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Investigating the Effects of Maximal Strength Training on Wrestlers' Physical, Physiological and Selected Motor Skills

Ismail Kaya

School of Physical Education and Sports, Dumlupinar University, Kütahya, Turkey
E-mail: ismail.kaya@dpu.edu.tr

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ABSTRACT The purpose of this study was to investigate the effects of an 8-week maximal strength training program on the physical, physiological and selected motor skills of wrestlers'. A total of 40 wrestlers voluntarily participated in the study. Measurements about physical, physiological and selected motor skills were made on the test and control groups before (BT) and after (AT) an 8-week weight training program. In the evaluation of the obtained data, student's t-test was applied. As a result of the 8-week maximal strength training program, when BT and AT results of the test and control group wrestlers were compared, significant differences were found between test group wrestlers' right hand grip strength, biceps, triceps and subrailiac skinfold thickness values and Max VO2 values before and after the study. However, there was no significant difference between vertical jump, left hand grip strength, back strength, subscapular skinfold thickness, wingate anaerobic power and capacity values.

INTRODUCTION

Wrestling, which is one of the oldest sports in the history of mankind, is a struggle between two wrestlers or two people with the intention to beat each other using techniques, tactics, skills, strength, and intelligence, which is performed on a mat with certain dimensions and without using any tools in accordance with FILA rules (Gökdemir 2000).

In wrestling, body coordination is very important. Wrestling is a sport which requires the coexistence of various functional features. Muscular strength, reaction time, agility, flexibility, quickness, neuromuscular coordination, a perfect static and dynamic balance, high anaerobic and aerobic capacity are important factors that play a role in performance. The purpose and content of wrestling training should aim to improve these features (Yoon 2002; Akgün 1992). Strength as a biomotoric feature is important in both defense and attack in the act of a technique and react against a technique and counter-attack (Cicioglu et al 2007). Strength is one of the most important motor skills for sporting success. Absolute and relative strength is required for the attainment of high success levels. In many sports, particularly those in which endurance or high scope of work is required, the short list should be based on not only quality of training of the athlete but also on the ability of the athletes to recover between training units. For wrestlers, Dragan (1979) defines the criteria of coordination; as response time, high aerobic and anaerobic capacity, tactical intelligence, broad shoulders and long arms.

In a study conducted by Filiz (2003), it was seen that when body weight of the wrestlers increase, their body fat percentage increases as well. Moreover, the body type of Turkish wrestlers was found to be mostly endo-mezomorf. In an investigation conducted on Turkish national team wrestlers using Heath-Carter method in 1984, the wrestlers were found to be usually endomesomorph. The body fat percentage of the wrestlers is generally low, especially in long-distance runners (about 5%). The average of the values detected in the wrestlers was about 7 percent. However, body fat percentage was found to increase with increasing weight category (Akgün 1992). High body fat percentage may lead to reduced strength, agility, flexibility and loss of energy (Günay and Onay 1999). Speed is a very important motor feature which is needed by a wrestler for an effective implementation as well as getting rid of techniques applied to a wrestler (Baktaal 2008).

Therefore, according to information given above, it is important to find out the effect of maximal strength training on wrestlers performance. The aim of this study was to determine the effects of an 8 weeks of maximal strength training on the body composition, back strength, grip strength, vertical jump, Max VO2, aerobic and anaerobic strengths of wrestlers' as predictors of performance.

MATERIAL AND METHODS

In the study, the mean age for test and control groups was 21.60 ± 1.75 years and 21.05 ± 1.50 years, respectively; the mean height for test and control groups was 176.31 ± 6.56 cm and 177.17 ± 7.13 cm, respectively, while the mean body mass for the test and control groups was 82.19 ± 13.99 kg and 71.55 ± 7.91 kg, respectively. A total of 40 athletes who actively engage in wrestling participated in the study. Among them, 20 athletes with a minimum training age of 5 years, who study at the school of physical education and sports and hold a national degree, comprised the test group while 20 athletes with the same features comprised the control group. A maximal strength training program with weights was applied to the test group 2 hours a day, 3 days a week for 8 weeks. Technical training program on the mat was applied to the control group 2 hours a day, 3 days a week for 8 weeks.

Table 1 is about the characteristics of training program applied to wrestlers. Program 1 was applied to the control group and Program 2 was applied to the training group.

Body Composition Measurements

Height measurement of the athletes in the study was done using a stadiometer (Holtain Ltd. U.K.) mounted on the wall with ± 1 mm sensitivity and their body weight measurement was done using a bascule (Tanita HD 358 Japan) with ± 100 g sensitivity. Skinfold thickness of the participants was measured at 4 regions (Biceps min, Triceps min, Subscapula min, Suprailiac min) (Tamer 2000).

Performance Measurements

Grip Strength: The grip strength of both right and left hands was measured using a digital hand dynamometer (TKK 5401, Takei Scientific Instruments, Japan) in a standing position with the shoulder adducted and with the elbow in full extension (Çeker 1996; Tamer 2000).

Back Strength: Isometric back strength of the subjects was measured with a digital back dynamometer (TKK 5402, Takei Scientific Instruments, Japan (Çeker 1996; Tamer 2000).

VO2 Max Measurements: VO2 max measurements of the participants were estimated from 20 m shuttle run test. The athletes ran a distance of 20 m forward and backwards. Running speed was checked using a tape that gave a signal at certain intervals (Demirkan et al. 2012).

Jumping Measurements: The squat tests were performed on a force platform (Newtest Powertimer, Finland). The squat jump started from a half-squat position with a knee angle of 90°. Subjects were asked to jump as high as possible. The jump was repeated twice, thereafter the better performance was recorded (Çeker 1996; Tamer 2000).

Wingate Test: Anaerobic power and capacity output were measured by the 30s Wingate test (Monark 894 E Peak Bike, Sweden). Prior to the Wingate test, a 5min warm-up was performed at a standardized workload 1 kg of resistance at

Table 1: Characteristics of training program

Training Program	
Load	80-100 %
Warm-up	25-30 min
Duration of training	120 min
Working time	60 sec
Tempo	Normal
Rest	60 sec
No of sets	4
Rest between sets	3 min
Relaxing movements	10-15 min
Program 1	*Program 2*
Circuit 1: rope climbing	Circuit 1: Cross buttock technique (to model wrestler)
Circuit 2: Pull-up	Circuit 2: Leg tackle (to model wrestler)
Circuit 3: The neck-press	Circuit 3: Chip technique (to model wrestler)
Circuit 4: Squat	Circuit 4: Fireman's lift from arm (to model wrestler)
Circuit 5: Bench-press	Circuit 5: Wrestling hold (to model wrestler)
Circuit 6: Skipping	Circuit 6:Take down by duck under (to model wrestler)
Circuit 7: Shouldering	Circuit 7: Shoulder throw technique(to model wrestler)
Circuit 8: Dumbbell	Circuit 8: Piolet work

60-70 RPM. Seat and handlebar adjustment was made for each subject. The test commenced after the external resistance was adjusted to 7.5 percent of each subject's body mass (Çeker 1996; Tamer 2000).

Statistical Analyses

While comparing the pre-study exercise performances of the athletes in both groups, t-test was used in the independent groups at $\alpha = 0.05$ significance level, whereas t-test was used for iterative measurements at $\alpha = 0.05$ significance level while comparing pre and post-study exercise performances of both groups.

RESULTS

Table 2 shows pre-study physical features of test and control group wrestlers who joined the study. According to test results, there were no significant differences between the mean age (21.60 ± 1.75 years) and body mass (82.19 ± 13.99 kg) of test group wrestlers and the mean age (21.05 ± 1.50 years) and body mass (71.55 ± 7.91 kg) of the control group wrestlers ($p > 0.05$), whereas the mean height (177. 17 ± 7.13 cm) of the control group wrestlers were found to be significantly higher than the mean height (176. 31 ± 6.56 cm) of the test group wrestlers ($p < 0.05$).

Table 2: Physical characteristics of test and control groups

Variables	*Test group Mean±SD*	*Control group Mean±SD*	*p*
Age (years)	21.60±1.75	21.05 1.50	.308
Height (cm)	176.31±6.56	177.17±7.13	.713
Body Mass (kg)	82.19±13.99	71.55±7.91	.011

Table 3 shows pre- and post-study performance values of test and control group wrestlers. According to the test results, significant differences were found between test group wrestlers' pre- and post-test right hand grip, biceps, triceps, suprailiac skinfold thickness and Max VO2 values ($p < 0.05$), while no significant differences were found between pre- and post-test vertical jump, left hand grip, back strength, subscapula skinfold thickness, wingate anaerobic strength and capacity values ($p > 0.05$). At the

Table 3: Pre and post-study exercise performances of test and control group wrestlers

	Pre-test (Mean±SD)	*Post-test (Mean±SD)*	*p*
Test Group			
Vertical Jump (kg)	53.95± 6.23	54.80± 5.94	0.497
Right Grip Strenght (kg)	49.91± 7.10	52.75± 7.04	0.004
Left Grip Strenght (kg)	49.92± 7.91	50.47± 7.98	0.424
Back Strenght (kg)	149.92± 24.38	155.20± 24.94	0.203
Absolute wingate anaerobic power (w)	896.55±162.48	912.59±180.13	0.609
Relative wingate anaerobic power (w/kg)	10.73± 1.13	11.15± 1.18	0.156
Absolute wingate anaerobic capacity (w)	627.34±105.25	639.81±108.20	0.45
Relative wingate anaerobic capacity (w/kg)	7.67± 0.70	7.82± 0.59	0.359
Max VO2 (ml/min.kg)	43.89± 4.58	45.16± 5.19	0.009
Bicebs Skinfold (mm)	4.75± 1.35	3.80± 0.88	0.001
Tricebs Skinfold (mm)	8.90± 2.18	7.25± 1.87	0
Subscapula Skinfold (mm)	12.62± 3.87	11.53± 3.07	0.061
Subrailiac Skinfold (mm)	12.88± 4.05	10.01± 3.93	0
Control Group			
Vertical Jump (kg)	50.80± 7.51	52.60± 7.50	0.255
Right Grip Strenght (kg)	46.17± 5.79	46.48± 6.21	0.707
Left Grip Strenght (kg)	44.05± 5.35	45.97± 5.08	0.042
Back Strenght (kg)	120.72± 21.88	123.72± 33.60	0.626
Absolute wingate anaerobic power (w)	763.10± 93.39	757.27± 99.17	0.684
Relative wingate anaerobic power (w/kg)	10.67± 1.21	10.65± 1.35	0.898
Absolute wingate anaerobic capacity (w)	562.84± 76.98	542.89± 61.47	0.147
Relative wingate anaerobic capacity (w/kg)	7.71± 0.59	7.56± 0.62	0.066
Max VO2 (ml/min.kg)	42.48± 4.37	43.09± 4.42	0.073
Bicebs Skinfold (mm)	4.82± 1.25	4.94± 1.09	0.216
Tricebs Skinfold (mm)	9.26± 2.56	9.05± 2.32	0.155
Subscapula Skinfold (mm)	11.64± 2.65	11.48± 2.46	0.357
Subrailiac Skinfold (mm)	11.48± 4.93	11.92± 4.74	0.254

end of pre-test and post-test measurements, there were no significant differences between all performance values of control group wrestlers, except for left hand grip strength ($p > 0.05$).

DISCUSSION

The mean age, body mass, and mean height of test group wrestlers were found to be 21.60 ± 1.75 years, 82.19 ± 13.99 kg, and 176.31±6.56 cm, respectively, while the mean age, body mass, and mean height of test group wrestlers were 21.05± 1.50 years, 71.55 ± 7.91 kg, and 177.17 ± 7.13 cm, respectively.

Aydos et al. (2004) conducted a study on 66 male wrestlers with a mean age of 19.53 ± 1.61 years, and found that their mean height was 1.73 ± 0.07cm while mean body weight was 76.77 ± 14,41kg, and these results are consistent with the data of our work.

Pre- and post-study body fat percentage of the test and control group wrestlers were as follows: pre- study- biceps 4.75±1.35mm, triceps 8.90±2.18mm, subscapular 12.62±3.87, suprailiac 12.88±4.05mm for test group; biceps 4.82± 1.25mm, triceps 9.26±2.56mm, subscapular 11.64± 2.65, suprailiac 11.64±2.65mm for control group; post-study-biceps 3.80±0.88mm, triceps 7.25± 1.87mm, subscapula 11.53±3.07, suprailiac 10.01± 3.93mm for test group and biceps 4.94±1.09mm, triceps 9.05±2.32mm, subscapula 11.48±2.46, suprailiac 11.92±4.74mm for control group. A significant reduction was detected in biceps, triceps, subrailiac skinfold thickness of the test group and such reduction was statistically significant. But no statistically significant reduction was found in subscapular skinfold thickness, although there was a reduction in subscapular skinfold thickness ($p > 0.05$). The results of measurements conducted on the control group were not statistically significant ($p > 0.05$).

This study also revealed that maximal strength training which was performed using weights, reduced body fat percentage. In a study conducted on Italian national team wrestlers by Zaccagni (2012), wrestlers' body fat percentages were reported as follows: biceps 3.2±0.9mm, triceps 8.6±2.6mm, subscapular 9.1±3.4, suprailiac 6.9±2.4mm. Previous research suggests that the body fat percentage in wrestlers should be in the range of 5 to 9. Similarly, the body fat percentage suggested by the American Medical Association for wrestlers is minimum 7 and maximum 10. Some researchers measured a mean fat ratio of 7.92 percent for 10 elite athletes from Etibank Sas freestyle wrestling team (Taºkiran 1990). Some researchers measured a mean fat ratio of 11.8 percent for 35 Olympic wrestler candidates from Canada (Kaplan 1996). The body fat ratio of college wrestlers determined by Kelly et al. (1978) during a competition period was 8.36 percent. In a study conducted by Schmidt et al. (2005) on college wrestlers, pre-, mid- and post-competition season body fat measurements were 11.6 ± 3.9, 10.5 ± 3.0 and 12.0 ± 3.4mm, respectively. Kaya et al. (2011) found the body fat percentages on free style to be 7.49 ± 1.16mm and on grekoromen style to be 7.93 ± 3.47mm. The values obtained from previous investigations support this study.

Pre-study right hand grip strength and left hand grip strength of test and control group wrestlers who participated in the study were as follows: 49.91± 7.10 and 49.92± 7.91 for test group and 46.17± 5.79 and 44.05± 5.35 for control group, respectively. It was revealed that post-study right hand grip strength and left hand grip strength of the test and control groups were 52.75± 7.04 and 50.47± 7.98 for test group and 46.48± 6.21 and 45.97± 5.08 for control group. But the right hand grip strength of the test group was found to be statistically significant ($p > 0.05$).

Baykus (1989) reported the following grip strength values for Greco-roman national team wrestlers: right hand: 40.77, left hand: 38.14. Kutlu and Cicioglu (1995) measured grip strength of star wrestlers and reported values of 35.90±8.73 for free style wrestlers. Kiliç et al. (1994) found grip strength of wrestlers from the age group of 14 to 16 as 38.44kg for right hand grip strength and 38.59kg for left hand grip strength. Right hand and left hand grip strength values of young Turkish national team Greco-roman wrestlers aged 17-18 were 40.51kg and 39.51kg respectively. Aydos and Koç (2003) mean right and left hand grip strength values estimated in these studies are similar to the mean values found in our study. It was discovered that weight training applied in this study improved hand grip strength.

The back strength of test and control group wrestlers who participated in the study were 149.92± 24.38 and 120.72± 21.88, respectively, before the study and 155.20± 24.94 and 123.72± 33.60, respectively, after the study. Although there was a positive improvement between the results of measurement, yet no statistically significant difference was observed ($p > 0.05$).

Senel et al. (2009) found a back strength value of 163.71 ± 40.32kg in a study conducted on wrestlers. In view of the literature, some of the values revealed in several studies conducted on wrestlers are consistent with the values in our study, though it is clear that the values in some studies are lower than our values. Although the findings in this study showed a mathematical difference, nevertheless, they were not statistically significant. This difference can be ascribed with respect to the duration and scope of the training applied. Aydos et al. (2009) found a back strength value of 155.80 ± 27.92kg in a study conducted on wrestlers.

Vertical jump values of test and control group wrestlers who participated in the study were 53.95±6.23 cm and 52.60±7.50 cm, respectively, before the study and 54.80±5.94 cm and 50.80±7.51cm, respectively, after the study. Although there was a positive improvement between the results of measurement, however, no statistically significant difference was observed ($p > 0.05$).

In a study by Yazici (1999), vertical jump of elite-level lightweight wrestlers was found as 53.16 ± 6.24 cm, and that of middleweight wrestlers as 52.25 ± 0.18cm. Aydos and Kürkçü (1997) reported a vertical jump value of 46.45 ± 7.38kg for high school students aged 17-18 doing sports. Given these findings, the high values obtained for the test group in this study can be said to be a result of maximal strength training performed with weights. Kilinç et al. (2012) found a squat variable on pre-test as 122.0 ± 18kg and that on post-test as 128.7±21.3kg.

The Max VO2 strength values of test and control group wrestlers who participated in the study were 43.89±4.58 ml/kg/min and 42.48±4.37 ml/kg/min, respectively, before the training and 45.16±5.19 ml/kg/min and 43.09±4.42 ml/kg/min, respectively after the training. In terms of the difference between pre- and post-training Max VO2 strength values of test group wrestlers, such difference was found to be statistically significant ($p > 0.05$). In this study, weight training program was identified to have positively affected aerobic strength development.

Researchers found a mean maximum oxygen consumption of 61.8 ml/kg/min for 49 Canadian freestyle wrestlers (Kaplan 1996). In a study conducted by Baykus (1989) on Turkish national team, mean Max VO2 values found for freestyle wrestling team were 48.01±3.51 ml/kg/min respectively. As a result of investigations, scientists established that there is a high correlation between aerobic capacity and success in wrestling. The more an athlete improves his aerobic capacity, the more his anaerobic capacity is improved. This is because athletes will be able to perform activities for longer periods before reaching O2 borrowing level and this will improve after creating O2 debt. This finding is very important for many sports for which anaerobic capacity is an important component. Most individual and team sports ensure that their technical and tactical behaviors reach the highest level by improving their aerobic capacity. Therefore, aerobic endurance should be the aim of continuous improvement for a majority of athletes (Bompa 1996; Kaplan 1996).

Peak strength development of test and control group wrestlers who participated in the study were 896.55±162.48 wat and 763.10±93.39, respectively, before the training and 763.10±93.39 wat and 912.59±180.13 wat, respectively, after the training. Moreover, relative peak strength values of test and control group wrestlers were 10.73±1.13 wat and 10.67±1.21 wat, respectively, before the study and 11.15±1.18 wat and 10.65±1.35 wat, respectively, after the study. The following absolute wingate anaerobic capacity values were identified for test group and control group wrestlers: 627.34±105.25 wat and 562.84±76.98 wat, respectively, before the study; 639.81± 108.20 wat and 542.89 ± 61.47 wat, respectively, after the study. The relative wingate anaerobic capacity values obtained for test group and control group wrestlers were 7.67±0.70 wat and 7.71± 0.59 wat, respectively, before the study, and 7.82±0.59 wat and 7.56±0.62 wat, respectively after the study. Although there was a mathematical improvement between the results of measurements, nevertheless, no statistically significant difference was revealed ($p > 0.05$).

In view of peak strength development of subjects at the end of training, Ersoy (2012) reported peak strength development values of 851.94±158 wat and 922.73±169 wat, relative peak strength values of 10.60±0.76 wat and 11.73±1.32 wat, absolute wingate anaerobic capacity values of 621.31±112.39 wat and 649.23±119.69 wat, and relative wingate anaerobic capacity values of 7.87±0.38 wat and 8.22±0.44 wat before and after a training program, respectively. This increase was found to be statistically significant. There are temporal and power capacity differences be-

tween this study and Ersoy's study resulting to observed differences between the results obtained.

In a study conducted by Demirkan et al. (2012) on junior elite wrestlers, the following values were obtained: Leg peak power (W) 1206±258, Leg average power (W) 611±144, Arm peak power (W) 838±225, Arm average power (W) 439±110. Furthermore, Horswill et al. (1989) asserted that there are significant differences between the elite and non-elite wrestlers, who are at the same age, weight and sport age, in terms of arm anaerobic power values (376±20 - 331±22) and leg anaerobic power values (540±25 -467±29) respectively. He opined that maximum relative anaerobic power value is the biggest matter that differentiates successful wrestlers from less successful ones.

CONCLUSION

In conclusion, the 8-week maximal weight training applied to the wrestlers was found to have positively affected wrestlers' performance in terms of right hand grip, biceps, triceps and subrailiac skinfold thickness values as well as Max VO2 values. This effect is presumably an outcome of the fact that the athletes participated in the training more intensely.

RECOMMENDATIONS

The results of this study should be evaluated carefully for proper identification of the method of training in terms of efficiency and for enhancement of success, as well as for future contribution. Also, this study will contribute to similar studies conducted in the literature.

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