European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

doi: 10.5281/zenodo.1203780 Volume 4 | Issue 3 | 2018

ASSESSMENT OF ANAEROBIC POWER WITH ARM AND LEG WINGATE TESTS IN ATHLETES[i]

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Abstract:
The research was carried out with the aim of determining and assessing arm anaerobic power, leg anaerobic power and aerobic capacity in individuals with different branches of active sports. A total of 60 subjects engaged in active sports at Elite level in different branches participated in the study. These branches are; wrestling (group G, n:10), football (Group F, N = 10), bicycle (BI group, n = 10), boxing (BO group, n = 10), taekwondo (TA group, n = 10), and tennis (TE group, n = 10). The research was carried out in the performance Laboratory of Selçuk University School of Physical Education and Sports. For anaerobic measurements, two separate Monark branded Wingate ergometers for arm and leg were used. Shuttle run tests were performed for aerobic measurements. SPSS for Windows 15.0 package program was used in the calculation and assessment of the obtained data. The normality distribution of the measured parameters was determined by the Shapiro-Wilks test. One-way variance analysis (ANOVA) was used to determine the differences between sports branches. In determining the source of difference, the LCD and Dunnett's C were applied from Post-Hoc tests. Significance level was taken as 0.05 in this study. As a result of the leg Wingate ergometer test, the peak power values of wrestlers were found to be significantly different at $p<0.05$ level compared to those of football, boxing, taekwondo and tennis players. The results of arm Wingate ergometer test showed that the peak power values of the boxers and wrestlers were significantly different in $p<0.05$ compared to the athletes in other branches. When their MaxVO2 levels were examined, it was observed that the values of cyclists differ significantly in $p<0.05$ compared to the average of athletes in other branches except wrestlers.

[i] This study was presented as a verbal presentation 12th International Scientific Conference of Montenegrin Sports Academy.

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Keywords: anaerobic capacity, aerobic capacity, leg Wingate, arm Wingate

1. Introduction

It is known by everyone that sports have a significant impact on the human organism. However, since it is composed of various branches, energy systems, duration, intensity, frequency and how long it has been played constitute the research subject of sports sciences.

Anaerobic performance is a term that is of great importance for sports branches that are defined in a short time and require explosive force. Because the performance of the athlete can be influenced by individual and environmental factors and can show an alteration. Trainers and sports experts aim to be able to increase the performance by determining the strength and capacity of the athletes they work with and by preparing an appropriate training program for them.

Regular training leads to an increase in the anaerobic performance of athletes. This increase in the anaerobic performance of athletes is an increase in the efficiency of ATP-PC stores and lactic acid system. For this reason, the athletes ' energy resources and the ability to use these resources are important elements for the performance of sports.

The energy required for the re-synthesis of ATP (Adenosine triphosphate) is supplied by aerobic or anaerobic metabolism. In these chemical reactions, the nutrients previously ingested by the digestive system are metabolized by aerobic and anaerobic ways (Ergen et al 1993, Günay 1999).

Aerobic metabolism consists of a series of chemical reactions that result in the conversion of carbohydrates, fats, and, if necessary, proteins into carbon dioxide and water, completely disintegrating in the presence of oxygen. These chemical reactions occur within the cell in an organelle called mitochondria, and these chemical reactions are called “oxidation”. Anaerobic metabolism involves the conversion of carbohydrates (except fats and proteins) to an intermediate by disintegration without (partially, but not entirely) oxygen use (Sönmez 2002).

All carbohydrates in our body are either converted into glucose, a simple sugar that can be used immediately, or stored as glycogen in muscles and liver for later use (Fox et al., 2012).

Carbohydrates form the basic energy source suitable for the anaerobic lactic system. As a result of this system, lactic acid is formed. When an action with a high level of difficulty is done for a long time, a large amount of lactic acid accumulates and this lactic acid limits the efficiency of each muscle and limits the duration of the sports, thus causing fatigue (Bompa, 2013).

Although anaerobic performance is important for all kinds of sporting activities, the importance of anaerobic performance is increasing in the branches where it is mainly used. As it is known, anaerobic performance is even more prominent because of the need for sudden and high strength formation in many sports such as football, basketball, handball, ice hockey, team games with sudden attack or suppressed

defensive moments such as American football, near the end of medium distance runs, short distance runs (100 m, 200 m), short distance swimming branches (50 m, 100 m), throwing and jumping sports, wrestling, tennis, skiing (alpine discipline) and gymnastics (Özkan et al, 2007).

The most important factors affecting anaerobic performance are age, gender, muscle structure, fibril composition, enzyme activities and training. It is not possible to reach the desired performance level unless the physical structure is suitable for the sport branch. In addition, strength, power, flexibility, speed, endurance and speed are combined with other performance indicators and affect the performance of the athlete positively (Özkan et al 2005). In addition, in some studies conducted by researchers, the increase in muscle volume and mass of the legs and thighs around the calf, lean leg volume and mass contributes positively to anaerobic performance and strength values (de Ste Croix et al, 2000).

Our second aim in this study is to determine how anaerobic performance in various branches is affected by two different methods.

2. Materials and Methods

60 male athletes, who are actively engaged in sports from 6 branches (Boxing n: 10, Taekwondo n: 10, Football n: 10, Tennis n: 10, Bike n: 10, Wrestling n: 10), with a mean age between 18-28 years, voluntarily participated in the study. The subjects were selected from athletes who had not suffered neurological, audiovisual (vestibular-visual) discomfort in the last 6 months and who had not suffered any serious injury to their upper extremities. This situation was determined by asking series of questions to the athletes before the application. Prior to the application, athletes were informed about the tests they were going to be exposed to and they signed a certificate of voluntary participation.

The research was carried out in the performance Laboratory of Selçuk University School of Physical Education and Sports. By using two Wingate ergometers of Monark brand, the arm and leg Wingate values of athletes of the same branch and 6 different groups in different branches were determined and compared. Required permissions were obtained from the ethics committee of Selçuk University.

2.1 Applied Measurements and Tests

A. Height and Weight Measurement

The weighing of the subjects was made on a bascule (Angel brand) that is sensitive up to 20 grams with bare feet and shorts only. Height measurements were made while the subjects were standing in an upright position, the height measurement was set on the scale so that the caliper touches the head of the subject, and the height was read with an accuracy of 1mm.

B. Shuttle Run Test (Aerobic Power)

In the basketball court, the distance required for the test was determined with 20 m steel meters, the test area was limited with colored strips, and the lines were made clear to

see with funnel and dots. In the previously prepared level follow-up form, the levels at which the subjects left the test were marked and the method developed by Ramsbottom et al. (1988) was used to convert the shuttle levels obtained from the test result to $MaxVO_2$.

C. Anaerobic Power

The anaerobic forces of the subjects were measured using two separate arm and leg ergometers of Monark brand. Wingate tests were performed on different days and anaerobic power was determined with the Monark Anaerobic Test Software. In arm Wingate test, a load of 50 g/kg per body is applied, while a load of 75 g/kg per was applied in leg Wingate test (Tamer 2000).

D. Wingate Anaerobic Power Test

For the Wingate test, a Monarch 894E (made in Sweden) arm and leg bike ergometer that is modified for computer connection and a compatible software were used. Before the tests, the height adjustments were made for each athlete. For each athlete, the load to be applied as external resistance in the arm ergometer during the test was calculated as 50 gr/kg and 75 gr/kg in the leg ergometer. Athletes were subjected to a 5-minute warming protocol with two or three sprints of 4-8 seconds at 60-70 rev/min pedals with 20% of the calculated test load of bicycle ergometer. They were given passive rest for 3-5 minutes after warming. Athletes were asked to reach the highest pedaling speed as soon as possible without resistance. When the maximum speed was reached (approximately 3-4 seconds later), the load previously calculated as 50 gr/kg and 75 gr/kg was released and the test was started. The athletes pedaled against this resistance at the highest speed for 30 seconds. Athletes were encouraged verbally throughout the test (Özkan et al., 2010).

2.2 Analysis of Data

SPSS for Windows 15.0 package program was used in the calculation and assessment of the obtained data**.** Measured variables were summarized by giving mean and standard deviation (±). The normality distribution of the measured parameters was determined by the Shapiro-Wilks test. One-way variance analysis (ANOVA) was used to determine the differences between sports branches. LCD and Dunnett's C in Post-Hoc tests were applied to determine the source of the difference. The significance level in this study was taken as 0.05.

3. Findings

Differences between age, height and body weight parameters of the groups participating in the study in Table 1 were determined using the lettering method at $P < 0.05$ level. In the study, Wingate leg bicycle ergometer was used to determine lower extremity anaerobic power levels of all groups, and Wingate arm bicycle ergometer was used to determine upper extremity anaerobic power levels. The data obtained after the test were recorded as peak power, relative peak power, and average power. In Table 2, the lower extremity power output averages and in Table 3 the upper extremity power

output averages were used and the differences between the groups were determined using the lettering method at P <0.05. The MaxVO2 levels, averages and differences of the groups were determined by using the lettering method at P <0.05 level in Table 4.

Table 1: Average age, height and body weight of the groups

Groups	N	Age(Year)	Height(cm)	Body Weight(kg)
G	10	21,70±2,35 **a**	174,20±7,05 **b**	77,50±13,44 **a**
F	10	21,80±1,75 **a**	177,90±3,84 **ab**	70,60±6,36 **a**
Bİ	10	22,70±2,54 **a**	178,20±4,44 **ab**	72,90±4,67 **a**
BO	10	22,20±2,74 **a**	178,50±5,40 **ab**	74,20±10,56 **a**
TA	10	22,50±3,10 **a**	180,60±2,98 **a**	73,40±7,84 **a**
TE	10	24,00±1,88 **a**	178,90±8,18 **ab**	73,80±12,64 **a**

a, b, c: The difference between the averages in the same column is significant (P <0.05).
Groups; Wrestling (G), Football (F), Bicycle (BI), Boxing (BO), Taekwondo (TA), Tennis (TE)

Table 2: Comparison of Leg Wingate Ergometer Test Parameters of Groups

	Peak Power (W)	Relative Peak Power(W/kg)	Average Power(W)
Groups	Mean±SD	Mean±SD	Mean±SD
G	857,94±127,47 **a**	11,22±1,10 **a**	609,51±87,55 **a**
F	698,65±89,56 **b**	9,90±1,13 **b**	522,33±54,92 **b**
Bi	775,24±90,46 **ab**	10,64±0,98 **ab**	598,14±60,38 **ab**
BO	735,08±93,90 **b**	9,96±0,91 **b**	536,83±73,04 **ab**
TA	748,53±136,42 **b**	10,51±1,23 **ab**	571,14±112,95 **ab**
TE	731,81±132,05 **b**	9,84±0,97 **b**	549,23±83,96 **ab**

a, b, c: The difference between the averages in the same column is significant (P <0.05).
Groups; Wrestling (G), Football (F), Bicycle (BI), Boxing (BO), Taekwondo (TA), Tennis (TE)

Table 3: Comparison of Group Arm Wingate Ergometer Test Parameters

	Peak Power (W)	Relative Peak Power(W/kg)	Average Power(W)
Groups	Mean±SD	Mean±SD	Mean±SD
G	675,45±110,88 **a**	8,87±0,72 **a**	436,32±90,42 **a**
F	440,85±82,50 **b**	6,30±0,86 **c**	302,48±55,07 **d**
Bİ	439,01±61,56 **b**	6,07±0,66 **c**	303,69±48,68 **d**
BO	649,37±133,43 **a**	8,84±1,28 **a**	406,54±72,74 **ab**
TA	536,44±120,02 **b**	7,32±1,19 **b**	372,06±57,69 **bc**
TE	524,89±84,34 **b**	6,94±1,23 **bc**	337,08±62,23 **cd**

a, b, c: The difference between the averages in the same column is significant (P <0.05).
Groups; Wrestling (G), Football (F), Bicycle (BI), Boxing (BO), Taekwondo (TA), Tennis (TE)

Table 4: Comparison of MaxVO2 Levels of Groups

	MaxVO2 (ml.kg/dk)	Distance(m)
Groups	Mean±SD	Mean±SD
G	51,37±3,58 **ab**	1966,00±244,95 **ab**
F	48,29±4,29 **bc**	1760,00±274,38 **bc**
Bİ	54,06±6,44 **a**	2160,00±435,22 **a**
BO	48,58±3,94 **bc**	1760,00±299,92 **bc**
TA	49,03±5,34 **bc**	1756,00±368,87 **bc**
TE	45,09±3,60 **c**	1548,00±234,60 **c**

a, b, c: The difference between the averages in the same column is significant (P <0.05).
Groups; Wrestling (G), Football (F), Bicycle (BI), Boxing (BO), Taekwondo (TA), Tennis (TE)

4. Discussion and Conclusion

A total of 60 subjects, active in various branches in elite levels, participated in the study on a voluntary basis. These branches are wrestling (n:10), football (n:10), Cycling (n:10), Boxing (n:10), taekwondo (n:10), and tennis (n:10).

In the study conducted, the groups were tried to be formed by determining the branches where the upper extremities and lower extremities were used intensively and predominately. When the Wingate anaerobic power tests performed to date were examined, the results obtained from the Wingate test were compared and assessed for each branch by performing the leg Wingate test, especially without regard to branch differences. As a matter of fact, only leg Wingate tests have been performed for the branches where the lower extremities are heavily used (Taekwondo, Football, Bicycle etc.) and the upper extremities are used more heavily (Boxing, Tennis, Handball, Grekomen Wrestling etc.) to reveal the anaerobic power levels. The study is based on this problem. For example, branches where the arms and legs were under close pressure such as Kickboxing were not included in the study; however, groups were tried to be determined by taking into consideration branches such as boxing, where the arm is dominant and taekwondo, where the leg is dominant.

When Table 1 was examined, it was determined that the average height of Taekwondo athletes is higher than the wrestlers ($p < 0,05$), but the other differences between the groups are not significant and the average of the body weight and age do not vary significantly. The applied Wingate test is important in terms of the objectivity of study that there is no significant difference between the groups due to the load given per kilogram of body.

Anaerobic capacity, which is one of the most important indicators of success in sport, is defined as the work capacity that occurs during maximal physical activity by using anaerobic energy transfer systems in the absence and deficiency of oxygen in skeletal muscles. The value of this work in the unit of time is expressed as the anaerobic force. (kg/sec, kg/min, watt) (Yıldız, 2012).

When the leg Wingate peak power levels of groups are examined, it was observed that the peak power level of the wrestlers was similar to that of the bike group, but it was found to be significantly higher ($p < 0.05$) than football, boxing, taekwondo and tennis groups. It was observed that the wrestling group was similar to the cycling and taekwondo groups at the relative peak power level and that it was significantly different with other groups ($p<0.05$), and it was observed that the cycling and taekwondo groups differ significantly with the wrestling group and other group athletes ($p<0.05$).

The optimal load setting for the Wingate anaerobic power test was not completely resolved (Özkan et al. 2010). In our study, we have used 75 grams / kg load recommended for Wingate anaerobic power test by the Wingate Institute.

In the studies where optimal load was applied 75 gr/kg for the Wingate test, Hübner-Wozniak et al. (2004) found the mean age of 22.7 years, body weight of 75.5 kg of 10 male wrestlers of Polish wrestling team with leg Wingate peak power levels ıf 859

watts (W), relative power levels of 11.4 W/kg. Oosthuyse et al (2013) reported that the leg Wingate peak power average of 22 Elite cyclists with an age average of 37, and body weight average of 75,1 kg as 735 W. Jelena et al (2009) reported peak power levels of 14 elite level boxers with an age average of 22,21 and a body weight average of 77.00 kg as 715 w, and the relative peak power levels were 9,27 W/kg after the Wingate anaerobic power test. The average leg Wingate test peak power averages of wrestlers, who are actively wrestling in different clubs, were found as 776,8 W (Zorba et al. 2010).

In the studies where optimal load was applied differently, Chtourou et al (2012) showed that when 87 gr/kg load were applied to 20 football players with an age average of 17,6 years and body weight averages of 71.3 kg, the peak power levels were obtained 769 W in the leg Wingate test and the relative peak power levels were obtained 10.7 W/kg. Zagutto et al (2008) reported that when 85 gr/kg load were applied to 8 national table tennis players with an age average of 18 years and body weight averages of 6 kg, the peak power levels were obtained 772 W in the leg Wingate test and the relative peak power levels were obtained 11.6 W/kg. Weber et al. (2005) found peak power and relative peak power levels of 743 W and 9.3 W/kg after arm Wingate anaerobic power test with 10 sedentary subjects who were given 83 gr/kg load. When the literature is examined, the leg Wingate test results, where the optimal load is 75 g/kg, are similar to the results of our study.

When the Wingate average power levels of the groups were examined, it was found that the wrestling group differed significantly from the soccer group ($p<0.05$) and there was no difference in the other comparisons. Demirkan et al (2012) reported in the study, which was alike ours, reported that leg Wingate anaerobic mean power levels of 11 wrestlers as 611 W. Jelena et al. (2009) reported that the average power levels of 14 Elite boxers were 517.31 W after the leg Wingate anaerobic power test. It is observed that the average power levels of both studies are consistent with the results of our study, as well as the method and material similarity. Souissi et al (2012) reported average power levels of 20 elite judoists leg Wingate test as 616.4 W, after loading 87 gr/kg body weight. Micklewright et al. (2006) in a study where they applied 70 g / kg body weight per kilogram, reported a mean power level of 464 W after leg Wingate anaerobic power test of 15 healthy male subjects with an average age of 24 years, who have regular physical activity. It is thought that optimal load, age, and performance levels of subjects affect Wingate test results.

When wrestling peak power levels of the groups in our study were examined, it was seen that wrestling and boxing group showed similarity but these two branches differed significantly ($p <0,05$) from football, bicycle, taekwondo and tennis groups. It was found that the relative peak power values were significantly different from the other groups of boxing and wrestling group and the taekwondo group were significantly different from the football and cycling groups ($p<0.05$). Other comparisons between groups were observed to be similar. In our study, 50 g/kg body weight per kg body weight was given for the arm Wingate test.

When the studies done with Wingate arm ergometer test are examined; Martinez-Abellan et al. (2010) reported a peak power level of 780.9 W for 18 National wrestlers with age average of 18.5 years and body weight average of 73.1 kg, when they were loaded with 50gr/kg body weight. Hübner - Wozniak et al (2004) reported peak power and relative peak power levels at 732 W and 9.6 W/kg as a result of the study conducted by 10 wrestlers in the Polish male national team that they bore 55 gr/kg per body. Hübner - Wozniak (2006) determined peak power levels of 13 fighters in the Polish national team at 574.4 W and relative peak power levels at 8.0 W/kg.

In the study conducted with ski, handball and canoe athletes, whom were given the load of 60 gr / kg body weight, arm Wingate anaerobic peak power and relative peak power levels of 9 athletes were reported as 679 W and 7.84 W / kg (Kounalakis et al. 2009). In the branches where upper extremities are used intensively and predominately, arm Wingate test results are higher than those in the branches where lower extremities are used intensively and predominately.

In particular, the results of our modified studies of differentiated anaerobic arm Wingate ergometer testing and optimal loading differed from those of our study (Koutedakis et al 1986, Weber et al 2005, Zagotto et al 2008).

It is observed that the arm Wingate test results of the upper extremities used in the intensive and dominant branches are higher than the lower extremities used in the intensive and dominant branches. The results of this study indicate that the performed sport branch and actively used energy systems cause significant differences in wing ate test results.

Oxygen use capacity or Maximum use of O_2 can be defined as the maximum oxygen consumption ($MaxVO_2$) that can be carried to the organism, in other words, containing definitions such as the amount of O_2 that the tissues can use in a minute. The rate of oxygen absorption at the lung level (activity of alveoli) is attached to the capacity of oxygen transport in the blood (activity of hemoglobin), the use of oxygen in muscles (activity of mitochondria) and the rate of type 1 fibers in the working muscle (Karatosun 2010).

When the $MaxVO_2$ levels of the groups were examined after the shuttle run test conducted in our study, it was determined that the bicycle group had higher levels than football, boxing, taekwondo and tennis groups and the wrestlers had significantly higher MaxVO2 levels ($p < 0,05$) than the tennis players. İmamoğlu et al. (2005) reported that 20 individuals who have been active wrestling for 10 years with a mean age of 23.5 years had MaxVO2 levels of 52.4 ml/kg/min after 12 min walking test. Uğraş et al. (2002) reported the value of MaxVO2 of amateur 18 soccer players with an average age of 21.67 years as 46.90 ml / kg / min and Erkmen et al (2005) reported the $MaxVO_2$ level of 17 professional players from Turkey 2 Leagues with an age average of 20.71 years as 51.36 ml/kg/min. It is observed that the oxygen use capacities of the players playing professional soccer are higher than amateur soccer players.

Kouassi and Hondschuh (1990) reported $MaxVO_2$ level of 11 Olympic level long-distance bikers as 69.6 ml / kg / min. Arseneau et al. (2011), Sevas et al. (1986), Khanna and Manna (2006), Joko (1983) found in their studies that the $MaxVO_2$ levels of boxers

respectively in Canadian, Greek, Indian and Hungarian teams had higher values than the boxing group in our study. Bouhlel et al (2006) reported $MaxVO_2$ levels of 8 male taekwondo players with an average age of 20 years at 56.22 ml/kg/min. Berdejo-del-fresnu et al (2010) determined $MaxVO_2$ levels of elite tennis players with mean age of 21,71 years at 54,17 ml/kg/min. Conducted studies show that $MaxVO_2$ is influenced by branches, age, body weight and performance values. The dominance of $MaxVO_2$ levels are observed in the branches where Aerobic capacity, therefore durability, is at the forefront of elite athletes. The differences between the studies are thought to be due to method changes, intergroup and individual differences, and most importantly to the performance levels of the subjects used in the study at the time of the test.

In conclusion, in the research that assessed aerobic and anaerobic capacity levels which are important indicators of performance, it is concluded that differences in performance, sporting experience, skill and achievement levels of groups affected the results obtained. Therefore, the aerobic or anaerobic capacities for the dominant energy system have come to the forefront. The arm and leg Wingate results obtained in our study are similar to the literature. Arm anaerobic powers were found to be higher in the branches where the upper limbs were used predominantly (G, BO) than in the branches where the lower extremities were heavily used (F, BI, TA), but it is observed that the anaerobic power outputs obtained in the leg ergometer are similar.

References

1. Arseneau E, Mekary S, Leger LA. Vo_2 requirements of boxing exercises. Journal of Stregth and Conditioning Research. 2011;25 (2) : 248-253.
2. Berdejo-del-Fresno, D., Vicente-Rodríguez, G., González-Ravé, J. M., Moreno, L. A., & Rey-López, J. P. (2010). Body composition and fitness in elite Spanish children tennis players. *Journal of Human Sport and Exercise*, (II).
3. Bompa TO. Sporda Çabuk Kuvvet Antrenmanı. Ankara. Spor Yayınevi ve Kitapevi. 2013;4: 31.
4. Bouhlel, E., Jouini, A., Gmada, N., Nefzi, A., Abdallah, K. B., & Tabka, Z. (2006). Heart rate and blood lactate responses during Taekwondo training and competition. *Science & Sports*, *21*(5), 285-290..
5. Chtourou H, Hammouda O, Souissi H, Chamari K, Chaouachi A, Souissi N. Diurnal variations in physical performances related to football in young soccer players. Asian Journal of Sports Medicine. 2012;3 (3) : 139-144.
6. De Ste Croix MBA, Armstrong N, Chia MYH, Welsman JR, Parsons G, Sharpe P. Changes in short-term power output in 10 to 12–year-olds, Journal of Sports of Sciences. 2000;19: 141-148.
7. Demirkan E, Ünver R, Kutlu M, Koz M. Genç elit güreşçilerin fiziksel ve fizyolojik özelliklerinin karşıalştırılması. Niğde Üniversitesi Beden Eğitimi Ve Spor Bilimleri Dergisi. 2012;2 (6): 140-147

8. Ergen E, Demirel H, Guner R, Turnagol H, Basoğlu S, Zergeroğlu AM. Egzersiz Fizyolojisi. Ankara. Nobel Yayınları. 1993.
9. Erkmen N, Kaplan T, Taşkın H. Profesyonel futbolcuların hazırlık sezonu fiziksel ve fizyolojik parametrelerinin tespiti ve karşılaştırılması. Spormetre Beden Eğitimi ve Spor Bilimleri Dergisi. 2005;3 (4) : 137-144.
10. Fox, Bowers, Foss. Beden Eğitimi ve Sporun Fizyolojik Temelleri. (Çeviri: Mesut Cerit). Ankara. Spor Yayınevi ve Kitap Evi. 2012: 11-239.
11. Günay M, Onay M. Artan Direnç Egzersizleri ve Genel Maksimal Kuvvet Antrenmanlarının Kuvvet Gelişimi, İstirahat Nabzı, Kan Basınçları, Aerobik-Anaerobik Güç ve Vücut Komposizyon Etkileri. Ankara. Gazi Beden Eğitimi ve Spor Bilimleri Dergisi. 1999;4: 21-31.
12. Hübner-Wozniak E, Kosmol A, Glaz A, Kusior A. The Evaluation of upper limb muscles anaerobic performance of elite wrestlers and boxers. Medsportpress. 2006;12: 218-221.
13. Hübner-Wozniak E, Kosmol A, Lutoslawska G, Ez Bem. Anaerobic performance of arms and legs in male and female free style wrestlers Journal of Sports Science and Medicine. 2004;7 (4): 473-480.
14. Hübner-Wozniak E, Kosmol A, Lutoslawska G, Ez Bem. Anaerobic performance of arms and legs in male and female free style wrestlers Journal of Sports Science and Medicine. 2006;7 (4): 473-480.
15. İmamoğlu O, Atan T, Kishali NF, Burmaığlu G, Akyol P, Yildirim K. Comparison of lipid and lipoprotein values in men and women differing in training status. Biology of Sport. 2005;22 (3) : 263-267.
16. Jelana Z, Otto F, Nikola G. Maximal anaerobic power test in athletes of different sport disciplines. Journal of Strength and Conditioning Research. 2009;23 (3) : 751-754.
17. Joko P. Physical and physiological characteristics of Hungarian boxers, Europe Box. Magazine. 1983;8: 28-29.
18. Karatosun H. Antrenmanın Fizyolojik Temelleri. Isparta. Altıntuğ Matbaası. 2010;3: 137.
19. Khanna GL, Mana L. Study of physiological profile of Indian boxers. Journol Sports Science Medicine 2006;5: 90-98.
20. Kouassi BYL, Handschuh R. Caracteristiques physiologiques des cyclistes de haut niveau. Sciences and Sports. 1990;5: 129-136.
21. Kounalakis SN, Koskolou MD, Geladas ND. Oxygen Saturation in the triceps brachii muscle during an arm wingate test: the role of training and power output. Research in Sports Medicine. 2009;17: 181-189.
22. Koutedakis, Y., & Sharp, N. C. (1986). A modified Wingate test for measuring anaerobic work of the upper body in junior rowers. *British Journal of Sports Medicine*, *20*(4), 153-156.
23. Martinez-Abellan A, Garcia-Pallares J, Lopez-Gullon JM, Otegui XM, Banos VM, Martiez-Moreno A. Factores anaerobicos predictores delexito en lucha olimpica. Cuadernos de Psicologia del Deporte. 2010;10: 17-23.

24. Micklewright D, Alkhatib A, Beneke R. Mechanically versus electro-magnetically braked cycle ergometer performance and energy cost of the wingate anaerobic test. European Journal of Applied Physiology. 2006;96: 748-751.
25. Oosthuyse T, Viedge A, Mcveigh J, Avidon I. Anaerobic power in road cyclists is improved after 10 weeks of whole-body vibration training. Journal of Strength and Conditioning Research. 2013;27 (2) : 485-489
26. Özkan A, Arıburun B, Kin-İşler A. Ankara'daki Amerikan Futbolu Oyuncularının Bazı Fiziksel ve Somatotip Özelliklerinin İncelenmesi. Ankara. Gazi Beden Eğitimi ve Spor Bilimleri Dergisi. 2005;5 (2):35-42.
27. Özkan A, Aşçı A, Açıkada C. Determination of the optimal load for the wingate anaerobic test. IV İnternatinal Mediterranean Sport Sciences Congress p108. 9-11 November 2007. Antalya. Türkiye.
28. Özkan A, Köklü Y, Ersöz G. Anaerobik Performans ve Ölçüm Yöntemleri. Ankara. Ofset Matbaacılık. 2010
29. Ramsbottom, R., J. Brewer, and C. Williams. "A progressive shuttle run test to estimate maximal oxygen uptake." *British journal of sports medicine* 22.4 (1988): 141-144.
30. Sevas PT, Alexander T, Elefthedous T, Vassilis K. Physiological profile of elite athletes to maximal efforts. In; Proceed Olympic Sc. Cong., Ed. By Malina, R.N. and Banchard, G. New York: Human Kinetic Publishers. 1986; 8: 94-177.
31. Souissi M, Abedelmalek S, Chtourou H, Atheymen R, Hakim A, Sahnoun Z. Effects of morning caffeine ingestion on mood states, simple reaction time and short-term maximal performance on elite judoists. Asian Journal of Sports Medicine. 2012; 3 (3) : 161-168.
32. Sönmez GT. Egzersiz ve Spor Fizyolojisi. Bolu. Ata Ofset Matbaacılık 2002: 163-167.
33. Tamer K. Sporda Fiziksel ve Fizyolojik Performansın Ölçülmesi ve Değerlendirilmesi. Ankara. Bağırgan Yayınevi. 2000: 11-15.
34. Uğraş A, Özkan H, Savaş S. Bilkent üniversitesi futbol takımının 10 haftalık ön hazırlık sonrasındaki fiziksel ve fizyolojik karekteristikleri. G.Ü. Gazi Eğitim Fakültesi Dergisi. 2002;22 (1) : 241-252.
35. Weber CL, Chia N, Inbar O. Gender diffrences in anaerobic power of the arms and legs – a scaling issue. Offical Journal of teh American College of Sports Medicine. 2005: 130-131. .
36. Yıldız AS. Aerobik ve anaerobik kapasitenin anlamı nedir? İstanbul. Solunum Dergisi. 2012;5 (2): 1.
37. Zagatto AM, Papoti M, Gobatto CA. Anaerobic capacity may not be determined by critical power model in elite table tenis players. Journal of Sports Science and Medicine. 2008;7: 54-59.
38. Zorba E, Özkan A, Akyüz M, Harmancı H, Taş M, Şenel Ö. Güreşçilerde bacak hacmi, bacak kütlesi anaerobik performans ve bacak kuvveti arasındaki ilişki. Uluslar arası İnsan Bilimleri Dergisi. 2010;7 (1) : 86-91.