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Comparison of Anthropometric Characteristics and Biomotor Ability Variables of Athletes in Different Combat Sports

Farklı Mücadele Sporcularının Antropometrik Özellikleri ile Biyomotor Yeti Değişkenlerinin Karşılaştırılması

*Nuray Satılmış[1], Mehmet Söyler[2], Gökmen Kılınçarslan[3]

[1] Alanya Alaaddin Keykubat Üniversitesi, Spor Bilimleri Fakültesi, Alanya, TÜRKIYE / nuray.satilmis@alanya.edu.tr / 0000-0002-2086-1436
[2] Çankırı Karatekin Üniversitesi, Sosyal Bilimler MYO, Çankırı, TÜRKIYE / mehmetsoyler@karatekin.edu.tr / 0000-0002-6912-4218
[3] BingölÜniversitesi, Spor Bilimleri Fakültesi,Bingöl, TÜRKIYE / gkilincarslan@bingol.edu.tr / 0000-0001-5176-6477
* Corresponding author

Abstract: This study aims to compare the anthropometric characteristics and the biomotor ability variables of the athletes in boxing, taekwondo, and wrestling and examine the relationships of the research variables in terms of branches. A total of 83 voluntary male athletes who took part in the national teams participated in the research in the branches of boxing (n=28), wrestling (n=33) and taekwondo (n=22). The mean age of the participants was 20.4, and the mean weight and height were 75.5 and 174.9. The mean BMI of the participants was 24.5. Indirect VO2max values of the athletes were obtained based on their height, weight, BMI, grip strength, squat jump (SJ) and countermovement jump (CMJ), anaerobic strength obtained from a vertical jump, standing long jump, 30 meters speed test and 20 meters shuttle running test. There was no significant difference between the groups regarding grip strength, anaerobic power and VO2max abilities. When the groups were compared regarding sprint values, there were significant differences between the athletes in the taekwondo and wrestling branches ($p<0,05$). The standing long jump test results determined that the boxers had statistically lower mean scores than the taekwondo and wrestling athletes ($p<0,05$). In the SJ and CMJ test values, in which vertical jumping abilities were determined, there was a similarity between the athletes in the boxing and wrestling groups, while it was understood that there were significant differences between the athletes in taekwondo and the other two branches. Taekwondo athletes were found to have higher mean scores when compared to box and wrestling groups ($p<0,05$). It is thought that this is due to the sport events-specific acts and training method of taekwondo.

Keywords: Anthropometric characteristics, biomotor ability, athletes, combat sports.

Özet: *Bu çalışmanın amacı boks, taekwondo ve güreş sporcularının antropometrik özellikleri ile biyomotor yeti değişkenlerinin karşılaştırılmasını yapmak ve araştırma değişkenlerinin branşlar özelinde ilişkilerinin incelenmesidir. Araştırmaya milli takımlarda görev alan Boks (n=28), Güreş (n=33) ve Taekwondo (n=22) branşlarında toplam 83 erkek sporcu katılmıştır. Sporcuların boy uzunlukları, vücut ağırlıkları, vücut kitle indeksleri, kavrama kuvveti, squat ve aktif sıçrama, dikey sıçramadan elde edilen anaerobik güç, durarak uzun atlama, 30 metre sürat ve 20 metre mekik koşusu testinden endirek VO2 max değerleri elde edilmiştir. Araştırma grubunun yaş, antropometrik özellikleri ve biyomotor değişkenlerine ait ortalama ve standart sapma değerleri hesaplanmıştır. Araştırma verilerinin normal dağılım gösterdiği, çarpıklık-basıklık testi sonuçları (±2) ile tespit edilmiştir. Branşlar arasında anlamlı farkların olup olmadığını anlamak için tek yönlü varyans analizi (One Way ANOVA) yapılmıştır. Anlamlı fark bulunan değişkenlerde hangi branşlar arasında olduğu da Tukey testi ile (Post Hoc Multiple Comparasion) tespit edilmiştir. Değişkenler arasındaki ilişkileri açıklamak için pearson korelasyon istatistiği kullanılmıştır. Kavrama kuvveti, anaerobik güç ve VO2max yetilerinde gruplar arasında anlamlı farklılık tespit edilmemiştir. Gruplar sürat koşu değerleri yönüyle karşılaştırıldığında taekwondocular ve güreşçiler arasında anlamlı farklar görülmüştür. Durarak uzun atlama test sonuçlarında boksörlerin hem taekwondo hem de güreş sporcuları arasında istatistiksel olarak anlamlı farklara sahip olduğu tespit edilmiştir. Dikey sıçrama yetilerinin tespit edildiği SJ ve CMJ test değerlerinde ise boks ve güreş sporcuları arasında benzerlik görülmüşken, taekwondocuların diğer iki branş sporcularla arasında anlamlı farklar olduğu tespit edilmiştir. Taekwondo sporcularının bazı parametrelerde daha başarılı oldukları görülmüştür. Bunun sebebinin taekwondo sporunun branşa özgü hareketlerinden ve antrenman metodundan kaynaklandığı düşünülmektedir.*

Anahtar Kelimeler: *Antropometrik özellikler, biyomotor yeti, sporcular, mücadele sporları.*

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INTRODUCTION

Martial arts and/or combat sports have been one of the needs of humanity since ancient times for people to protect themselves (Söyler, 2020). Combat sports and techniques, which can be used in attacks encountered, were systemized based on various rules and defined as the common name for the physical challenges, performance, training traditions and sports branches (Rao&Rao, 2010). The aim of combat sports, including boxing, taekwondo and wrestling, is to improve the body and spirit in terms of strength development and receive training in martial arts. There are some differences since these sports, each with separate rules, are martial arts and involve different activities that include physical training intensity and mental control techniques (Purcel, et all., 2011). Each of these sports consists of physical and physiological factors that affect athletes' success, such as aerobic-anaerobic energy systems, different strength exercises, various speed drills, endurance, body composition, and technical and tactical training separately (Savaş and Uğraş, 2004).

Boxing is a sport where all energy systems work together. Especially since it combines all physical and physiological elements, it stands out with the high level of effort and the high level of struggle it requires today (Quindry , 2008 & Shoepe, 2011). On the other hand, the importance of maximal strength and anaerobic power in boxing is understood from this point of view, where energy loss is high due to sudden combined hits. The punching activity in boxing is a dynamic and short-term movement. This movement requires highly developed muscle strength and agility. Upper and lower extremity muscle strength, which is positively related to each other, is one of the most important factors that ensure the development of the boxer's performance (Chaabène, et all., 2015) anaerobic power, muscle strength endurance, flexibility, hand and eye coordination, foot games that are gained through training. It is seen that it provides an improvement in agility and reflexes (Çakmakçı, 2002).

Regarding energy systems, wrestling is a sport with intense aerobic capacity, and the lactic acid (LA) ratio can reach severe levels due to intense and short-term parameters depending on physiological factors (Ziyagil, et all., 1996). This sport, which lasts for two three-minute periods, requires a dominant anaerobic power, depends on a high level of body strength, and because of its biomotor properties, it also requires a high level of performance (Bahman, et all., 2009). In various scientific studies, it is stated that the most used

energy system in wrestling is the ATP-CP and LA system, and 90% of the energy is produced from the ATP-CP+LA system, and 10% of the energy is produced from the LA+O2 system (Grindstaff, 2006). In terms of performance, muscular strength, fast reaction time, agility, neuromuscular coordination, static and dynamic balance, high anaerobic capacity, and an optimal high aerobic capacity are important factors that play a role in performance (Kürkçü, 2005).

Taekwondo is a multivariate martial art since it works and develops biomotor properties such as strength, agility, endurance, and velocity, and anaerobic energy systems are dominant because of the durations based on competition rules (Singh, 2015). On the other hand, the absolute development of anaerobic capacity needs to be developed more than aerobic capacity in sudden accelerations and double struggles in short seconds (Singh, 2015). Physical and physiological structure, height, weight, body composition, aerobic power, anaerobic power, strength, velocity, and flexibility are necessary for taekwondo. It has been determined that elite taekwondo players need a high level of physical fitness (Heller, 1998&Singh, 2015).

In martial arts, where the lower and upper extremities are used fast, and sports performance parameters such as strength, endurance, velocity, and agility are important, measuring and developing physical and physiological performance parameters are significant in sports branches (Singh, 2021). Box, wrestling, and taekwondo have similarities in winning and losing; however, the athletes differ in physiological and performance characteristics; each has different rules, and they include different volumes of physical training and mental control techniques (Purcell, 2012). The study aims to compare specific parameters (standing long jump, SJ, CMJ, etc.) in terms of both the lower and upper extremities for the national athletes of different martial arts.

METHODS

Research Model: The participants were informed about the tests before the beginning of the tests. Each athlete signed a voluntary consent form. In the G*power analysis, the alpha significance level (Type I error) was taken as $\alpha = 0.05$, and the power value we wanted to obtain (Type II error) was taken as $\beta = 0.80$. The effect width was taken as $|\rho|=0.1$ for the high validity of our study. As a result, the number of people included in the study was determined to be at least 26. In order to determine the anthropometric characteristics of the athletes, their height and body weights were measured, and BMI was calculated using these data. Twenty-meter (20m) test was carried out to determine aerobic abilities. Indirect VO_2max values were obtained using the shuttle running test. The grip strength test was used to determine strength levels, SJ, CMJ and standing long jump were used to determine jumping abilities. In determining anaerobic power abilities, calculations in watts were made using the Levis nomogram, active jump, and body weights. Thirty meters sprint test was applied to determine the speed abilities. The measurement values of the whole research group are given in Table 2. The age, anthropometric characteristics, and arithmetic mean (±SD), skewness and kurtosis values of the biomotor variables of the research group are given in Table 1.

Table 1. Arithmetic mean (±SD), skewness and kurtosis values of the research group's age, anthropometric characteristics and biomotor variables.

Variables	n	Mean	SD	Skewness	Kurtosis
Age (year)	83	20.4	3.1	0.6	-0.8
Weight (kg)		75.5	16.6	1.0	1.5
Height (cm)		174.9	8.6	-0.2	-0.3
BMI (kg/m^2)		24.5	4.0	1.0	1.4
VO_2max (ml/kg/min)		54.1	4.7	-0.5	0.6
HG-dominant (kg)		48.1	9.1	0.2	0.4
HG-nondominant (kg)		46.2	9.0	-0.1	-0.3
Standing Long Jump (cm)		223.7	23.9	0.3	-0.1
SJ (cm)		33.85	4.5	-0.1	0.2
CMJ (cm)		36.09	4.8	-0.1	0.5
AP (watt)		982.6	205.3	0.7	1.4
30m speed (s)		4.358	0.171	0.2	0.4

Tests and Measurements

Anthropometry: The height of the research group was measured with a height meter in cm (Holtain/UK; accuracy between 50 mm to 570 mm). Body weights were measured in kilograms with a Tanita brand electronic scale. These data were also used in the calculation of body mass index.

Hand Grip: A hand grip dynamometer (Takei/Japan; accuracy of ±2.0kg) was used for grip strength. The measurement was made with the subject standing, without bending the arm, without contacting the body, and at an angle of 45º to the body. The same measurement method was repeated twice for the dominant and non-dominant arm, and the best value was recorded in kilograms.

Squat Jump: The squat jump (SJ) test was applied in the squat jump test, in which the explosive force characteristic of the leg muscles depending on the maximal strength, was measured in a squat position with the knees flexed at 90º and performing a full jump upwards while the hands were on the waist. In the active jump (CMJ) test, in addition to measuring the explosive strength of the leg muscles, the elastic force that affects the explosive force in jumping also comes into play. The active jump test was applied with the knees fully extended and upright by quickly kneeling and jumping vertically (Ateş, et all., 2007). Measurements of vertical jump tests were made using a jump mat (Smart Jump/Australia).
In determining anaerobic power, it was calculated in watts using the Lewis nomogram and the athletes' active jump heights and body weights.

$P = \sqrt{4.9} \times Weight \times \sqrt{D} \times 9.81$
P= Anaerobic Power (watts)
D=Vertical jump distance (m)
$\sqrt{}$ 4.9= Standard time

Standing Long Jump: The purpose of the standing long jump test, which is another test applied, is to measure the explosive strength of the leg extensor muscles of the athlete. It is one of the tests based on maximal anaerobic power (Ateş, 2007). Athletes stood behind a marked line, waited with their feet shoulder-width apart, and bent both hands simultaneously when ready. With the forward movement of the arms, they jumped towards the furthest distance and fell. The distance between the athlete's starting line and the furthest jump was taken as a basis for the evaluations, and the best score was noted by taking two attempts for each athlete.

Sprint Speed: In the speed test, the length of the running area has been determined as 30m. A sufficient distance beyond the

finish line is reserved as a stopping distance. The ground start, and finish lines are determined by a straight line. Start and finish line photocell (Smart speed/Australia) is placed. The starting and ending points are determined by signs (cone, etc.). The best scores of the athletes after two trials were evaluated.

Shuttle Run Test: A calibrated sound recording with 0.5 km/h increments of signal intervals per minute was used. Athletes were asked to touch the line at the end of 20m at each signal. When the signal came, the test was terminated for the athlete who could not reach the lines one meter before the lines determining 20m twice in a row (Tamer, 2000).

Purpose of the research: This study aims to compare the anthropometric characteristics and the biomotor ability variables of the athletes in boxing, taekwondo, and wrestling and examine the relationships of the research variables in terms of branches.

Research Group: A total of 83 male athletes who took part in the national teams participated in the research in boxing (n=28), wrestling (n=33) and taekwondo (n=22).

Data Collection: Participants' cardiovascular fitness, body composition, and physical and physiological fitness parameters were measured. All measurements were taken in the morning, between 8:30 a.m. and 11:30 a.m. The same researcher at the sports center administered the whole test program. The participants were asked not to consume excessive fatty foods or engage in strenuous activities. Participants were not given any specific nutritional program or food restriction during their training.

Analysis of Data: The mean and standard deviation values of the research group's age, anthropometric characteristics and biomotor variables were calculated. It was determined by the results of the kurtosis test (±2) that the research data showed a normal distribution (George, 2011). One-way analysis of variance (One-Way ANOVA) was performed to understand whether there were significant differences between the sports. Tukey's test (Post-Hoc Multiple Comparison) was used to determine which sports were among the variables with a significant difference. Pearson's correlation statistics were used to explain the relationships between variables; the interpretation of correlation coefficients was as follows: $r \leq 0.49$ weak relationship; $0.50 \leq r \leq 0.74$ moderate relationship; and $r \geq 0.75$ strong relationship (Portney, 2015). The significance level was accepted as 0.05 for all statistical analyses.

RESULTS

Table 2. Mean (±SD) values of age, anthropometric characteristics and biomotor variables of the research group according to sports branches.

Variables	**Taekwondo** (n=22)		**Boxing** (n=28)		**Wrestling** (n=33)	
	Mean	SD	Mean	SD	Mean	SD
Age (year)	20.3	3.0	20.7	3.1	20.2	3.3
Weight (kg)	74.0	9.8	73.7	17.5	78.1	19.2
Height (cm)	180.0	5.9	174.3	8.0	172.0	9.2
BMI (kg/m^2)	22.9	2.5	24.0	4.1	26.1	4.4
VO_2max (ml/kg/min)	54.0	3.5	55.4	4.8	52.9	5.1
HG-dominant (kg)	46.0	8.8	49.3	10.1	48.4	8.3
HG-nondominant (kg)	43.6	10.4	48.3	8.5	46.2	8.2
Standing Long Jump (cm)	234.9	21.1	205.5	18.1	231.8	21.2
SJ (cm)	37.18	3.51	32.92	4.83	32.42	3.71
CMJ (cm)	39.32	3.86	34.12	4.97	35.61	4.29
AP (watt)	1012.9	144.1	931.2	206.7	1005.9	234.2
30m speed (s)	4.286	0.142	4.358	0.166	4.405	0.180

When the demographic information of the research group is examined, it is seen that the average age is between 20.2 years and 20.7, and the average body weight varies between 73.7 kg and 78.1 kg, as can be seen in Table 2. Contrary to the average height values, an increase was found in the average body mass index values in taekwondo, boxing and wrestling rankings.

Table 3. ANOVA results of the differences between the sports of the values belonging to the research group.

Variables	**df**	**F**	**p**	**Significant differences**
Age (year)	2-80	0.178	0.838	-
Weight (kg)	2-80	0.650	0.525	-
Height (cm)	2-80	6.647	0.002*	Taekwondo-Boxing Taekwondo-Wrestling
BMI (kg/m^2)	2-80	4.923	0.010*	Taekwondo-Wrestling
VO_2max (ml/kg/min)	2-80	2.261	0.111	-
HG-dominant (kg)	2-80	0.877	0.420	-
HG-nondominant (kg)	2-80	1.736	0.183	-
Standing Long Jump (cm)	2-80	17.442	0.000*	Boxing-Taekwondo Boxing-Wrestling
SJ (cm)	2-80	10.091	0.000*	Taekwondo-Boxing Taekwondo-Wrestling
CMJ (cm)	2-80	8.834	0.000*	Taekwondo-Boxing Taekwondo-Wrestling
AP (watt)	2-80	1.341	0.267	-
30m speed (s)	2-80	3.369	0.039	Taekwondo-Wrestling

** p<0.05*

Table 3 shows significant differences between the athletes in taekwondo and boxing and between the athletes in taekwondo and wrestling in favor of taekwondo athletes regarding height variable. Regarding body mass index values, significant differences were found between the groups of athletes in taekwondo and wrestling in favor of wrestlers. No significant differences were observed for all groups in VO_2max values obtained from the 20m shuttle run test, in which aerobic abilities were determined. There was no significant difference between the groups regarding grip strength and anaerobic power abilities. When the groups were compared regarding sprint values, there were significant differences between the athletes in taekwondo and wrestling in favor of wrestlers. In the standing long jump test results, it was determined that the boxing group had significantly lower mean scores when compared to the other two groups. In the SJ and CMJ test values, significant differences were found in favor of taekwondo athletes compared to other groups.

Table 4. The relationship between the age variable and other parameters of the research group according to the sports.

	Combat Sports		Weight	BMI	VO_2max	HG-dominant	HG-non-dominant	SLJ	SJ	CMJ	AP
Age	Taekwondo	r	0.52*	0.44*	0.01	0.52*	0.59*	0.50*	0.38	.418	0.61*
		p	0.01	0.04	0.98	.013	0.00	0.02	0.08	.053	0.00
	Boxing	r	-0.00	0.04	0.15	-0.01	-0.03	-0.10	0.04	0.08	0.03
		p	0.98	0.84	0.46	0.98	0.89	0.61	0.85	0.69	0.87
	Wrestling	r	0.44*	0.64*	-0.55*	0.33	0.09	0.44*	0.49*	0.46*	0.57*
		p	0.01	0.00	0.00	0.06	0.62	0.01	0.00	0.01	0.00

** p<0.05*

Table 5. The relationships between the resilience abilities of the research group according to the sports and other parameters.

Combat Sports			Weight	BMI	SLJ	SJ	CMJ	30m speed	AP
VO_2max	Taekwondo	r	0.09	-0.09	-0.07	0.06	-0.03	-0.07	0.08
		p	0.68	0.69	0.75	0.79	0.88	0.76	0.73
	Boxing	r	-0.48*	-0.51*	0.66*	0.45*	0.46*	-0.45*	-0.33
		p	0.01	0.01	0.00	0.02	0.01	0.02	0.09
	Wrestling	r	-0.55**	-0.64*	-0.07	-0.07	-0.01	-0.30	-0.58*
		p	0.00	0.00	0.71	0.68	0.97	0.09	0.00

** p<0.05*

It is seen in Table 4 that as the age of the wrestling athletes increased, a low and moderate increase was observed in body weight, BMI values, horizontal and vertical jumping abilities and AP values. It was understood that resilience abilities showed a decreasing relationship with increasing age (r=-0.55, p<0.05). Statistically significant, positive, low and moderate relationships were found between the ages of the athletes in the taekwondo and their body weight, BMI values, grip strength, standing long jump and anaerobic power abilities. It can be said that these abilities of athletes develop as they get older. There was no relationship between the ages of the boxing athletes and any variable evaluated within the scope of the research.

In Table 5, where the relationships between the endurance abilities of the athletes and other variables were examined, no relationship was found between the endurance abilities of the athletes in taekwondo. As the body weights and BMI index values of other sports athletes increase, it is understood from the low and moderate negative correlation between the variables that their endurance abilities decrease. This situation is also observed in wrestlers as endurance abilities decrease in athletes whose AP values increase (r=-0.58, p<0.05). It has been observed that the horizontal and vertical jump and sprint performances in boxers have moderate and low correlations with endurance abilities.

When Table 6 is considered, there were moderate and high correlations between the AP power values of the athletes in all three sports and their grip strength. While a high correlation was found between the grip strength of both hands and the AP of the boxing athletes, a high correlation was found between the AP values of the athletes in the taekwondo and wrestling and their dominant hand and a moderate relationship was observed between the non-dominant hands.

Table 6. The relationship between the AP variable and grip strength values of the research group according to the sports.

	Combat Sports		HG-dominant	HG-non-dominant
AP	Taekwondo	r	0.77*	0.69*
		p	0.00	0.00
	Boxing	r	0.84*	0.81*
		p	0.00	0.00
	Wrestling	r	0.83*	0.73*
		p	0.00	0.00

** p<0.05*

Table 7. The relationship between the AP variable and grip strength values of the research group according to the sports.

Combat Sports			VO_2max	SLJ	SJ	CMJ
30m speed	Taekwondo	r	-0.07	-0.46*	-0.60*	-0.56*
		p	0.76	0.03	0.00	0.01
	Boxing	r	-0.45*	-0.43*	-0.55*	-0.67*
		p	0.02	0.02	0.00	0.00
	Wrestling	r	-0.30	-0.61**	-0.52*	-0.58*
		p	0.09	0.00	0.00	0.00

** p<0.05*

Table 7 indicates that the speed performances of the wrestlers were moderately related to their horizontal and vertical jumping abilities. In boxing and taekwondo, low-level correlations were found with horizontal and moderate correlations with vertical jumping abilities.

DISCUSSION

At this stage, the findings obtained from the research were discussed and interpreted in line with the literature. The current study aims to compare specific parameters (standing long jump, SJ, CMJ, etc.) for the lower and upper extremities of the national athletes of different martial arts. According to the results, there are significant differences between the athletes in taekwondo and boxing and between the athletes in taekwondo and wrestling in favor of taekwondo athletes regarding height variable. Kazemi et al. (2010) found in their study that taekwondo players were taller than men and even found a significant difference in the height of the winners.

They have also included in their research that they can be advantageous with more energy generation since they have longer upper and lower extremities specific to the branch compared to other sports (Kazemi, 2010)). Regarding body mass index values, significant differences were found between the groups of athletes in taekwondo and wrestling. Bridge et al. (Bridge, 2014) reported that body mass index is also among the determining factors in determining the performance level of taekwondo athletes, and it is a distinguishing factor compared to other sports (Bridge, 2014). In another study, it was reported that taekwondo athletes have an important parameter in terms of the target and severity of the kick due to the high relationship between body composition and kicking performance (Tasiopoulos, 2015).

In this respect, the findings corroborate with the literature, as it has a relative structure in terms of body straightness depending on height compared to other sports and has a variable structure according to boxing and wrestling, and differs due to kick performance, which is among the technical factors specific to the sport. On the other hand, in different studies conducted by Özsoy et al. (2018) the average height (cm) of the athletes of the study on the national team athletes during the European championship was 1.80±6.6 cm, while the average BMI (kg/m^2) was 22.99±2.5 kg/m2 , in this study, it is seen that the average height of taekwondo athletes is 180.0±5.6 cm, and the average BMI (kg/m^2) is 22.9±2.5 kg/m^2. In light of the data obtained, the difference in body composition of taekwondo athletes compared to boxing and wrestling athletes, it can be said that it is important to consider that athletes should have a specific body structure or height in order to perform optimally and in this respect, they should be included in the body mass index depending on a body composition that supports their height. The findings are in parallel with the literature.

The similarity was observed for all groups in VO_2max values obtained from the 20m shuttle run test, in which aerobic power was determined. Aerobic power is an important factor in the ability of both high-level and normal threshold athletes to resist fatigue during training and competition, the level of endurance and the rapid recovery of the athlete after the activity and also plays an import ant role in this process (Prampero and Pietro, 2003). The results show similarities with the VO_2 values of the study by Mathunjwa et al. (2017) on combat sports athletes. In the study of Bridge et al. (2014), where the VO_2max capacities of taekwondo athletes were examined, VO_2max was 54.59 ml/kg/min for the national taekwondo athletes; on the other hand, Kim et al. (2021) found VO_2max capacities of elite male taekwondo athletes as 52.0 ml/kg/min.

In this study, VO_2max (ml/kg/min) value is 54. ±03.5 ml/kg/min in taekwondo athletes, 55.4±4.8 ml/kg/min in boxers, and 52.9±5.1 ml in wrestling athletes. It was found as /kg/min. Heller et al. (1998) found the VO_2 max value as 53.9 ml/kg/min in the study they conducted on Czech national team male taekwondo players, while Pieter found it to be 55.8 in athletes in the American Olympic taekwondo team. It was found as ml/kg/min (Aziz, at all., 2002). In recent studies, Kim et al. (2021) found in their study on elite male taekwondo players that the aerobic power of the athletes was 52.0 ml/kg/min. In their study, Aydaş et al. (2002) found that the aerobic power average of the A national boxing team was 52,916±4,844 ml/kg/min. Chaabène et al. (2015) obtained similar results with VO_2 max values in their study on amateur boxers. Horswill (1992), in his research, gave the VO_2max value for wrestlers as 52-63 ml/kg/min. Yoon (2002) stated that the 1988 Seoul Olympic Games wrestlers had a VO_2max capacity of 60-70 ml/kg/min. While the results of this study show parallelism with the literature, due to the similarity of sports with intermittent recovery periods that include high-intensity activities in all three sports, the development of aerobic capacity and aerobic power of athletes during and after training, and the rapid increase in blood lactate concentration result from high-intensity activities during competitions. It can be said that it plays an active role in the similarity in VO_2max values.

HG-dominant (kg) / HG non-dominant (kg) values obtained from the handgrip strength test (HSGT), in which hand grip strength was determined, were similar for all groups. In this study, the HG-dominant (kg) value was 46.0±8.8 kg in taekwondo athletes, 49.3±10.1 kg in boxing athletes and 48.4±8.3 kg in wrestling athletes. The HG non-dominant (kg) value was 43.6±10.4 kg in taekwondo athletes, 48.3±8.5 kg in boxing athletes and 46.2±8.2 kg in wrestling athletes. The techniques applied in taekwondo must be sufficiently strong to be effective and get points. Even in the kyorugi branch, the arm technique must be applied very strongly for the knockdown. While Ghorbanzadehkoshi (2009) stated in his study that taekwondo players should have a good level of arm strength specific to the branch, in terms of wrestling, hand grip strength is closely related to all other strength parameters and continuity in strength determines high-level wrestling performance. Accordingly, trunk stability, which reflects the strength of the performance towards the hand region, is affected by functional mobility and upper extremity balance (Chaabène, et all., 2017).

In boxing, the sport's basic movements emerge with hand muscles consisting of fist variations. It is important to use the punch and the target-oriented techniques of the punch equally in both training and competitions. Information has been obtained that punch-based techniques will increase balance, strength, and endurance. It can be said that it can positively affect the aerobic and anaerobic performance of the athletes in boxing competitions, where sportive performance is displayed in competition environments and where there is a struggle for technical superiority for minutes (Guidetti, et all., 2002). For all three sports, the reason for the lack of a

significant difference despite the differences in the styles of training specific to the sports may be related to the fact that the participants in the research group are composed of highly trained athletes, and it is thought that the athletes of these three sports actively use both their dominant and non-dominant hands both in training and competitions.

When the sports were compared in terms of SJ and CMJ test values, significant differences were found between taekwondo and boxing, taekwondo and wrestling in terms of taekwondo athletes. Finding similar values to the data obtained in the study of Singh et al. (2015) on different sports supports this study. Moreover, anaerobic power and muscle structure related to jumping performance are considered important in taekwondo, as it consists of explosive and short-term combined movement forms where jumping techniques are frequently applied in training and competitions (Franchini, et all., 2012). It should be noted that specific taekwondo training performed to generate power within the muscle contraction-muscle stretching cycle due to vertical jumping is also important in power generation.

On the other hand, muscular anaerobic power, which is defined as the ability to generate a large amount of power in a short time unit in boxing, is one of the main factors of success for sports that fall into the highly dynamic and static group such as boxing (Purcell, 2011). While it is thought that it affects the horizontal jump values since it is an anaerobic-based sport, it is predicted by the researchers that the jump force is directly related to the general muscle strength structure of boxing and is a determining criterion in performance (Cochrane, et all., 2004&Zileli and Söyler, 2018). The increase in the jumping abilities of the elite taekwondo players depending on the type of sport created creates the thought that this sport is the gains of this branch, while it is thought that the exercises for the leg strength and power abilities in the training play a role in the formation of this effect after the training in boxing. On the other hand, when wrestling is evaluated in terms of the jump, Garcia-Pallares et al. (2011) reported that the anaerobic power of elite wrestlers provides an advantage in performing the techniques and maintaining the necessary frequent and strong muscle contractions during the wrestling match. Yoon (2002) stated that the general physiological characteristics that elite wrestlers should have should be high anaerobic power and capacity and high muscular endurance. Nikooie et al. (Nikooie, 2015) reported that it is important to have a high level of forearm and hand flexor musculature activity in many wrestling functions and maneuvers, such as grasping the opponent's extremities and controlling their movements.

In wrestling, maximal anaerobic power requirement, throwing and shaking the opponent, making fast, hard attacks against the opponent, and sudden dives are important in developing fast-short-term and explosive movements. When we look at the data obtained from this study, the fact that wrestling is behind compared to other branches can be considered as a decrease in efficiency in vertical jump due to weight difference, more power expenditure due to body weight and power requirement. In this study, the speed of 30 meters was 4.28±0.14 seconds for taekwondo athletes, 4.35±0.16 seconds for boxing athletes, and 4.40±0.18 seconds for wrestling athletes. Accordingly, significant differences were found between taekwondo and wrestling athletes in the direction of taekwondo athletes. Pal et al. (2021) showed that 6-week plyometric exercises increased the sprint scores of the participants in a study conducted with 36 karate students whose average age was 16. Data from the literature also support this study.

On the other hand, it has been determined that the maximum speed and quickness performances of taekwondo athletes are in the range of 0-5 seconds, and this performance has a significant relationship with the maximum kick speed and quickness. While these results confirm that taekwondo-specific maximum speed and quickness should be measured with taekwondo-specific methods, it also shows that the effect of competition-specific field area on performance should be measured with special methods in the same way (Mirzaei, et all., 2011). On the other hand, in wrestling, the fact that the wrestlers are fast and agile in the competitions allows the wrestling techniques to be performed quickly. In his study, Saygın (2014) did not find a significant difference in the measurements of 30m sprint ability between the weights, but he found it to be 4.68± .42 seconds on average in sprint times. The data related to the literature support this study, which was done similarly.

An evaluation was made for both sports since both taekwondo and wrestling, especially wrestling, are sports that take place at a very high tempo, the fact that the competition areas are close in size, they work at different degrees depending on all energy systems and the energy demands already exist in the body. While wrestling produces more energy from the anaerobic system than taekwondo, it also consumes more energy (Bridge, 2009). Taekwondo is in the foreground compared to wrestling in movements that require rapid and explosive movements (Vávrová, 2021). In light of the data obtained, it is thought that there are significant differences in the sprint parameter due to different training drills, different body structures and sport-specific factors. It can be said that the individual effort capacities and physical characteristics of the wrestlers (height, body weight) and the weight factor also cause differences.

Conclusions: While the results of this study show parallelism with some studies in the literature, they differ from the results of some studies. These differences were found in age, number of groups, sports and training level in favor of taekwondo athletes. It is thought that this is due to the branch-specific movements and training method of taekwondo sport. Also, not only individual capacities such as height and body weight cause physiological and neuromuscular differences but also the athlete's VO_2max, regardless of being a fighter or any other sport. Determining the physical and physiological characteristics of the athletes in national-level boxing, taekwondo and wrestling can contribute to future research.

***Ethics Consideration**: In this article, during the research process, journal writing rules, publication principles, research and publication ethics rules, journal ethics rules were followed. Responsibility for any violations that may arise regarding the article belongs to the author. Ethical approval for this study was obtained from Bingöl University Ethics Evaluation Committee, (104082-10.04.2023) and the study was conducted following the World Medical Association Declaration of Helsinki.*

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GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı: Bu çalışma üç farklı mücadele sporcundaki sporcuların antropometrik özellikleri ile biyomotor yeti değişkenlerinin karşılaştırılması, araştırma değişkenlerinin ilişkilerinin branşlar özelinde incelenmesini amaçlamaktadır.

Literatür Araştırması: Boks, taekwondo ve güreş branşlarının da dahil olduğu mücadele sporlarının amacı, kuvvet gelişimi yönünden bedeni ve ruhu iyi yönde geliştirmek, savunma sanatlarının eğitimini almaktır. Her biri ayrı kurallara sahip olan bu branşların bir savunma sanatı olması ve içeriğinde fiziksel antrenman yoğunluğu ile zihinsel kontrol tekniklerini içeren farklı faaliyetleri içermesinden dolayı bazı farklılıklar görülmektedir (Purcell ve Leblanc, 2012).

Birbiri ile pozitif ilişkili olan üst ve alt ekstremite kas kuvveti boksörün performansının gelişimini sağlayan en önemli faktörlerden birisi olup (Chaabene ve diğ., 2015), yapılan antrenmanlar sonrasında meydana gelen anaerobik güç, kas kuvveti dayanıklılığı, esneklik, el ve göz kordinasyonu, ayak oyunları, çabukluk ve reflekslerde gelişme sağladığı görülmektedir (Çakmakçı, 2002). Aynı zamanda vücut kompozisyonuna göre erkek ve kadınlarda 12-19 yaş arasına kadar geçen süredeki değişkenler özellikle vücut ağırlığında meydana gelen artış kuvveti de etkilerken, bu değişim 30 yaşına kadar yavaş düzeyde devam etmekte ve 30'lu yaşlardan sonra azalmaktadır (Çınar, 2011).

Uzun Süreli Sporcu Gelişim programlarında ise elit sporda başarı arayışlarının bir uzantısı olarak "Uzun Süreli Sporcu Geliştirme Modelleri" son yıllarda birçok ülkede yoğun bir uygulama alanı oluşturmuştur. Yaygın bir düşünce olarak sporda başarılı birçok ülkenin etkili olarak uyguladığı "Yetenek Modelleri" veya son yıllarda daha yaygın olarak kullanılan "Uzun Süreli Sporcu Geliştirme Modeli (LTAD)"ne göre; boks branşında katılım: spora başlama yaşı 13-15,özelleşme: 16-17, gelişim: 22-26, Güreş branşına katılım: spora başlama yaşı 11-13, özelleşme: 17-19, gelişim: 24-27, taekwondo branşında ise katılım: spora başlama yaşı: 11-13, özelleşme: 16-18 gelişim: 24-27 olduğu görülmektedir.

Üç branşta da LTAD evrelerinin yakın yaş aralığında olduğu görülmektedir (Açıkada ve Hazır, 2016). Mevcut çalışma kapsamında branşlardaki Türk spor tarihindeki olimpik başarılarımız incelendiğinde; boks branşında 1 altın, 3 gümüş, 3 bronz madalya, güreş branşında 29 altın, 18 gümüş, 19 bronz madalya, taekwondo branşında 1 altın, 3 gümüş ve 5 bronz madalya kazanıldığı görülmektedir. Ata sporumuz olan güreş branşında Olimpiyat oyunları tarihinde kazanılan toplamda 66 madalya ile üst düzey sporculara sahip en başarılı spor branşımız olduğunun da altının çizilmesi gerektiği düşünülmektedir.

Yöntem: Araştırmaya milli takımlarda görev alan Boks (n=28), Güreş (n=33) ve Taekwondo (n=22) branşlarında toplam 83 erkek sporcu katılmıştır. Sporcuların antropometrik özelliklerinin belirlenmesi için boy uzunlukları, vücut ağırlıkları ölçülmüş ve bu veriler kullanılarak vücut kütle indeksleri hesaplanmıştır. Aerobik yetilerinin belirlenmesi için 20 m. mekik koşu testi kullanılarak endirekt VO2max değerleri elde edilmiştir. Kuvvet düzeylerinin tespit edilmesi için kavrama kuvveti testi, sıçrama yetilerinin belirlenmesinde squat sıçrama, aktif sıçrama ve durarak uzun atlama kullanılmıştır. Anerobik güç yetilerinin belirlenmesinde Levis nomogramı ile aktif sıçrama ve vücut ağırlıkları kullanılarak watt cinsinden hesaplama yapılmıştır. Sürat yetilerinin tespit edilmesinde 30 metre sürat koşu testi uygulanmıştır. Araştırma grubunun tümüne ait ölçüm değerleri Tablo 1'de verilmiştir.

Araştırma grubunun boy uzunlukları Holtain marka boy ölçer ile cm. cinsinden ve vücut ağırlıkları ise Tanita marka elektronik baskül ile kilogram cinsinden ölçülmüştür. Vücut kütle indeksi hesaplamasında da bu veriler kullanılmıştır.

Kavrama kuvveti için el dinamometresi (Hand Grip- Holtain) kullanıldı. Ölçüm sırasında denek ayakta olacak şekilde kolu bükmeden, vücuda temas ettirmeden ve vücuda 45 derece açılı bir şekilde ölçüm yapıldı. Aynı ölçüm metodu dominant ve nondominant kol için iki defa tekrar edildi, en iyi değer kilogram olarak kaydedilmiştir.

Squat sıçrama (SJ) testi, bacak kaslarının maksimal kuvvete bağlı olarak sergilediği patlayıcı kuvvet özelliğinin ölçüldüğü squat sıçrama testinde, dizler 90o fleksiyonda squat pozisyonunda ve eller belde iken yukarı doğru olarak tam bir sıçrama gerçekleştirme şeklinde uygulanmıştır (Açıkada ve diğ., 2003). Aktif sıçrama (CMJ) testinde de bacak kaslarının patlayıcı kuvvet özelliği ölçülmesinin yanı sıra sıçramada patlayıcı kuvveti etkileyen elastik kuvvet özelliği de devreye girmektedir. Aktif sıçrama testi, dizler tam olarak ekstensiyonda ve dik pozisyonda iken dizlerden hızla çöküp dikey olarak sıçramasıyla uygulanmıştır (Açıkada ve diğ., 2003). Dikey sıçrama testlerinin ölçümleri sıçrama matı (Smart Jump/ Avustralya) kullanılarak yapıldı.

Sporcular işaretlenmiş bir çizginin gerisinde ayakta durup, ayaklarını omuz genişliğinde açarak beklemiş, hazır olduğunda her iki elini geriye doğru alırken dizlerini de aynı anda bükmüştür. Kolların ileri hareketi ile birlikte, en uzak mesafeye, doğru sıçrayıp düşmüştür. Sporcunun, başlangıç çizgisi ile sıçradığı en uzak mesafe arasındaki uzunluk değerlendirmelere esas alınmış, her sporcu için iki deneme alınarak en iyi derece not edilmiştir.

Sürat testinde koşu alanının uzunluğu 30 m. olarak belirlenmiştir. Durma mesafesi olarak bitiş çizgisinden öteye yeterli bir mesafe ayrılmıştır. Zemin başlangıç ve bitiş çizgileri düz bir hatla belirlenmiştir. Başlangıç ve bitiş çizgisi fotosel (Smart speed - Avustralya) yerleştirilmiştir. Ayrıca başlangıç ve bitiş noktaları işaretlerle (koni vs.) belirlenmiştir. Sporcuların iki deneme sonrasındaki en iyi dereceleri değerlendirmeye alınmıştır.

Mekik Koşusu Testi için sinyal aralarının her bir dakika- da 0.5 km/s artan kalibre edilmiş ses kaydı kullanılmıştır. Sporculardan her sinyalde 20 m'nin sonundaki çizgiye temas etmeleri istenmiştir. Sinyal geldiğinde 20 m'yi belirleyen çizgilerin bir metre önündeki çizgilere iki kez üst üste ulaşamayan sporcu için test sonlandırılmıştır (Tamer, 2000).

Sonuç ve Değerlendirme: Yapılan bu çalışmanın sonuçları literatürdeki bazı çalışmalarla paralellik gösterirken bazı çalışma sonuçlarından farklıdır. Bu farklılık, yaş, grup sayısı, branş ve antrenman düzeyi gibi nedenlerden kaynaklanabilir ama taekwondo sporcularının; bazı parametrelerde daha başarılı oldukları görülmüştür. Bunun sebebinin taekwondo sporunun branşa özgü hareketlerinden ve antrenman metodundan kaynaklandığı düşünülmektedir. Milli takım seviyesinde boks, taekwondo ve güreş erkek takımlarında yer alan sporcuların fiziksel ve fizyolojik özelliklerinin belirlenmesinin, ülkemizde milli takımlar seviyesinde farklı yaş grubundaki savunma sporları üzerine yapılacak araştırmalara ve sporcuların ileriki yıllarda tekrar test edilmesi neticesinde elde edilecek verilerle fizyolojik kıyas oluşturmasına yardımcı olacağı düşünülmektedir.