAEROBIC POWER AND CAPACITY OF UPPER AND LOWER LIMBS IN YOUNG GRECO-ROMAN WRESTLERS

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ABSTRACT: The aim of the present study was to examine the effect of training on selected markers of anaerobic capacity of upper and lower limbs in male, Greco-Roman wrestlers from 16 to 19 years of age. The study was conducted four times at one-year intervals on the same group of male competitors (n=12). Every year at the beginning of the second preparatory period all wrestlers performed arm cranking and leg cycling 30 s Wingate tests. The relative peak and mean power of upper limbs were higher in 17-, 18-, and 19-year-old wrestlers compared to 16-year-old ones, but were similar in 17- and 18-year-old athletes. The highest peak and mean power of legs were found in 19-year-old wrestlers. In 18-year-old athletes, the peak power was lower than in 17-year-olds and was similar to 16-year-old wrestlers. The relative mean power in the group of 18-year-old athletes was lower compared to 16- and 17-year-old ones, but it was similar in 17- and 19-year-old wrestlers. Changes in the levels of the relative peak and mean power of upper and lower limb muscles in wrestlers occurred at different periods between the age of 16 and 19. However, it seems that inappropriately chosen training loads may reduce short-term power outputs despite age correct increase in anthropometric parameters. Wrongly applied training did not bring positive effects and could inhibit, for some time, the natural development of power in young wrestlers.

KEY WORDS: young Greco-Roman wrestlers, anaerobic power, anaerobic capacity, upper limbs, lower limbs

INTRODUCTION

Wrestling presents some unique metabolic demands on the body and there is a general agreement that development of muscular power is crucial to success in this sport discipline [27]. A wrestling match consists of several explosive offensive and defensive manoeuvres causing elevation of blood lactate concentration to 20 mmol$\cdot$l^{-1} [17,22]. The anaerobic system is necessary for technique manifestation through fast movements with energy supplied by the creatine phosphate and glycolytic system [10,30]. During a wrestling match the ratio of lactic to alactic anaerobic processes is 1:9 [7]. The anaerobic power is an important criterion for performance in sports such as wrestling where short-term explosive efforts are made [8,9].

Wrestlers compete in weight categories, and they temporarily lose weight to reach the correct body mass. The data concerning the effect of weight loss on physical performance have been inconsistent, due to different dietary and dehydration interventions. Rankin et al. [24] established that weight loss by dietary restriction significantly reduced anaerobic performance in wrestlers. Also Housh et al. [13] found that participation in wrestling, which typically includes repeated reduction of body mass, does not adversely affect normal anthropometric growth patterns in young athletes. There is evidence that in the general population of adolescent boys, growth and maturation are not influenced by level of physical activity [4,6]. At the same time, regular physical activity contributes to anaerobic power performance as well as isometric and explosive strength. Armstrong et al. [2], studying 12-year-old boys at a one-year interval, confirmed an increase in both the peak and mean power of their lower limbs.

The 30 s Wingate test has been commonly used to evaluate athlete performance by measuring muscle power and obtaining information about muscle metabolism during short-term, high-intensity exercise [15]. Anaerobic power and capacity of senior and adolescent wrestlers has been the subject of numerous studies to estimate muscle peak and mean power [21, 29]. Hübner-Woźniak et al. [14], while studying elite free style Polish wrestlers, established that the peak power for upper and lower limbs was 6.9 and 11.4 W$\cdot$kg^{-1} respectively. Similar results were obtained by Horswill [8], who found that the peak power was 7.8 and 10.9 W$\cdot$kg^{-1}. A somewhat lower peak muscle power for lower limbs in senior wrestlers (9.8 W$\cdot$kg^{-1}) was measured by Popadic Gacesa et al. [23]. There is no information available in the literature on the anaerobic power and capacity obtained in a longitudinal study of the same young wrestlers.

The aim of the present study was to examine the anaerobic power and capacity of upper and lower limbs in young Greco-Roman wrestlers across three years of training.

MATERIALS AND METHODS

The subjects of the present study were 12 young, male Greco-Roman wrestlers. At the commencement of the study the wrestlers were 16 years old, at the end 19 years old, and their training experience in this time increased from 3.5 to 6.5 years. Body mass and height were recorded using standard anthropometric medical scales, with the accuracies of 0.1 kg and 0.1 cm, respectively. Body fat measurements were performed by bioelectrical body impedance analysis (BIA) using a body fat analyser model Tanita TBF 300P (Japan). Fat free mass (FFM) was calculated by subtracting the fat tissue mass (in kg) from the total body mass. Physical characteristics of the young wrestlers are presented in Table 1. All wrestlers or their parents gave their written consent and the experimental protocol was approved by the local Ethics Commission according to the Declaration of Helsinki.

The study was repeated four times at one-year intervals on the same group of competitors in identical conditions, in 2006, 2007, 2008, and 2009.

Every year at the beginning of the second preparatory period all wrestlers performed arm cranking and leg cycling 30 s Wingate tests. Both tests were preceded by a warm-up lasting five to eight minutes with submaximal load until the heart rate of 130-150 beats$\cdot$min^{-1} was reached. The arm cranking test was performed in a sitting position on an 814 Monark ergometer (Sweden). The load was selected individually and it was 62 g$\cdot$kg^{-1} body mass. The leg cycling test was performed on a Monark 874E (Sweden) ergometer with the load of 75 g$\cdot$kg^{-1} body mass. In both tests the peak power (P_{max}) and the mean power (Pmean) were registered using the computer program MCE version 5.1. These parameters were expressed in relative values (W$\cdot$kg^{-1}).

Data were reported as mean values (x) and standard deviation (SD). Differences between variables were determined using one-way analysis of variances (ANOVA). Additionally, Pearson correlation coefficients were calculated to examine relationships between variables. The level of significance for all statistics was set at $p < 0.05$.

RESULTS

Body mass, fat free mass, and body height of young wrestlers increased with age (Table 1). These parameters in 19-year-old wrestlers were higher compared to 16-year-old ones by about 14.9%, 15.8%, and 5.7%, respectively. Fat content (in %) and BMI were similar in all age groups of wrestlers.

The relative peak and mean power of upper limbs were higher in 17-, 18-, and 19-year-old wrestlers compared to 16-year-old ones, but they were similar in 17- and 18-year-old athletes (Table 2). The highest peak and mean power of legs was found in 19-year-old wrestlers. In 18-year-old athletes, the peak power was lower than in 17-year-old ones and was similar to 16-year-old wrestlers. The relative mean power in the group of 18-year-old athletes was lower compared to 16- and 17-year-old ones, but it was similar in 17- and 19-year-old wrestlers.

Taking into account the results of the four-year study it was found that the peak and mean power of arms were correlated with fat free mass ($r=0.35$ and $r=0.43$, $p<0.05$, respectively). In the case of lower limbs only the peak power was related to FFM ($r=0.33$, $p<0.05$).

The changes in the relative peak and mean power over four years of study were different for upper and lower limbs (Fig. 1 and 2).

TABLE 1. PHYSICAL CHARACTERISTICS OF YOUNG WRESTLERS (MEAN ± SD)

Age (years)	Body mass (kg)	Body height (cm)	BMI	Fat content (%)	Fat free mass (kg)	Training experience (years)
16 (n=12)	65.9 ± 6.9**	172.8 ± 5.1**	20.1 ± 4.4	7.8 ± 3.4	60.7 ± 10.0**	3.5 ± 0.6
17 (n=12)	70.3 ± 7.6**	175.4 ± 5.2**	20.8 ± 4.3	7.5 ± 3.3	64.9 ± 10.1**	4.5 ± 0.6
18 (n=12)	73.5 ± 7.0**	180.3 ± 7.0**	21.7 ± 3.8	7.2 ± 2.8	68.2 ± 10.7**	5.5 ± 0.6
19 (n=12)	75.7 ± 7.0	182.6 ± 7.1	22.1 ± 3.8	7.1 ± 2.9	70.3 ± 9.9	6.5 ± 0.6

Note: ** Significantly lower compared to the one year older group (p<0.01)

TABLE 2. RELATIVE PEAK POWER AND MEAN POWER OF UPPER AND LOWER LIMBS IN YOUNG WRESTLERS (MEAN ± SD)

	Upper limbs		Lower limbs	
Age (years)	Pmax (W kg^{-1})	Pmean (W kg^{-1})	Pmax (W kg^{-1})	Pmean (W kg^{-1})
16 (n=12)	8.0 ± 0.2^{A}	6.7 ± 0.2^{A}	10.3 ± 0.5^{B}	8.1 ± 0.3^{B}
17 (n=12)	8.8 ± 0.6^{B}	7.0 ± 0.4^{B}	11.1 ± 0.4^{B}	8.6 ± 0.3
18 (n=12)	8.6 ± 0.6^{B}	7.1 ± 0.5^{B}	10.1 ± 0.5^{B,C}	7.7 ± 0.3^{B,D}
19 (n=12)	9.3 ± 0.6	7.3 ± 0.4	11.8 ± 1.0	8.5 ± 0.6

Note: ^{A} Significantly lower compared to 17-, 18-, and 19-year-old wrestlers (p<0.01), ^{B} Significantly lower compared to 19-year-old wrestlers (p<0.01), ^{C} Significantly lower compared to 17-year-old wrestlers (p<0.01), ^{D} Significantly lower compared to 16-, 17-, and 19-year-old wrestlers (p<0.01)

The peak power of upper and lower limbs of young wrestlers from 16 to 19 years of age increased significantly, by 16.3% and 14.6%, respectively, but the increase of mean power of upper and lower limbs was less pronounced, being 9.0% and 4.9%, respectively. Between 17 and 18 years of age the relative peak of upper limbs diminished by 2.3% and the mean power of upper limbs remained unchanged (Fig. 1), but for lower limbs (Fig. 2) in the same period there was a decrease in the peak and mean power by 9.0% and 11.5%, respectively.

DISCUSSION

It is well known that body mass and height as well as muscle mass increase with growth and maturation together with strength and power of muscle [1, 19]. The results of the present study indicated that training of young wrestlers on one hand had no effect on the increase of body mass, fat free mass and body height, which were related to age, but on the other hand it caused disturbances in the development of the anaerobic peak and mean power of legs and arms across age. It is believed that exercise training of young wrestlers does not adversely affect normal anthropometric growth patterns and that anthropometric characteristics were similar for the wrestlers and a representative sample of adolescent males [13]. Also the findings of Camic et al. [5] confirmed that in young wrestlers body mass, body height, and fat free mass were related to age in a similar pattern to that in non-trained adolescents. At the same time Martin et al. [20], while studying non-active boys aged from 7 to 17 years, showed that the peak power increased with age.

In the available literature, there are no reports of longitudinal studies of leg and arm anaerobic peak and mean power in the same group of young wrestlers or any other combat sport discipline. These athletes engage in sports which require short bursts of peak power and high anaerobic capacity during competition [30]. Terbizan et al. [28], while studying 15-, 16-, and 17-year-old wrestlers, established that arm and leg mean power increased with age, but statistically significant differences were only observed between the youngest group and both older groups.

The development of muscular strength and power is crucial to the success of wrestlers [27]. It was shown that the isokinetic peak torque in young wrestlers (11.1-18.2 years) increased with age and it was related to not only body mass, fat free mass, and body height, but to neural maturation. Kim et al. [16], while studying South Korean judoists, found that peak and mean power of legs was correlated with fat free mass. Also Vardar et al. [29] established that peak power was positively correlated with FFM in male wrestlers aged from 15 to 19 years. In the present study, a significant correlation with FFM was found for the peak and mean power for upper limbs, but for legs such a correlation was only observed between the peak power and FFM. The lack of correlation between the mean power and FFM for legs may be explained by a significant decrease of mean power (by 11.5%) in 18-year-old wrestlers. Horswill et al. [9], while studying wrestlers in the 14 to 18 years age group, found that the relative peak and mean power of upper limbs was 7.4 and 5.9 $W \cdot kg^{-1}$, respectively, while for lower limbs it was 10.6 and 8.6 $W \cdot kg^{-1}$. In the present study the relative peak and mean power of upper limbs were higher in every age group (8.0-9.3 and 6.7-7.3 $W \cdot kg^{-1}$, respectively), while for lower limbs the differences were less pronounced and regular. It should be noted that the relative peak and mean power of upper and lower limbs of 19-year-old wrestlers in this study were similar to senior wrestlers [8,14].

Housch et al. [12], while comparing the increases in height and body mass in wrestlers aged 15, 16 and 17 years with non-training boys of similar age, found that training did not change the direction and magnitude of the yearly changes in anthropometric characteristics. These results suggest that wrestling, which typically involves repeated bouts of weight reduction, does not affect anthropometric growth. However, during bouts of weight loss wrestlers frequently use harmful methods and techniques. Repeatedly losing and regaining weight, called "weight cycling", can have negative effects on health and performance [11]. Dietary restriction in wrestlers had no effect on anthropometric parameters but the reduction in protein nutritional status caused a decrease in muscular strength and power [11,12]. It was shown that insufficient dietary intake of protein and carbohydrates impairs muscular performance during acute weight

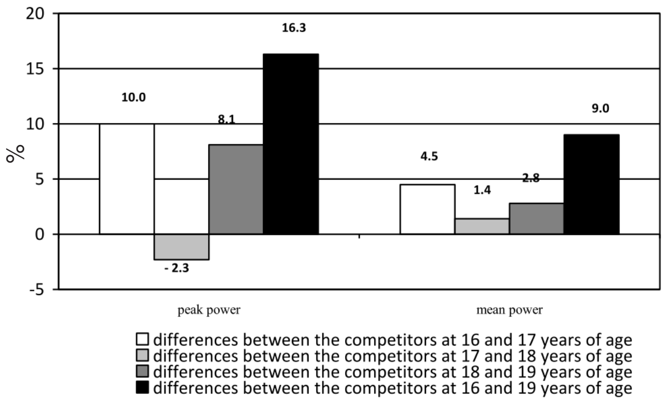

FIG. 1. DIFFERENCES (IN %) IN THE PEAK AND MEAN POWER OF UPPER LIMBS ACROSS AGE

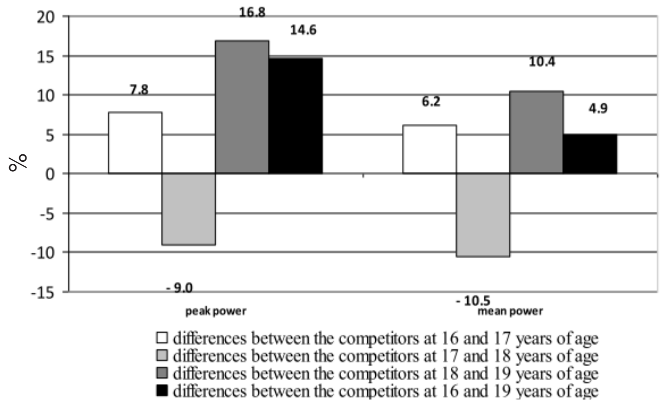

FIG. 2. DIFFERENCES (IN %) IN THE PEAK AND MEAN POWER OF LOWER LIMBS ACROSS AGE

loss [26]. Because of reduced body mass the positive effects of training on power and strength may be compromised or even annulled when wrestlers reduce their body weight [10].

Wrestler training has several essential elements including high levels of dynamic and isometric strength, anaerobic and aerobic conditioning, quickness, flexibility, and power. The complexity of these demands suggests the need for a highly integrated and individualized strength and conditioning training programme. Whole body power is necessary for wrestlers, so the specific mode of training has to include maximal and submaximal loads. Such training methods might be too extreme for some individuals, causing a decrease of physical capacity [18].

The present study showed that the relative peak and mean power of arms and legs in 18-year-old wrestlers were decreased (or stabilized) compared to 17-year-old athletes. It is a rather unexpected result, because their anthropometric parameters increased with age. A decrease in arm and leg muscle strength and power is observed during the wrestling season and is mostly related to the loss of lean tissue [25]. In the present study, the lean body mass increased with age, so it could be presumed that the decrease/stabilization of the peak and mean power was caused by an incorrect choice of exercise loads in the training process.

There are some limitations of the present study. First, there is no documentation of training methods and the magnitude and type of exercise loads in the consecutive years of training of the young wrestlers. Second, it is difficult to determine the effect of wrestler training on changes in peak and mean power of arms and legs, since there was no control group of non-training boys studied in the same way, and it is known that these variables depend on age and increase with the body mass and fat free body mass.

CONCLUSIONS

Summarizing the obtained results, wrestler training does not cause disturbances in the age-related anthropometric growth pattern. The relative peak and mean power of arms and legs increased between the 16th and 19th year of wrestlers' age, although between the 17th and 18th year of age there were either no changes or a decrease of these variables. The obtained results indicate that the relative peak and mean power of upper and lower limbs depend on the fat free body mass. Nevertheless, it seems that incorrectly chosen training loads can cause the reduction of short-term power outputs, despite proper age-related increases in anthropometric parameters.

Conflict of interest

The authors declare no conflict of interest.

REFERENCES

1. Armstrong N., McManus A.M. Physiology of elite young male wrestlers. Med. Sport Sci. 2011;56:1-22.
2. Armstrong N., Welsman J.R., Williams C.A., Kirby B.J. Longitudinal changes in young people's short-term power output. Med. Sci. Sports Exerc. 2000;32:1140-1145.
3. Arslan C. Relationship between the 30-second Wingate test and characteristics of isometric and explosive leg strength in young subjects. J. Strength Cond. Res. 2005;19;658-666.
4. Beunen G.P., Malina R.M., Renson R., Simons J., Ostyn M., Lefevre J. Physical activity and growth, maturation and performance: a longitudinal study. Med. Sci. Sports Exerc. 1992;24:576-585.
5. Camic C.L., Housh T.J., Mielke M., Hendrix C.R., Zuniga J.M., Johnson G.O., Housh D.J., Schmidt R.J. Age-related patterns of anthropometric characteristics in young wrestlers. Med. Sci. Sports Exerc. 2009;41:1014-1019.
6. Camic C.L., Housh T.J., Weir J.P., Zuniga J.M., Hendrix C.R., Mielke M., Johnson G.O., Housh D.J., Schmidt R.J. Influences of body-size variables on age-related increases in isokinetic peak torque in young wrestlers. J. Strength Cond. Res. 2010;24:2358-2365.
7. Gierczuk D., Długołęcka B. Anaerobic capacity of lower limb muscles in juvenile wrestlers. Polish J. Sport Tourism 2009;16:115-120.
8. Horswill C.A., Miller J.E., Scott J.R., Smith C.M., Welk G., Van Handel P. Anaerobic and aerobic power in arms and legs of elite senior wrestlers. Int. J. Sports Med. 1992;13:558-561.
9. Horswill C.A., Scott J.R., Galea P. Comparison of maximum aerobic power, maximum anaerobic power, and skin fold thickness of elite and nonelite junior wrestlers. Int. J. Sports Med. 1989;10:165-168.
10. Horswill C.A. Applied physiology of amateur wrestlers. Sports Med. 1992; 14:114-143.
11. Horswill C.A. Weight loss and weight cycling in amateur wrestlers: implications for performance and resting metabolic rate. Int. J. Sport Nutr. 1993;3:245-260.
12. Housh T.J., Evetovich T.K., Stout J.R., Housh D.J., Johnson G.O., Briese M.C., Perry S.R. Longitudinal assessment of anthropometric growth in high school wrestlers. J. Strength Cond. Res. 1997;11:159-162.
13. Housh T.J., Johnson G.O., Stout J., Housh D.J. Anthropometric growth patterns of high school wrestlers. Med. Sci. Sports Exerc. 1993;25:1141-1150.
14. Hübner-Woźniak E., Kosmol A., Lutosławska G., Bem E.Z. Anaerobic performance of arms and legs in male and female free style wrestlers. J. Sci. Med. Sport 2004;7:473-480.
15. Inbar O., Bar-Or O., Skinner J.S. The Wingate Anaerobic Test. Human Kinetics, Champaign 1996;pp.95-104.
16. Kim J., Cho H.C., Jung H.S., Yoon J.D. Influence of performance level on anaerobic power and body composition in elite male judoists. J. Strength Cond. Res. 2011;25:1346-1354.
17. Kraemer W.J., Fry A.C., Rubin M.R., Triplett-NcBridge T., Gordon S.E., Koziris L.P., Lynch J.M., Volek J.S., Meuffels D.E,. Newton R.U., Fleck S.J. Physiological and performance responses to tournament wrestling. Med. Sci. Sports Exerc. 2001;33:1367-1378.
18. Kraemer W.J., Vescovi J.D., Dixon P. The physiological basis of wrestling: implications for conditioning programs. Strength Cond. J. 2004;26:10-15.
19. Martin J.C., Farrar R.P., Wagner B.M., Spirduso W.W. Maximal power across the lifespan. J. Geront. A Biol. Sci. Med. Sci. 2000;55:M311-M316.
20. Martin R.J., Dore E., Twisk J., Van Praagh E., Hautier C.A., Bedu M. Longitudinal changes of maximal short-term peak power in girls and boys during growth. Med. Sci. Sports Exerc. 2004;36:498-503.
21. Mirzaei B., Curby D.G., Rahmani-Nia F.,

Moghadasi M. Physiological profile of Iranian junior freestyle wrestlers. J. Strength Cond. Res. 2009;23:2339-2344.
22. Nilsson J., Csergo S., Gullstrand L. Tweit P., Refsnes P.E. Work-time profile, blood lactate concentration and rating of perceived exertion in the 1998 Greco-Roman World Championship. J. Sports Sci. 2002;20:939-945.
23. Popadic Gacesa E.Z., Barak O.F., Grujic N.G. Maximal anaerobic power test in athletes of different sport disciplines. J. Strength Cond. Res. 2009;23:751-755.
24. Rankin J.W., Ocel J.V., Craft L.L. Effect of weight loss and refeeding diet composition on anaerobic performance in wrestlers. Med. Sci. Sports Exerc. 1996;28:1292-1299.
25. Roemich J.N., Sinning W.E. Sport-seasonal changes in body composition, growth, power and strength of adolescent wrestlers. Int. J. Sports Med. 1996;17:92-99.
26. Roemmich J.N., Sinning W.E. Weight loss and wrestling training: effects on nutrition, growth, maturation, body composition and strength. J. Appl. Physiol. 1997;82:1751-1759.
27. Schmidt W.D., Piencikowski C.L., Vandervest R.E. Effects of a competitive wrestling season on body composition, strength and power in National Collegiate Athletic Association Division III college wrestlers. J. Strength Cond. Res. 2005;19:505-508.
28. Terbizan D.J., Selievold P.J. Physiological profile of age-group wrestlers. J. Sports Med. Phys. Fitness 1996;36:178-184.
29. Vardar S.A., Tezel S., Öztürk L., Kaya O. The relationship between body composition and anaerobic performance of elite young wrestlers. J. Sports Sci. Med. 2007;6:34-38.
30. Yoon J. Physiological profiles of elite senior wrestlers. Sports Med. 2002;32:225-233.