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Comparison of Physical and Physiological Profiles Between Elite Freestyle Men and Women Wrestlers

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Abstract: This study aims to compare the physical and physiological profiles between elite men and women wrestlers of free style category. The research group consist of twenty-nine men and twenty-one women freestyle wrestlers who camped for performance tests at the Turkish Olympic Preparation Center in Ankara 2 months before the European Wrestling Championship in Budapest on March 28-April 3, 2022. Subjects performed the leg and arm Wingate anaerobic test (anaerobic power and capacity), VO_{2max} (aerobic endurance), Reactive agility, isokinetic and isometric strength test. The results showed that Lower Extremity anaerobic power obtained from men, knee flexor at VO_{2max}, 60°/s and 180°/s peak torque, isometric force values of arm and trunk extensor muscles, are higher than in women ($p<0.05$). In contrast, upper extremity anaerobic power values seem to be similar ($p>0.05$). As a result, it can be said that the endurance capacity, isometric, and isokinetic strength parameters are more effective than the force parameter in gender. These results can be used by coaches, strength and conditioning specialists, and sport scientists to create a comprehensive physical and physiological profile of wrestlers that will help them adapt their training programs.

Keywords: anaerobic power; aerobic power; isokinetic strength; isometric strength; reactive agility.

1. Introduction

Men Olympic wrestling has a long history around the world and has been a component of the modern Olympic Games since its founding in 1896.(Chaabene et al., 2017). It was originally included in a World Championship held by the International Federation of Associated Wrestling Styles in 1987 (FILA). However, it was not on the Olympic program until the games were held in Athens in 2004 (Pallarés, López-Gullón, Torres-Bonete, & Izquierdo, 2012). In addition, while the Olympic Games program acknowledges two different forms of wrestling for men (namely, Greco-Roman and Freestyle), only Freestyle is featured in the Olympic program for women. Since female wrestling was included in the Olympic Games in 2004, it has gained popularity. This may be the reason behind the increased focus that the scientific community has placed on female wrestlers over the past ten years(Hamilton, van Anders, Cox, & Watson, 2009; Hübner-Wozniak, Kosmol, Lutoslawska, & Bem, 2004; Zi-Hong et al., 2013). In addition, the changes to the regulations that have taken place over the past ten years (for example, the length of the match, the criteria for judging, and the weight categories in the Olympic Games) may, without a doubt, affect the physical and physiological demands of the match (Chaabene et al., 2017).

Due to the trend of modern wrestling to increase the intensity of wrestling bouts, particular endurance has become an increasingly important factor in judging the quality of a sport. A very high level of endurance capacities is required in order to do a large number of actions (activities) related to quickly overcoming an opponent's resistance and increasing it, as well as the capacity to surprise an opponent and to force one to react in a short amount of time (Kruszewski, Cherkashin, Kruszewski, Cherkashina, & Tomczak, 2021; Pallarés et al., 2012). In terms of sporting regulations, freestyle wrestling and female wrestling are equivalent. In both female and male freestyle wrestling, using the legs to execute technical activities and executing acts on the opponent's legs is permitted. As a result, both men and women have the same number of technical resources and the ability to deploy strategies to gain an advantage and win. Furthermore, for both genders, tactical preparation for a match against high-level athletes can be identical (Kruszewski et al., 2021).

Investigating the differences in performance variables between genders in wrestling; is essential for trainers and researchers. It is known that women exhibit various anatomical and physiological differences compared to men, and these differences are significant when examining physiological reactions to exercise. When the literature is examined to summarize the gender differences in performance in general, men have higher absolute muscle strength than women in various muscle groups and different exercise conditions and produce higher power output than women (Falgairette, Billaut, Giacomoni, Ramdani, & Boyadjian, 2004; Krivickas et al., 2001). It was also determined that men's lean body mass and muscle cross-sectional areas were significantly higher than those of women, and the muscle cross-sectional areas of women corresponded to approximately 75% of those of men (Hazir & Kosar, 2007).

However, some researchers found that a female muscle had a longer endurance time than a male muscle; in other words, it shows more excellent fatigue resistance and can recover faster (Clark, Manini, Thé, Doldo, & Ploutz-Snyder, 2003; Semmler, Kutzscher, & Enoka, 1999). It describes the differences in strength, power production, and fatigue resistance between the genders as well as the morphological, metabolic, and neuromuscular characteristics of muscle tissue. In studies related to wrestling, researchers mainly examined the performance variables, fatigue, and recovery processes of freestyle and Greco-Roman style athletes in different age groups (Demirkan, Koz, Kutlu, & Favre, 2015; García-Pallarés, López-Gullón, Muriel, Díaz, & Izquierdo, 2011; Zi-Hong et al., 2013). Experimental studies are needed on the effect of the gender factor on these protocols in creating training strategies. Therefore, this study aims to compare the physical and physiological profiles of elite freestyle men and women wrestlers.

2. Materials and Methods

This study was designed to compare strength, power, endurance, and reactive agility tests of elite wrestlers of free style category in relation to gender and to examine the effect of gender factor on these protocols in the creation of training strategies.

In our study design, we included 29 men and 21 women freestyle wrestlers who camped for performance tests at the Turkish Olympic Preparation Center in Ankara 2 months before the European Wrestling Championship in Budapest on March 28-April 3, 2022.

At the start of the study, wrestlers participated in a familiarization session and had the chance to complete the tests while exerting less than their maximum effort. Then, the tests were divided into 5 groups:

(a) Aerobic Endurance (VO2max)

(b) Anaerobic Power

(c) Reactive Agility

(d) Isokinetic strength test

(e) Isometric strength test

The tests were performed between at 9:00 and 11:00 am, and throughout the course of the study, wrestlers adhered to identical eating regimens set up by their dietician. They were also prohibited from using any supplements during this time or engaging in any vigorous exercise within 24 hours prior to the testing days.

Wrestlers were verbally urged to perform at their best during the tests (Figure 1).

Subjects - All the freestyle wrestlers (29 men and 21 women) were selected for the European Wrestling Championship training camp in Budapest on March 28-April 3, 2022. In this research wrestling's designed in accordance with their body weight (light, middle, and heavy weight), wrestlers were divided into 3 categories as follows: light weight (9 men body mass ranged between 59 and 66 kg – 7 women body mass ranged between 49 and 57), middle weight (10 men body mass ranged between 70 and 88 kg-7 women body mass ranged between 57 and 62), heavy weight (10 men body mass ranged between 89 and 118 kg-7 women body mass ranged between 63 and 78). The research protocol was approved by the ethics committee of Ankara Gazi University (E-77082166-604.01.02-358641). Descriptive physical characteristics for each group are presented in Table 1.

Figure 1. Study Design

1st day	Familiarization
2nd day	The measurement of physical characteristics and VO2max Test
	Reactive Agility
3rd day	Wingate Leg Test
	Wingate Arm Crank Test
4th day	Isokinetic strength test
	Isometric strength test
A rest period of 48 hours was included between the testing days. Tests were performed in the mornings and afternoons when two tests were applied.	

Table 1. Physical characteristic of elite free style men and women wrestlers in the 3 weight classes.

	Light weight		Middle weight		Heavy weight	
	Men	Women	Men	Women	Men	Women
Age	26,5 ± 4,5	22,3 ± 3,3	25,7 ± 3,6†	20,5 ± 2,5†	25,8 ± 2,5‡	21,8 ± 3,2‡
Body height (cm)	166,8 ± 2,3*	156,7 ± 6*	172,6 ± 5,5†	160,2 ± 2,1†	179,5 ± 4,5‡	168,5 ± 5,5‡
Body mass (kg)	63,9 ± 2,4*	53,3 ± 2,4*	79,1 ± 6,1†	60,2 ± 2,1†	99,0 ± 10,1‡	71,4 ± 5,8‡
Fat %	8,5 ± 3,4*	14,9 ± 4,4*	13,0 ± 3,4†	19,6 ± 3,7†	17,9 ± 4,8‡	23,6 ± 4,0‡
Fat Mass (kg)	5,5 ± 2,3*	7,9 ± 2,2*	10,4 ± 3,2	11,8 ± 2,4	18,4 ± 7,0	17,0 ± 4,2
Fat Free Mass (kg)	58,4 ± 2,1*	45,3 ± 3,8*	68,7 ± 4,1†	48,3 ± 2,2†	80,8 ± 4,5‡	54,3 ± 2,2‡
Muscle Mass (kg)	55,5 ± 2*	43,0 ± 3,6*	65,3 ± 3,9†	45,9 ± 2,1†	76,9 ± 4,3‡	51,6 ± 2,1‡
BMI (kg.m^2)	22,9 ± 0,5	21,7 ± 1,5	26,5 ± 1,6†	23,5 ± 1,4†	30,7 ± 2,8‡	25,1 ± 1,5‡
Training experience (years)	13,8 ±5,2*	7,4 ±3,7*	14,8 ± 3,6†	6,9 ± 1,6†	14,9 ± 3‡	9,1 ± 4,1‡

BMI: Body mass index.* $p < 0.05$, significant differences compared with light-weight wrestlers; † $p < 0.05$, significant differences compared with middle-weight wrestlers; ‡ $p < 0.05$, significant differences compared with heavy-weight wrestlers

Methodology - Physical Characteristics - Body mass (BM), body fat percentage (Fat %), fat free mass FFM (kg) were measured using the bioelectrical impedance analysis method (BIA) (MC 980, Tanita Corp.,1000 kHz, Japan) after 12 hours of fasting. With the help of hand and foot electrodes in the device, the electric current passing through the body provides a comprehensive body analysis.

Aerobic Endurance (VO2max) Test - Oxygen consumption (VO2) was measured with a mobile cardiopulmonary exercise test (Cosmed K5, Italy Serial No: 2019030706) system, which is capable of automatic gas analysis from each expiratory air, with a ramp protocol (Scheer, Ramme, Reinsberger, & Heitkamp, 2018) on the treadmill. The portable metabolic gas analyzer was calibrated using a sample of recognized gases (5.0% CO_2 and 16.0% O_2) before each test. To eliminate the negative effects of room conditions on performance and oxygen consumption data during the tests carried out in the laboratory environment, the temperature was 18-23°C and the relative humidity was below 70% with air conditioners (Tanner & Gore, 2012).

Anaerobic Power and Capacity Tests - On an adjustable Monark cycle ergometer, the subjects completed 30-second Wingate anaerobic tests in both legs and arms to test anaerobic power and capacity (Model 894-E, Stockholm, Sweden). For each subject, the Wingate leg test included maximum cycling in a standing body posture against a resistance load of 75 g·kg-1 BM, whereas the Wingate arm crank test included maximal cycling in a standing body posture against a resistance load of 55 g·kg-1 BM. Wrestlers warmed up in the first part by cycling at 60–70 rpm for 5 minutes, followed by three all-out sprints in the last 5 seconds of the last 3 minutes. The subjects were then given a 5-minute passive rest time. The Wingate testing performed 30 seconds. At the order "start," subjects began pedaling against the predetermined workloads and were directed to quickly attain maximal pedaling speed. The peak power (PP) in watts—the maximum power ever recorded during any 5-second interval—was computed, together with the mean power (MP) and fatigue index during the 30-second period. Additionally, BM-related relative values were computed.

Reactive agility test - The reactive agility test was evaluated with the SpeedCourt™ system (Düking, Born, & Sperlich, 2016). The SpeedCourt system consists of a square area (6.20x6.20 m) with a screen and 10 pressure sensors. Pressure sensors are arranged in 50x50 cm squares in the field. During the test, the entire area and 10 pressure sensors are shown on the screen. Each pressure sensor detects a minimum force of 150 Newtons and contact times are determined in milliseconds. With the countdown, the test starts and the pressure sensors in the square area randomly turn white on the screen. Subject must run to the sensor with a white light and touch it with their feet. As soon as the subject touches a square, another random sensor lights up white and the athlete must run towards the white sensor as soon as possible and touch it with her foot.

Isokinetic strength test - The IsoMed 2000 isokinetic dynamometer was utilized to perform a bilateral assessment of the isokinetic strength of the knee flexors and extensors (Dirnberger, Wiesinger, Kösters, & Müller, 2012). Dirnberger et al. (2012) provided evidence that substantiated the validity of the measurements (Dirnberger et al., 2012). Before beginning the actual test, the subjects completed a general warm-up on a stationary bicycle ergometer for a period of six minutes at an intensity level that was self-regulated between low and moderate. Wrestlers were then positioned in a relaxed position on an adjustable dynamometer chair with their hip joints at an angle of approximately 75 degrees (where 0 degrees represents full extension). Shoulder pads were used to secure the shoulders in both the ventral-dorsal and cranial-caudal directions. Straps were used to secure the pelvis and the thigh of the right leg, which was tested first. While the athletes were seated, they were held in place by a shoulder apparatus that was placed over their shoulders as well as stabilization bands that were wrapped around their waists and distal femurs. Wrestlers were observed while seated, and the lateral condyle of the femur was used as the pivot point for the evaluations. The range of motion (ROM) for the test was set from 0 degrees of full knee extension to a maximum of 90 degrees of knee flexion. Five flexion/extension exercises at 60º/s angular velocity and fifteen flexion/extension exercises at180º/s angular velocity were used to assess the strength of the dominant and non-dominant side knee flexor/extensor muscles. For the warm-up and practice in the assessment, three flexion/extension exercises were performed before each angular velocity. The dominant right side was assessed first, followed by the non-dominant left side after 3 minutes. Peak Torque and Peak Torque / Bodyweight data for knee flexor and extensor muscles were recorded because of the evaluation and used in statistical analysis. The strength of the identical muscle groups in the dominant and non-dominant extremities was compared using the Limb Symmetry Index (LSI) (dominant extremity muscle strength/non-dominant extremity muscle strength 100). Athletes were defined as symmetric between two extremities with a maximum difference of 10% in paired comparisons using this index. Asymmetry was defined as a discrepancy of more than ten percent (Steidl-Müller, Hildebrandt, Müller, Fink, & Raschner, 2018). In addition, the Conventional Ratio (CR) was calculated and recorded, which is defined as the flexor/extensor muscle strength ratio of the same leg. The normal CR at 60º/s angular velocity was reported to be between 50–60%, while the normal CR at 180º/s angular velocity was reported to be between 60–65%, according to this ratio (Houweling, Head, & Hamzeh, 2009). The device calculated the LSI and CR automatically.

Isometric strength test - The DIERS-Myoline Isometric Muscular Strength Analysis System was used to evaluate the wrestler ' isometric muscle strength. (DIERS International GmbH, Schlangenbad, Germany). Before beginning the actual test, the wrestler completed a general warm-up on a stationary arm and leg bicycle ergometer for a period of ten minutes at an intensity level that was self-regulated between low and moderate. The wrestler was seated in the most appropriate position on the device using measuring pads. After selecting the area to be measured on the control panel on the computer and showing the movement pattern to the athlete, the measurement was started from the computer. Maximum force was applied to the wrestler for 10 seconds. At the end of the test, the data was automatically saved by the device. Within this system, shoulder internal/external rotation, elbow flexion/extension, trunk flexion/extension, trunk lateral flexion, trunk rotation, knee flexion/extension, and hip abduction/adduction muscle strength were measured.

Statistical Analysis- Statistical analyses were performed using SPSS version 21.0 software, and p value #0.05 was considered as significant. The normality of data was controlled using the Shapiro-Wilk test. Data were analyzed using descriptive statistics, and the results are presented as mean ± SD. The differences of according to body mass between the men and women wrestlers were determined using an independent t-test. In addition, the effect size (0.2: small; 0.5: medium; and 0.8: large) was calculated to determine practical importance (Cohen, 2013). Furthermore, a discriminant function analysis was used to determine which set of variables most accurately discriminated top elite and elite wrestlers. The matrices of homogeneity were checked using Box's M test of equality of covariance. The collinearity of data was analyzed to identify correlations between independent variables. The variables that were highly correlated (r=0.70) with each other were excluded from the discriminant function analysis model. Structural coefficient was used to determine the variables that discriminate between top-elite and elite wrestlers. A structural coefficient above 0.30 was considered as relevant for the interpretation of the linear vectors.

3. Results

Based on weight categories, the physical characteristics and training experience of men and women elite wrestlers in 3 weight classes are presented in Table 1. Table 2, table 3 and table 4 includes VO2max and reactive agility test, leg anaerobic power and capacity, performance measurements of arm anaerobic power and capacity, and isokinetic and isometric strength measurement values in table 5-6-7-8-9 and 10. Discriminant function analyses of variables for men and women wrestlers are shown in Tables 5,6 and 7.

Physical Characteristics and Training Experience - Body height, Body mass, Fat %, Fat Free Mass, Muscle Mass and training experience values of man and women wrestlers in each of the 3 groups show statistically significant differences in their own weight categories (p<0,05). No significant differences were detected in terms of fat mass. Fat mass values of men and women in each weight- categories were similar (p>0,05). No significant differences were detected BMI in light weight group (p>0,05). (Table 1.)

Anaerobic Power and Capacity (Leg and Arm-Crank Wingate) - Both leg and arm crank tests show that relative and absolute peak and average power of male and female wrestlers in each weight group were statistically different (p<0,05). Men had significantly higher power values than women. However, for leg test power drop and time to peak power values of male and women wrestlers were similar in each weight group (p>0,05). Arm crank test time to peak power values of male and women wrestlers were similar in each weight group. For arm crank test power drop values were similar between light and middle weight group (p>0,05). Yet the heavy-weight group values were statistically different (p<0,05). Men had significantly higher power drop values than women. (Table 2-3-4).

Table 2. 30-second Wingate test results, VO2max test results, and leg and arm anaerobic values from the reactive-agility test for the lightweights of elite freestyle male and female wrestlers.

	Light weight			
	Men	Women	p	ES
Leg Peak Power (W)	880,3 ± 93,7	590,7 ± 44,2	0,00	3,95
Leg Relative Peak Power (W/kg)	13,8 ± 1,3	11,1 ± 0,6	0,00	2,67
Leg Time to Peak Power (ms)	2,9 ± 1,4	3,2 ± 1,2	0,60	0,23
Leg Average Power (W)	605,8 ± 41,2	430,8 ± 48,3	0,00	3,9
Leg Relative Average Power (W/kg)	9,5 ± ,0,4	8,1 ± 0,6	0,00	2,74
Leg Power Drop (%)	51,6 ± 7,2	50,8 ± 7,2	0,82	0,11
Arm Peak Power (W)	794,4 ± 70,4	544,2 ± 126,0	0,00	2,45
Arm Relative Peak Power (W/kg)	12,5 ± 1,4	10,2 ± 2,1	0,02	1,28
Arm Time to Peak Power (ms)	1,4 ± 0,6	1,6 ± 1,2	0,59	0,21
Arm Average Power (W)	414,3 ± 24,2	290,0 ± 28,6	0,00	4,7
Arm Relative Average Power (W/kg)	6,5 ± 0,4	5,4 ± 0,4	0,00	2,75
Arm Power Drop (%)	80,4 ± 11,3	73,6 ± 8,0	0,20	0,69
VE	130,5 ± 7,7	98,3 ± 18,8	0,00	2,24
RQ	1,2 ± 0,1	1,1 ± 0,1	0,35	1
VO2	3880,8 ± 452,2	2816,8 ± 403,05	0,00	2,48
VO2/kg	58,5 ± 7,7	50,1 ± 6,1	0,03	1,2
HRmax	190,5 ± 8,2	195,4 ± 5,6	0,20	0,69
Reactive Agility	25,5 ± 1,7	27,1 ± 1,6	0,06	0,97

*ES: Effect Size, VE: Ventilation, RQ: Respiratory quotient, VO2: Oxygen consumption, HRmax: Maximum heart rate. * p <0.05, significant differences compared with light-weight wrestlers ; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 3. 30-second Wingate test results, VO2max test results, and leg and arm anaerobic values from the reactive-agility test for the middleweights of elite freestyle male and female wrestlers.

	Middle weight			
	Men	**Women**	**p**	**ES**
Leg Peak Power (W)	1142,5 ± 114,9	681,2 ± 35,8	0,00	5,42
Leg Relative Peak Power (W/kg)	14,5 ± 1,9	11,5 ± 0,5	0,00	2,16
Leg Time to Peak Power (ms)	2,5 ± 0,9	3,0 ± 1,5	0,42	0,4
Leg Average Power (W)	715,9 ± 53,1	488,1 ± 29,6	0,00	5,3
Leg Relative Average Power (W/kg)	9,1 ± 0,6	8,2 ± ,06	0,02	1,5
Leg Power Drop (%)	64,6 ± 9,1	50,3 ± 9,3	0,01	1,55
Arm Peak Power (W)	961,4 ± 104,3	472,4 ± 66,9	0,00	5,58
Arm Relative Peak Power (W/kg)	12,2 ± 1,5	7,8 ± 1,0	0,00	3,45
Arm Time to Peak Power (ms)	1,4 ± 0,7	2,6 ± 0,8	0,26	1,59
Arm Average Power (W)	517,0 ± 42,7	301,0 ± 36,5	0,00	5,43
Arm Relative Average Power (W/kg)	6,6 ± 0,3	5,0 ± 0,5	0,00	3,88
Arm Power Drop (%)	80,0 ± 10,7	71,7 ± 20,4	0,29	0,51
VE	131,3 ± 26,5	104,2 ± 8,1	0,02	1,38
RQ	1,1 ± 0,1	1,2 ± 0,1	0,29	1
VO2	4068,3 ± 561,2	2995,2 ± 216,6	0,00	2,52
VO2/kg	51,8 ± 7,9	50,3 ± 4,2	0,66	0,23
HRmax	186,1 ± 7,3	197,0 ± 5,0	0,00	1,74
Reactive Agility	24,8 ± 0,7	29,0 ± 2,7	0,00	2,13

*ES: Effect Size, VE: Ventilation, RQ: Respiratory quotient, VO2: Oxygen consumption, HRmax: Maximum heart rate. * p <0.05, significant differences compared with light-weight wrestlers.; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 4. 30-second Wingate test results, VO2max test results, and leg and arm anaerobic values from the reactive-agility test for the heavyweights of elite freestyle male and female wrestlers.

	Heavy weight			
	Men	**Women**	**p**	**ES**
Leg Peak Power (W)	1180,4 ± 134,6	770,2 ± 118,6	0,00	3,23
Leg Relative Peak Power (W/kg)	13,1 ± 1,8	10,7 ± 1,5	0,00	1,44
Leg Time to Peak Power (ms)	2,6 ± 1,5	2,1 ± 0,8	0,41	0,41
Leg Average Power (W)	786,5 ± 58	516,3 ± 28,6	0,01	5,90
Leg Relative Average Power (W/kg)	8,7 ± 0,6	7,2 ± 0,5	0,00	2,71
Leg Power Drop (%)	59,5 ± 11,0	55,2 ± 13,1	0,48	0,35
Arm Peak Power (W)	1151,7 ± 427,4	490,9 ± 61,4	0,01	2,16
Arm Relative Peak Power (W/kg)	10,9 ± 2,2	6,9 ± 1,0	0,00	2,34
Arm Time to Peak Power (ms)	2,0 ± 1,1	4,6 ± 3,9	0,05	0,90
Arm Average Power (W)	591,8 ± 43,5	332,2 ± 16,0	0,00	7,92
Arm Relative Average Power (W/kg)	6,0 ± 0,5	4,7 ± 0,3	0,00	3,15
Arm Power Drop (%)	77,9 ± 12,3	63,8 ± 13,2	0,04	1,10
VE	147,8 ± 15,3	104,5 ± 10,1	0,00	3,34
RQ	1,1 ± 0,0	1,2 ± 0,1	0,11	1,00
VO2	4791,0 ± 390,1	3152,5 ± 297,2	0,00	4,72
VO2/kg	49,9 ± 6,3	45,4 ± 3,7	0,11	0,87

Table 4. Continued

HRmax	183,9 ± 6,0	190,4 ± 7,0	0,06	1,00
Reactive Agility	25,3 ± 1,8	29,3 ± 2,4	0,00	1,89

*ES: Effect Size, VE: Ventilation, RQ: Respiratory quotient, VO2: Oxygen consumption, HRmax: Maximum heart rate. * p <0.05, significant differences compared with light-weight wrestlers; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 5. Isokinetic strength test values obtained for elite free style men and women wrestlers in the lightweight class.

	Light weight			
Dominant 60°/sec	**Men**	**Women**	**p**	**ES**
Dominant-Peak Torque (Flex.60°/sec)	115,7 ± 12,8	78,2 ± 9,2	0,00	3,36
Dominant-Peak Torque/Weight (Flexion.60°/sec	1,9 ± 0,2	1,4 ± 0,1	0,00	3,16
Dominant-Peak Torque (Extension.60°/sec)	213,7 ± 32,9	154,8 ± 28,6	0,00	1,91
Dominant-Peak Torque/Weight (Extension.60°/sec)	3,5 ± 0,6	2,9 ± 0,4	0,03	1,17
Dominant-Peak Torque (Flexion/Extension.60°/sec)	55,3 ± 10,0	51,2 ± 6,1	0,36	0,5
Nondominant 60°/sec				
Nondominant-Peak Torque (Flexion.60°/sec)	111,2 ± 9,7	80,0 ± 9,7	0,00	3,21
Nondominant-Peak Torque/Weight (Flexion.60°/sec)	1,8 ± 0,1	1,5 ± 0,2	0,00	1,89
Nondominant-Peak Torque (Extension.60°/sec)	208,1 ± 35,5	147,5 ± 28,6	0,00	1,88
Nondominant-Peak Torque/Weight (Extension.60°/sec)	3,3 ± 0,7	2,7 ± 0,4	0,04	1,05
Nondominant-Peak Torque (Flexion/Extension.60°/sec)	54,9 ± 9,7	55,1 ± 6,9	0,95	0,02
Dominant 180°/sec				
Dominant-Peak Torque (Flexion.180°/sec)	97,3 ±8,5	68,8 ± 8,1	0,00	3,43
Dominant-Peak Torque/Weight (Flexion.180°/sec)	1,6 ± 0,1	1,3 ± 0,1	0,00	3
Dominant-Peak Torque/Weight (Extension.180°/sec)	2,5 ±0,3	2,1 ±0,3	0,01	1,33
Dominant-Peak Torque (Extension.180°/sec)	157,2 ±18,8	111,3 ±18,8	0,00	2,44
Dominant-Peak Torque (Flexion/Extension.180°/sec)	62,7 ± 9,6	62,6 ±5,9	0,98	0,01
Nondominant 180°/sec				
Nondominant-Peak Torque (Flexion.180°/sec)	92,3 ±8,6	65,5 ±6,9	0,00	3,43
Nondominant-Peak Torque/Weight (Flek.180°/sec)	1,5 ±0,1	1,2 ±0,1	0,00	3
Nondominant-Peak Torque (Extension.180°/sec)	150,3 ±9,8	111,2 ±14,3	0,00	3,19
Nondominant-Peak Torque/Weight (Extension.180°/sec)	2,4 ±0,2	2,1 ±0,2	0,00	1,5
Nondominant-Peak Torque (Flexion/Extension.180°/sec)	61,6 ± 7,0	59,7 ±8,0	0,61	0,25

*ES: Effect Size. * p <0.05, significant differences compared with light-weight wrestlers.; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 6. Isokinetic strength test values obtained for elite free style men and women wrestlers in the middle weight class.

	Middle weight			
Dominant 60°/sec	**Men**	**Women**	**p**	**ES**
Dominant-Peak Torque (Flex.60°/sec)	130,1 ± 21,5	82,7 ± 7,7	0,00	2,93
Dominant-Peak Torque/Weight (Flexion.60°/sec	1,7 ± 0,3	1,4 ± 0,2	0,03	1,17
Dominant-Peak Torque (Extension.60°/sec)	253,2 ± 43,2	162,8 ± 8,1	0,00	2,9
Dominant-Peak Torque/Weight (Extension.60°/sec)	3,3 ± 0,6	2,7 ± 0,3	0,03	1,26
Dominant-Peak Torque (Flexion/Extension.60°/sec)	52,0 ± 6,1	50,8 ± 3,8	0,65	0,23

Table 6. Continued.

Nondominant 60°/sec				
Nondominant-Peak Torque (Flexion.60°/sec)	129,7 ± 22,4	79,1 ± 11,3	0,00	2,85
Nondominant-Peak Torque/Weight (Flexion.60°/sec)	1,7 ± 0,3	1,3 ± 0,2	0,02	1,56
Nondominant-Peak Torque (Extension.60°/sec)	252,3 ± 31,6	165,5 ± 14,1	0,00	3,54
Nondominant-Peak Torque/Weight (Extension.60°/sec)	3,3 ± 0,5	2,8 ± 0,3	0,03	1,21
Nondominant-Peak Torque (Flexion/Extension.60°/sec)	51,6 ± 6,6	47,7 ± 4,4	0,20	0,69
Dominant 180°/sec				
Dominant-Peak Torque (Flexion.180°/sec)	101,1 ± 11,4	71,2 ±11,2	0,00	2,64
Dominant-Peak Torque/Weight (Flexion.180°/sec)	1,3 ±0,2	1,2 ±0,1	0,15	0,63
Dominant-Peak Torque/Weight (Extension.180°/sec)	2,3 ±0,3	1,9 ±0,1	0,00	1,78
Dominant-Peak Torque (Extension.180°/sec)	180,2 ±27,0	111,8 ±4,9	0,00	3,52
Dominant-Peak Torque (Flexion/Extension.180°/sec)	56,7 ±7,0	63,8 ±10,6	0,12	0,79
Nondominant 180°/sec				
Nondominant-Peak Torque (Flexion.180°/sec)	100,7 ± 18,5	70,7 ±11,9	0,00	1,92
Nondominant-Peak Torque/Weight (Flek.180°/sec)	1,3 ±0,2	1,2 ±0,2	0,26	0,5
Nondominant-Peak Torque (Extension.180°/sec)	184,0 ±21,7	118,2 ±6,5	0,00	4,1
Nondominant-Peak Torque/Weight (Extension.180°/sec)	2,3 ±0,3	2,0 ±0,1	0,00	1,34
Nondominant-Peak Torque (Flexion/Extension.180°/sec)	54,6 ±6,1	59,7 ±8,2	0,16	0,7

*ES: Effect Size; * p <0.05, significant differences compared with light-weight wrestlers; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 7. Isokinetic strength test values obtained for elite free style men and women wrestlers in the heavy weight class.

	Heavy weight			
Dominant 60°/sec	**Men**	**Women**	**p**	**EB**
Dominant-Peak Torque (Flex.60°/sec)	145,8 ± 22,1	95,8 ±11,5	0,00	2,83
Dominant-Peak Torque/Weight (Flexion.60°/sec	1,5 ± 0,2	1,4 ± 0,2	0,18	0,5
Dominant-Peak Torque (Extension.60°/sec)	297,7 ±39,1	188,8 ± 18,6	0,00	3,55
Dominant-Peak Torque/Weight (Extension.60°/sec)	3,1 ±0,4	2,7 ±0,2	0,02	1,26
Dominant-Peak Torque (Flexion/Extension.60°/sec)	49,3 ±5,8	51,0 ±6,7	0,58	0,27
Nondominant 60°/sec				
Nondominant-Peak Torque (Flexion.60°/sec)	141,0 ± 30,1	94,1 ±16,2	0,00	1,94
Nondominant-Peak Torque/Weight (Flexion.60°/sec)	1,5 ±0,3	1,4 ±0,2	0,32	0,39
Nondominant-Peak Torque (Extension.60°/sec)	270,5 ±55,6	181,0 ±15,5	0,00	2,19
Nondominant-Peak Torque/Weight (Extension.60°/sec)	2,8 ±0,6	2,6 ±0,2	0,35	0,44
Nondominant-Peak Torque (Flexion/Extension.60°/sec)	53,1 ± 8,4	52,1 ±8,2	0,83	0,12
Dominant 180°/sec				
Dominant-Peak Torque (Flexion.180°/sec)	121,2 ±18,6	76,3 ±13,13	0,00	2,78
Dominant-Peak Torque/Weight (Flexion.180°/sec)	1,3 ±0,1	1,1 ± 0,2	0,06	1,26
Dominant-Peak Torque/Weight (Extension.180°/sec)	2,3 ±0,3	1,9 ±0,2	0,02	1,56
Dominant-Peak Torque (Extension.180°/sec)	216,7 ±30,7	135,1 ± 17,5	0,00	3,26
Dominant-Peak Torque (Flexion/Extension.180°/sec)	56,4 ±7,5	57,3 ±13,0	0,85	0,08
Nondominant 180°/sec				
Nondominant-Peak Torque (Flexion.180°/sec)	116,9 ±18,8	75,5 ±11,6	0,00	2,65
Nondominant-Peak Torque/Weight (Flek.180°/sec)	1,2 ±0,1	1,1 ±0,1	0,07	1

Table 7. Continued

Nondominant-Peak Torque (Extension.180°/sec)	211,3 ±19,3	136,5 ±16,3	0,00	4,18
Nondominant-Peak Torque/Weight (Extension.180°/sec)	2,2 ±0,3	2,0 ±0,2	0,05	0,78
Nondominant-Peak Torque (Flexion/Extension.180°/sec)	55,6 ±8,7	55,5 ±6,6	0,98	0,01

*ES: Effect Size; * p <0.05, significant differences compared with light-weight wrestlers; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 8. Isometric strength test values obtained for elite free style men and women wrestlers in the lightweight class.

Isometric strength (N)	Light weight			
	Men	**Women**	**p**	**ES**
ARMS-Elbow-Extension-Left	322,4 ± 89,6	449,5 ± 96,4	0,02	1,36
ARMS-Elbow-Extension-Right	332,6 ± 131,1	474,7 ± 102,3	0,03	1,29
ARMS-Elbow-Flexion-Left	403,3 ± 111,4	309,8 ± 65,4	0,07	1,02
ARMS-Elbow-Flexion-Right	422,9 ± 128,1	328,4 ± 70,2	0,10	0,91
TRUNK-Extension	245,4 ± 103,0	152,6 ± 29,5	0,04	1,22
TRUNK-flexion	132,9 ± 43,6	118,9 ± 33,2	0,49	0,36
Trunk-lateral-flexion-left	445,8 ± 146	285,0 ± 93,5	0,02	1,31
Trunk-lateral-flexion-right	507,7 ± 68,5	270,0 ± 86,1	0,00	3,05
Trunk-lateral-rotation-left	430,0 ± 255	269,4 ± 65,9	0,13	0,86
Trunk-lateral-rotation-right	398,1 ± 169,4	268,6 ± 78,3	0,08	0,98
SHOULDER-external-rotation-left	428,0 ± 155,6	301,7 ± 172,6	0,15	0,76
SHOULDER-external-rotation-Right	423,9 ± 140,3	292,1 ± 147,4	0,10	0,91
SHOULDER-inward-rotation-left	490,3 ± 132,8	377,1 ± 149,8	0,13	0,8
SHOULDER-inwards-rotation-Right	518,1 ± 92,1	346,7 ± 126,6	0,01	1,54
Leg-abduction-left	889,1 ± 244,4	717,7 ± 189,3	0,15	0,78
Leg-abduction-Right	832,9 ± 207,8	684,5 ± 147,2	0,13	0,82
Leg-adduction-left	979,7 ± 222,8	752,4 ± 123,4	0,03	1,26
Leg-adduction-Right	1094,1 ± 252,4	773,6 ± 116,7	0,01	1,63

*ES: Effect Size; * p <0.05, significant differences compared with light-weight wrestlers; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 9. Isometric strength test values obtained for elite free style men and women wrestlers in the middleweight class.

Isometric strength (N)	Middle weight			
	Men	**Women**	**p**	**ES**
ARMS-Elbow-Extension-Left	446,5±103,1	517,3±174,3	0,31	0,49
ARMS-Elbow-Extension-Right	441,3±79,7	517,4±165,1	0,22	0,58
ARMS-Elbow-Flexion-Left	480,3±41,2	337,3±82,4	0,00	2,19
ARMS-Elbow-Flexion-Right	509,8±65,1	363,6±78,4	0,00	2,02
TRUNK-Extension	308,4±129,7	176,3±37,8	0,02	1,38
TRUNK-flexion	190,1±134,4	148,9±131,9	0,54	0,30
Trunk-lateral-flexion-left	445,1±202,6	400,6±139,3	0,62	0,25
Trunk-lateral-flexion-right	498,6±234,2	448,7±59,8	0,59	0,29
Trunk-lateral-rotation-left	534,4±321,8	251,7±151,3	0,05	1,12

Table 9. Continued.

Trunk-lateral-rotation-right	521,0±297,3	268,3±158,1	0,06	1,06
SHOULDER-external-rotation-left	560,5±97,3	361,4±255,5	0,04	1,03
SHOULDER-external-rotation-Right	502,1±121,5	359,1±281,0	0,17	0,66
SHOULDER-inward-rotation-left	585,0±123,0	480,1±149,2	0,13	0,76
SHOULDER-inwards-rotation-Right	560,0±114,5	515,3±158,7	0,51	0,32
Leg-abduction-left	1047,8±151,8	712,9±121,1	0,00	2,43
Leg-abduction-Right	985,6±109,2	740,9±182,4	0,00	1,62
Leg-adduction-left	1051,8±289,3	851,1±242,4	0,15	0,75
Leg-adduction-Right	1122,7±290,6	839,9±217,2	0,05	0,71

*ES: Effect Size; * p <0.05, significant differences compared with light-weight wrestlers; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 10. Isometric strength test values obtained for elite free style men and women wrestlers in the heavy weight class.

Isometric strength (N)	Heavy weight			
	Men	**Women**	**p**	**ES**
ARMS-Elbow-Extension-Left	492,7 ±182,1	482,9 ±120,8	0,90	0,06
ARMS-Elbow-Extension-Right	528,9 ±239,1	496,4 ±156,0	0,76	0,16
ARMS-Elbow-Flexion-Left	504,9 ±158,7	293,3 ±105,7	0,01	1,56
ARMS-Elbow-Flexion-Right	534,0 ±129,3	325,0 ±117,7	0,00	1,69
TRUNK-Extension	381,3 ±167,6	190,1 ±57,1	0,01	1,52
TRUNK-flexion	193,5 ±77,6	127,4 ±65,1	0,09	0,92
Trunk-lateral-flexion-left	515,7 ±236,9	396,7 ±170,5	0,27	0,57
Trunk-lateral-flexion-right	627,1 ±193,6	486,3 ±171,1	0,14	0,77
Trunk-lateral-rotation-left	673,8 ±229,6	272,4 ±73,3	0,00	2,35
Trunk-lateral-rotation-right	686,4 ±202,2	292,3 ±73,6	0,00	2,59
SHOULDER-external-rotation-left	846,3 ±434,4	468,4 ±160,8	0,05	1,15
SHOULDER-external-rotation-Right	802,9 ±425,2	455,9 ±215,8	0,07	1,02
SHOULDER-inward-rotation-left	864,1 ±222,8	481,1 ±142,9	0,00	2,04
SHOULDER-inwards-rotation-Right	825,5 ±243,0	474,6 ±140,3	0,00	1,76
Leg-abduction-left	1279,3 ±220,7	758,8 ±151,7	0,00	2,74
Leg-abduction-Right	1262,6 ±256,5	714,6 ±131,9	0,00	2,68
Leg-adduction-left	1404,0 ±279,7	747,4 ±235,3	0,00	2,54
Leg-adduction-Right	1416,9 ±154,6	760,0 ±232,7	0,00	3,32

*ES: Effect Size; * p <0.05, significant differences compared with light-weight wrestlers; † p <0.05, significant differences compared with middle-weight wrestlers; ‡ p <0.05, significant differences compared with heavy-weight wrestlers*

Table 11. Aerobic and anaerobic power (leg and arm) test values obtained for elite free style men and women wrestlers in the 3 weight classes.

Variables	Function coefficients
Leg Relative Peak Power (W/kg)	,138
Leg Relative Average Power (W/kg)	,537
Arm Relative Peak Power (W/kg)	-,018
Arm Relative Average Power (W/kg)	,778
VO2/Kg	-,244

Table 12. Isokinetic strength test values obtained for elite free style men and women wrestlers in the 3 weight classes.

Variables	Function coefficients
Dominant-Peak Torque/Weight (Flexs.60/sec)	,934
Dominant-Peak Torque/Weight (Extension.60/sec)	,280
Nondominant-Peak Torque/Weight (Flex.60/sec)	-,084
Nondominant-Peak Torque/Weight (Extension.60/sec)	-,375
Dominant-Peak Torque/Weight (Flek.180/sec	,313
Dominant-Peak Torque/Weight (Extension.180/sec	-,226
Nondominant-Peak Torque/Weight (Flek.180/sec	,102
Nondominant-Peak Torque/Weight (Extension.180/sec)	,467

Table 13. Isometric strength test values obtained for elite free style men and women wrestlers in the 3 weight classes.

Variables	Function coefficients
Trunk-extension	,356
Trunk-flexion	-,032
Trunk-lateral-flexion-left	,146
Trunk-lateral-flexion-right	,007
Trunk-lateral-rotation-left	,044
Trunk-lateral-rotation-right	,066
Shoulder-external-rotation-left	-,446
Shoulder-external-rotation-Right	,395
Shoulder-inwards-rotation-left	-,321
Shoulder-inwards-rotation-Right	,220
Leg-abduction-left	,835
Leg-abduction-Right	-,382
Leg-adduction-left	-,267
Leg-adduction-Right	,784

Aerobic Performance (VO_{2max}) - Absolute oxygen consumption of men and women wrestlers in each weight group were statistically different (p<0,05). Men had higher oxygen consumption than women. While the relative oxygen consumption values of men and women in light weight groups were statistically different (p<0,05) but middle and heavy weight groups were similar (p>0,05). As the body weights of male and female wrestlers increase, relative oxygen consumption shows similarity. The ventilation values of men and women were statistically different in each weight group (p<0,05). Men had higher ventilation than women.

Reactive agility

Reactive-agility test results in men and women differ statistically in middle and heavyweight, unlike similar results in light weight (p<0,05). As the body weights of male and female wrestlers increase, the reactive agility values differ, and according to these results, men have higher reactive agility than women (Table 2-3-4).

Isokinetic strength

Peak torque, peak torque/weight values of dominant knee flexor and extensor muscles of men and women wrestlers in light and middle weight groups at 60°/sec were statistically different (p<0,05). Men had higher value than women. Peak torque, peak torque/weight values of dominant knee extensor muscles and peak torque values of knee flexor muscles in heavy weight group of men and women wrestlers were statistically different at 60°/sec (p<0.05). Men had higher value than women. Peak torque/weight value of dominant knee flexor muscles of men and women wrestlers in heavy weight group at 60°/sec were similar (p>0,05). Conventional ratio of men and women wrestlers in each weight groups were similar (p>0,05) (Table 5-6-7).

Peak torque, peak torque/weight values of dominant knee flexor and extensor muscles of men and women wrestlers in light and heavy weight groups at 180°/sec were statistically different (p<0,05). Men had higher value than women. Peak torque, peak torque/weight values of dominant knee extensor muscles and peak torque values of knee flexor muscles in middle weight group of men and women wrestlers were statistically different at 60°/sec (p<0.05). Men had higher value than women. Peak torque/weight value of dominant knee flexor muscles of male and female wrestlers in middle weight group at 180°/sec were similar (p>0,05). Conventional Ratio of men and women wrestlers in each weight groups were similar (p>0,05) (Table 5-6-7).

Isometric strength

The strength of the elbow extensor muscles of men and women wrestlers in the lightweight groups was statistically different (p<0,05). Men had higher strength values than women. However, the middle and heavy weight groups were similar (p>0,05). The strength of the elbow flexors muscles of men and women wrestlers in middle and heavy weight is statistically different (p<0,05). Men had higher strength values than women. Isometric muscle strength values of elbow flexors were similar in the lightweight groups (p>0,05). (Table 8-9-10).

The strength of the trunk extensor muscles of men and women wrestlers in each weight group was statistically different (p<0,05). Men had higher strength values than women.

The strength of trunk lateral flexor muscles in the lightweight group was statistically different (p<0,05). Men had higher strength values than women. Nevertheless, the middle and heavy weight groups were similar (p>0,05). The strength of trunk rotator muscles in the heavy weight group was statistically different (p<0,05). Men had higher strength values than women. Nevertheless, the light and middle weight groups were similar (p>0,05) (Table 8-9-10).

The strength of the leg abductor muscles of men and women wrestlers in middle and heavy weight groups was statistically different (p<0,05). Men had higher strength values than women. However, the lightweight group was similar (p>0,05). The strength of the leg adductor muscles of men and women wrestlers in light and heavy weight groups was statistically different (p<0,05). Men had higher strength values than women. However, the middleweight group was similar (p>0,05) ((Table 8-9-10).

Discriminant Function Analysis - The variations in the Freestyle men's and women's elite wrestlers' physical and physiological fitness factors were examined using discriminant analysis. The discriminant function procedure's classification function was applied to the isokinetic and isometric strength, as well as the anaerobic and aerobic power (leg and arm) variables. Final Wilks' lambda of 0.334 ($p < 0.01$) and average squared canonical correlation of 0.82 for the aerobic and anaerobic power (leg and arm) variables indicated that these factors accounted for about 66% (0.816) of the variance in predicting group membership. With an overall prediction accuracy of 90%, this model accurately identified 25 of 29 subjects for male wrestlers and 20 of 21 subjects for female wrestlers (Table 11). A final Wilks' lambda of 0.627 ($p < 0.01$) and an average squared canonical correlation of 0.61 for variables related to isokinetic strength show that these variables accounted for about 37% (0.610) of the variance in predicting group membership. With an overall prediction accuracy of 78%, this model accurately identified 25 of 29 male wrestlers and 14 of 21 female wrestlers (Table 12). Isometric strength variables resulted in a final Wilks' lambda of 0.415 ($p < 0.01$) and an average squared canonical correlation of 0.77, indicating that these variables accounted for approximately 59% (0.765) of the variance in predicting group membership. This model correctly classified 28 of 29 subjects for men and 21 of 21 subjects for women wrestlers, with an overall prediction accuracy of 98% (Table 13).

4. Discussion

This is the first study to compare elite men and women wrestlers in freestyle category in different wight classes (light, middle, and heavy). The differences between wrestlers in terms of their styles (freestyle and Greco-Roman), weight classifications (light, middle, and heavy), and competition levels have typically been examined in previous studies (elite and amateur).

Due to the sport's complicated physiological demands, wrestlers must have highly developed capacities for maximum strength, agility, flexibility, muscular power, strength endurance, oxidative capacity, anaerobic capacity, and power (Chaabene et al., 2017; Özbay & Ulupınar, 2022; J. Yoon, 2002). However, it seems likely that the differences of the wrestling styles and gender are reflected in the performance characteristics of the wrestlers. It is crucial for free style wrestlers to increase their agility and flexibility since they will be required to use tactics like leg attack, ankle pick, or toe hold as well as protect against their opponent's offensive movements (Mirzaei, Curby, Rahmani-Nia, & Moghadasi, 2009; Thomas & Zamanpour, 2018; J. R. Yoon, 2012). Given the significance of the performance criteria, it is crucial to comprehend the differences in wrestling styles and gender among wrestlers to correctly create training plans and performance evaluation techniques. There are fast counterattacks, defensive fights, and full-on offensive moves during a wrestling match (López-González & Miarka, 2013). Additionally, to sustain high muscular performance through repeated, intense activities, wrestlers need to increase both anaerobic and aerobic energy metabolism (López-González & Miarka, 2013; Mirzaei, Ghahremani Moghaddam, & Alizaee Yousef Abadi, 2017). Furthermore, fighting matches typically need for coordinated actions involving both upper and lower body muscular groups (Mirzaei et al., 2017).

Anaerobic energy level is crucial for determining the outcome of a wrestling match (Horswill, 1992; Pallarés et al., 2012). Due to the fact that the energy provided by anaerobic energy systems is an essential factor in the decisive moments of the match of the match and its development is important for wrestlers. (Hübner-Wozniak et al., 2004). Successful wrestlers have significant levels of anaerobic power and capacity in both the legs and arms, according to Horswill (Horswill, 1992) and Yoon (J. Yoon, 2002). The Wingate anaerobic test has been utilized frequently to evaluate wrestlers' anaerobic characteristics (Demirkan et al., 2015; Maria Lopez-Gullon, Muriel, Dolores Torres-Bonete, Izquierdo, & Garcia-Pallares, 2011; Pallarés et al., 2012; J. R. Yoon, 2012). For elite-level male wrestlers, the range of lower limb PP and MP outputs expressed relative to total body mass ranges from 10 to 17 W/kg and from 4 to 9 W/kg, respectively. The same anaerobic values for top-level female wrestlers range from 4 to 7 W/kg for MP and from 7 to 9 W/kg for PP (Chaabene et al., 2017). In these studies, the range of lower limb PP and MP outputs of men extends from 10,02 to 17,79 W/kg and from7,16 to 9,93 W/kg, respectively. For women the same anaerobic parameters extend from 9 to13 W/kg for PP and from 6 to 9 W/kg for MP. For elite-level male wrestlers, the upper-limb PP and MP outputs vary from 7 to 11 W/kg and from 4 to 7 W/kg, respectively (Chaabene et al., 2017). Studies on the same variables among top-level female wrestlers, however, are few and far between.

Hubner-Wozniak et al. found that Polish elite-level female wrestlers had upper-limb PP and MP of 5.9 0.5 and 4.6 0.4 W/kg, respectively. Lower-limb PP and MP outputs in cadet elite-level male wrestlers range from 8 to 15 W/kg and 6 to 7 W/kg, respectively. The same values range from 8 to 11 and 4 to 5 W/kg for upper-limb PP and MP, respectively (Hübner-Wozniak et al., 2004). In the findings of this study; upper-limb PP and MP outputs range between 8 and 16 W/kg and between 5 and 7 W/kg, respectively, for elite-level male wrestlers. For women the same anaerobic parameters extend from 5 to 14 W/kg for PP and from 4 to 6 W/kg for MP. The absolute arms and leg PP and MP outputs of heavier wrestlers were higher in both sexes, as was to be expected (Demirkan et al., 2015; Maria Lopez-Gullon et al., 2011; Mirzaei et al., 2009; Pallarés et al., 2012; Zi-Hong et al., 2013). However, close results were recorded when standardized to each wrestler's body mass (Demirkan et al., 2015; García-Pallarés et al., 2011; Maria Lopez-Gullon et al., 2011; Mirzaei et al., 2009). The outcome of this investigation was the same results. Results for wrestlers competing at various levels revealed that elite men wrestlers showed larger upper- and lower-limb PP and MP outputs than their amateur peers and women counterparts (Abellán et al., 2010; Demirkan et al., 2015; García-Pallarés et al., 2011).

The researchers attributed this difference to the elite male wrestlers' increased lean body mass and stronger brain activity. According to this understanding, anaerobic power and capacity are critical components for achieving high-level wrestling performance, and they dependably distinguish between successful and unsuccessful wrestlers regardless of age, weight class, wrestling style, or gender.

To effectively get prepared for competition in wrestling, various physical attributes must be refined, including aerobic power and capacity. Aerobic capacity is one of the most crucial physical criteria for winning wrestling matches. They engage in activities that call for intense bursts of power and have little recovery time (CALLAN et al., 2000). Since 2016, the United World Wrestling (UWW) has changed several rules, making wrestling a more aggressive, complex, visually stimulating sport that calls for greater anaerobic and aerobic capacities. The Wrestling Federation reduced the length of the bout from two rounds of 3 minutes each to one round of 6 minutes without a rest period. The focus of energy delivery systems returned to anaerobic metabolism with aerobic support (Isik, Cicioglu, Gul, & Alpay, 2017).

The aerobic system primarily assists in maintaining effort throughout competition and promoting recovery between sessions (Callan et al., 1998; Horswill, 1992; Ratamess, 2011; J. Yoon, 2002). For senior wrestlers that are male or female, the VO2max values recorded range from 37 to 67 ml and 39 to 52 ml, respectively. The wide variety of VO_{2max} values found in both men and women appears to be caused mainly by the wrestler's degree of training, training phase, method of testing (lab vs. field and treadmill vs. cycle ergometer), and the various weight divisions. Horswill (Horswill, 1992) reported VO_{2max} values ranging from 52 to 63 ml, which are consistent with the current study's findings. National and international wrestlers' VO_{2max} levels were found to range between 53 and 56 m, according to Yoon (J. Yoon, 2002). Both men and women in this study had similar VO_{2max} readings (45–65 and 40– 60 ml for men and women, respectively). For elite wrestlers to perform well, Yoon (J. Yoon, 2002), Mirzaei et al. (Mirzaei, Curby, & Rahmani-Nia, 2011; Bahman Mirzaei, David G Curby, Ioannis Barbas, & Navid Lotfi, 2011a; Bahman Mirzaei, David G Curby, Ioanis Barbas, & Navid Lotfi, 2011b), and Utter et al. (Utter, O'BRYANT, Haff, & Trone, 2002) argued that aerobic metabolism is a fundamental necessity. These data imply that high aerobic power and capacity are crucial for achieving a high level of wrestling performance. The findings showed that one of the key elements in reaching a high level of wrestling performance is having an ideal VO_{2max}. Given the dearth of scientific information on female wrestlers, the VO_{2max} statistics of women in this study are crucial, and additional research is required.

With a few exceptional cases, testing on cardiovascular fitness have always been the prerequisite for research on wrestlers' pulmonary systems. Sharratt and Cipriano's (Sharratt & Cipriano, 1987) findings were in line with those of Rasch and Brandt (Rasch & Brant, 1957), namely that wrestlers' lung volumes and functions were higher than nonathletes' but average when compared to other well-trained athletes. The average minute ventilation rate varied from 129 L/min elite adolescent wrestlers [25] to 156.6 L/min during maximal aerobic exertion (in first-team members of the US Olympic team) (Nagle, Morgan, Hellickson, Serfass, & Alexander, 1975). In the findings of this study, the average minute ventilation rate ranged from 130 L/min (in elite adolescent men wrestlers) to 147 L/min. For women and wrestlers rate ranged from 100 L/min to 105 L/min. Although the general anatomy of the respiratory system does not differ according to gender, various morphological differences have been defined in the respiratory system. Women have smaller lungs than men (Brooks & Strohl, 1989). It has been demonstrated that at maximum exercise, men allocate ~9% of whole-body VO2 to respiratory muscles, and women ~14%. The fact that women allocate ~5% more of their whole-body VO2 to respiratory muscles is vital given the role that respiratory muscle energy plays in developing locomotor fatigue and blood flow distribution (Dominelli et al., 2015). Women's higher respiratory oxygen expenditure indicates that they allocate a more significant amount of blood flow to the respiratory muscles during maximal exercise. Therefore, reduced blood flow to the leg muscles results in lower physical performance in women (Molgat-Seon, Peters, & Sheel, 2018).

Because there is a correlation between strength and athletic performance for sports that rely on strength, it seems important to measure muscular performance using the isokinetic dynamometer (Brown, 2000). Muscle power, strength, and velocity are the critical success factors in a sport like wrestling. As a result, the number of type II fibres is crucial in predicting athletic success. Dynamic contractions with an isokinetic dynamometer at various angular velocities may be used to identify the various myosin isoforms (Gür, Gransberg, VanDyke, Knutsson, & Larsson, 2003).

Elite-level cadet wrestlers of 42 and 46 kg demonstrated a higher relative strength than the other classes, according to Mirzaei et al. (Mirzaei, Curby, et al., 2011b). According to Zi-Hong et al. (Zi-Hong et al., 2013), heavier weight classes had higher absolute maximal strength and knee and back absolute isokinetic torque than lighter weight classes. However, this trend was reversed for maximal strength indices when expressed relative to body mass, with no noticeable difference for isokinetic exercises.

According to Garcia Pallares et al. (Pallarés et al., 2012), the middle-weight elite female group had a greater 1RM strength than the light-weight ones (18.3 and 20.1% for the squat and bench press, respectively). However, when 1RM strength levels were allometrically standardized, no discernible difference was seen between the two weight classes. This study revealed that, in three weight categories, the absolute strength differences between men and women athletes were more significant than the relative strength differences. This finding highlights the significance of allometrically expressing strength performance. Maximum strength in the upper and lower limbs is necessary for excellent wrestling performances (Horswill, 1992; Mirzaei, Curby, et al., 2011a; J. R. Yoon, 2012). This is since a high level of maximal power is necessary to lift the opponent, which is the main determinant of wrestling. Wrestlers' maximal strength should be strictly developed as it is a prerequisite for the development of the other fitness qualities because the capacity of a wrestler to lift and resist an opponent's attack is fundamental to performing well in wrestling. This can be done by incorporating a variety of upper- and lower-limb exercises (Kraemer, Vescovi, & Dixon, 2004).

Studies that examined wrestlers' isometric strength results concur that it is crucial for obtaining high-level wrestling success ((Table 8-9-10). Since it is one of the most important parts of several wrestling holds ((Kraemer et al., 2004; McGuigan, Winchester, & Erickson, 2006; Pallarés et al., 2012). However, in previous research, back, leg, and hand grip dynamometers were used to quantify isometric force. This study is significant since it used the gold standard in isometric assessment, the DIERS-Myoline Isometric Muscle Strength Analysis System. According to Gierczuk et al. (Gierczuk, Hübner-Woźniak, & Długołęcka, 2012) high isometric strength levels are necessary to achieve high wrestling performance. Furthermore, elite-level groups may produce more strength due to their higher lean mass than groups with lesser lean mass. Isometric power values of all wrestlers show an increase in all weights (Table 8-9-10).

In wrestling, the neck muscles of the athlete are heavily utilized (Rezasoltani, Ahmadi, Nehzate-Khoshroh, Forohideh, & Ylinen, 2005; Tsuyama et al., 2001). To effectively counter the opponent's offensive and defensive movements in order to keep the neck and head in a fixed position in the face of the competitor's force, wrestlers need well-developed cervical extensor muscles (Rezasoltani et al., 2005). Because of this, many researchers believe that enhancing cervical muscle performance is very important for wrestlers (Rezasoltani et al., 2005; Tsuyama et al., 2001). Overall, it can be said that having a high degree of isometric strength is one of the most essential criteria in reaching wrestling success.

5. Practical Applications.

These results can be used by coaches, strength and conditioning specialists, and sport scientists to create a comprehensive physical and physiological profile of wrestlers that will help them adapt their training programs. To undertake an in-depth analysis, future research should focus on offering sport-specific examinations that lead to an accurate overview of the physiological and physical characteristics of wrestlers.

6. Conclusions

Because aerobic power, anaerobic power and capacity are associated physical abilities to improve wrestling performance, adding high-intensity interval training to the wrestling routine appears to be a promising method. This sort of training leads to gains in all these parameters. Maximum dynamic strength, isometric strength, explosive strength, and strength endurance are the most important conditioning aspects for obtaining top performance success in wrestling, with special emphasis on the wrestler's neck muscular region. Lower Extremity anaerobic power obtained from men, knee flexor at 60°/s and 180°/s peak torque, VO_{2max}, isometric force values of arm and trunk extensor muscles are higher than in women. In contrast, upper extremity anaerobic power values were similar. As a result, it can be said that the endurance capacity, isometric, and isokinetic strength parameters are different in both elite men and women wrestlers, this difference is more noticeable than that of strength value.

These results can be used by coaches, strength and conditioning specialists, and sport scientists to create a comprehensive physical and physiological profile of wrestlers that will help them adapt their training programs.

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