

Comparison of Kinanthropometric Profiles of Elite Turkish Taekwondo Players With or Without Medals in European Championships

Comparación de Perfiles Cineantropométricos de Peleadores Turcos de Élite de Taekwondo con o sin Medallas en Campeonatos Europeos

Ani Agopyan¹; Tugce Yesilcimen¹; Havva Burce Gocmez²; Beyzanur Ozturk¹; Sonnur Gulesce¹; Tulay Bulut¹; Kubra Cemre Gungor¹; Dicle Hazal Ucar¹; Yasemin Ulucan¹; Cansel Cumbur¹; Meral Kucuk Yetgin¹ & Nusret Ramazanoglu¹

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SUMMARY: This study aims to determine the possible differences anthropometric characteristics and body composition profiles of elite taekwondo players with or without medals in European championships. Twenty-one black-belt elite taekwondo athletes (17.4±1.2 years) from the Turkish national team were divided into two groups, namely, medalists (MEC; n=11) and non-medalists (NmEC; n=10) in European championships. Twenty-eight anthropometric measurements including height, body mass, length, circumferences, breadth, and skinfolds were taken following the standard techniques proposed by the International Society for the Advancement of Kinanthropometry (ISAK). Body composition variables were evaluated by using skinfold thickness measurements. Results demonstrated that anthropometric and body composition, variables did not differ significantly between medalist and non-medalist taekwondo players ($p>0.01$). Our athletes have a low percentage of body fat and high muscle mass profile. Medalist and non-medalist elite Turkish taekwondo players in the European championships do not differ in terms of anthropometric and body composition components. They have a similar body composition profile suitable for taekwondo players and within acceptable healthy ranges. The present study assists coaches in the formulation of appropriate training programs aiming the development for managing the body composition status of players, which will be associated with high-level performance in taekwondo. Future studies should include body composition and somatotype profile inspection throughout the weight categories.

KEY WORDS: Anthropometry; Body composition; Taekwondo.

INTRODUCTION

Taekwondo is a traditional Korean martial art that became an official medal sport at the 2000 Sydney Games (Liao *et al.*, 2016). Performance in taekwondo is related to technical and select physical fitness components such as anthropometric characteristics (body height, body mass, body mass index- BMI, body fat percentage-BF), aerobic fitness, and neuromuscular function (Gaamouri *et al.*, 2019).

In this sport, players gain higher scores with specific fighting techniques such as kicks and punches, accuracy and power, in the legal scoring areas of the abdomen, both sides of the flank, and the permitted parts of the face (Razi, 2016).

For this reason, they must develop aerobic and anaerobic strength, muscular strength, muscular endurance, speed, and flexibility (Bridge *et al.*, 2014). Additionally, a high level of all anthropological dimensions is required for success in taekwondo (Cular *et al.*, 2021) an extremely important aspect of preparation for competitions is the maintenance of an optimal ratio of body fat to muscle tissue (Górski & Orysiak, 2019). BMI of approximately 21 kg/m² and body fat percentage of approximately 10 % in male taekwondo players has also been shown to be associated with elite performance. Therefore, athletes should achieve body mass change through reductions in body fat mass with minimal deterioration in muscle structure (Bridge *et al.*).

¹ Department of Coaching Education, Faculty of Sport Sciences, Marmara University, 34815 Istanbul, Turkey.

² Department of Coaching Education, School of Physical Education and Sport, Halic University, 34330 Istanbul, Turkey.

Owing to these complex factors affecting performance, numerous studies have been conducted in taekwondo literature (Bridge *et al.*; Liao *et al.*; Razi; Gaamouri *et al.*; Górski & Orysiak; Cular *et al.*) from different perspectives. Although there has been increased focus on the effects of physical characteristics on the performance variables, there is a lack of research on the detailed anthropometric and body composition evaluations considering aspects such as different level of experience. Anthropometric and body composition information facilitates the design of training programs by coaches and indicates the performance potential of an athlete. Therefore, further investigations are needed.

In light of the above considerations, we aimed to compare anthropometric and body composition characteristics of international level players with a group formed by medalist/non-medalists in European championship level athletes. A further goal of the study was to present detailed anthropometric and body composition characteristics of Turkish national team taekwondo players. Such a definition of the success-related fitness profile structure in taekwondo may have both scientific and practical value.

MATERIAL AND METHOD

Participants. A total of 21 male black belt elite taekwondo athletes, 16 to 20 years of age from the Turkish national team volunteered to participate in the study. The sample included three 3rd Dan grades, sixteen 2nd Dan grades, and two 1st Dan grades. All participants regularly competed in World Taekwondo Federation international level events (e.g. European Championship and World Championship events) under different weight categories. All participants were high-level junior and senior taekwondo athletes with over two years of experience (black belts) and trained 8.7 ± 1.4 sessions per week.

The participants were free from any lower or upper body injury or neuromuscular disorder. They were divided into two groups according to their competitive results achieved at the European Championships, namely, medalist (MEC; $n = 11$) and non-medalist (NmEC; $n = 10$). Each group consisted of athletes competing in the weight categories from 54-73 kg who had already won one or more medals in competition in the last three years. All participants reported that their right leg was dominant for kicking during matches.

The study was initiated after the necessary permissions (Protocol number: 09.2021-664) had been obtained from the Research Ethics Committee of the School

of Medicine, XXX University. All provided written consent after being informed about the purpose, procedures, and associated risks. In addition, when participants were younger than 18, their families were informed about the content of the study, and the families' written permissions were obtained later.

Procedure. This study is a cross-sectional, analytical, and descriptive study for the comparison of elite taekwondo athletes in the Turkish National Team, who are classified as medalists and non-medalists according to their achievements in the European Championships. The study was conducted during the competition season. The tests were assessed in a single session (i.e., 17:00 pm and 20:00 pm hours) in the same conditions. The players were requested not to perform strenuous exercise in the 24 hours before testing and to avoid drinking or eating at least three hours before measurements. The parents or participants completed a questionnaire regarding participant's personal information (training age, daily and weekly taekwondo training hours), and medical histories. All tests were conducted during the week of competition.

Anthropometric measurements and body composition assessment. Measurements involving height, body mass, length, circumferences, breadth, and skinfolds were taken by a trained investigator following the standard techniques proposed by the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart *et al.*, 2011). Measurements were taken twice while variation between them was less than 1 % for body mass, stature, girths, and breadths with the variability of less than 5 % for skinfolds. The technical error of measurement was <2 % for all skinfolds and <1 % for all bone breadths, limb girths, and length.

All participants were examined while wearing sports shorts and barefoot. Height was measured to the nearest 0.1 cm on a portable stadiometer (Seca stadiometer 213) and body mass to the nearest 0.1 kg using a calibrated scale (Seca 714, Hamburg, Germany). Five lengths [sitting height, arm span, humerus length, front arm (olecranon+acromelion) femur, and calf], eight circumferences (upper arm relaxed, upper arm flexed and tensed at 90° , relaxed chest, chest while breathing in, waist, hip, thigh, and calf; flexible, non-elastic metallic anthropometric tape measure, Gulick measuring tape, model J00305, Lafayette Instrument, U.S.A.; accurate to 0.1 cm), and four diameters (humerus, femur, biacromial and bitrochanteric; bicondylar caliper, GPM, SiberHegner Ltd., Zurich, Switzerland; accurate to 0.1 cm) and six skinfolds (subscapular, triceps, biceps, suprailiac, abdominal, and calf; skinfold caliper, Holtain Ltd, Crosswell,

Crymych, UK.; accurate to 0.1 mm, total amplitude of 85 mm, and pressure of 10 g•mm⁻²), were also collected from each participant. Skinfold thicknesses were taken from the right side of the body, regardless of handedness or stance. Lower and upper limbs bone breadths, limb girths, and length measurements were taken bilaterally.

BMI was calculated by dividing weight by height squared (kg/m²). The sum of 6 skinfolds was also determined. Body composition was determined by skinfold measurements. BF % was calculated with formulas developed by Slaughter *et al.* (1988) [0.735 x (triceps+medial calf)+1]. The following equations of VanItallie *et al.* (1990) were utilized to assess the proportion of Fat Mass (FM), Fat-Free Mass (FFM), Fat Mass Index (FMI), and Fat-Free Mass Index (FFMI): FM (kg) = [PBF/100] × weight (kg); FFM (kg) = Weight (kg) -FM (kg); FMI (kg/m²) = FM/Height² (m²); FFMI (kg/m²) = FFM/Height² (m²).

Ethics Approval. All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by Ethics Committee of the School of Medicine, Marmara University (approval number: 09.2021.664)

Statistical analysis. Data are expressed as mean and standard deviation (SD), values. The fit to a normal distribution was examined using the Shapiro-Wilk Test. Levene's test was used to ensure the homogeneity of variances. The Mann-Whitney U Test was used for inter-group evaluations. To reduce the risk of Type I error, the level of significance was set at p≤0.01 rather than p≤0.05. The SPSS version 19.0 was used for all analyses (SPSS, Inc., Chicago, IL, USA).

RESULTS

Descriptive statistics of the present study including demographic and training characteristics are shown in Table I. There was no statistically significant difference (p>0.01) among the results related to physical characteristics (age, height, body mass, BMI) of both groups; further, these results were determined to be homogeneous of medalist and non-medalist groups (Table I). It was found that the weekly training volume (number) and daily training volume (hour/day) was higher in the medalist group (p<0.01). No significant differences in length, circumference, diameters (Table II), at six-side

Table I. Comparisons for participants' characteristics, skinfold-thickness measurements at six sites and body composition by group.

Characteristic Variables		MEC (n = 11)	NmEC (n= 10)	PValue
		M±SD	M±SD	
Participant's Characteristics	Age (year)	16.86±0.71	18.00±1.42	0.072
	Height (cm)	1.79±0.06	1.77±0.07	0.291
	Body mass (kg)	61.34±6.29	60.77±9.27	0.398
	BMI (kg/m ²)	19.11±1.45	19.39±2.03	0.888
	Weekly training volumes (number)	10.73±2.41	6.60±2.95	0.005*
	Training volume (hours/day)	3.64±0.81	2.40±0.84	0.006*
Skinfolds (mm)	Subscapula	7.64±1.31	7.41±1.43	0.525
	Triceps	6.32±1.68	6.82±1.22	0.548
	Biceps	3.85±0.67	3.24±0.48	0.022
	Suprailiac	9.05±2.12	9.64±3.62	0.724
	Abdominal	7.98±1.76	9.45±2.38	0.105
	Calf	7.05±1.35	7.37±1.97	0.621
Body composition	Skinfold total	41.9±6.53	43.9±7.82	0.805
	Percent body fat (%)	10.83±1.61	11.43±2.04	0.526
	Total body fat (kg)	6.66±1.39	6.92±1.58	0.725
	Fat-free mass (kg)	54.67±5.37	53.85±8.44	0.360
	Fat mass index (kg/m ²)	2.08±0.41	2.21±0.42	0.481
	Fat-free mass index (kg/m ²)	17.04±1.19	17.18±1.90	0.725

^aMann Whitney U Test; * Significant differences between groups (P < 0.01); M=Mean SD=Standard Deviation; MEC=Medalist in the European Championships; NmEC= Non-medalist in the European Championships.

skinfold-thickness measurements, and body composition parameters (Table I) were observed between MEC and NmEC group players ($p < 0.01$). Physical characteristics of

the medalist and non-medalist players were found to be similar. Accordingly, results for the groups were found to be homogeneous.

Table II. Comparisons for length, circumference, and diameters measurements by groups.

	Characteristic	SEC (n = 11)	NmEC (n = 10)	^a P Value
	Variables	M±SD	M±SD	
Length (cm)	Sitting height	96.88±3.74	96.45±7.10	0.379
	Arm span	179.07±5.36	176.39±6.74	0.275
	Humerus- left	33.03±1.51	33.09±1.44	0.218
	Humerus-right	32.30±1.67	32.06±1.48	0.425
	Front arm-left	42.69±3.42	43.12±1.77	0.778
	Front arm-right	42.79±3.53	43.37±1.65	0.888
	Femur-right	39.43±2.96	37.35±3.30	0.193
	Femur-left	39.41±3.01	37.32±3.29	0.158
	Calf -right	38.67±1.68	37.95±2.15	0.324
	Calf -right	38.68±1.62	37.78±2.12	0.307
Circumference (cm)	Upper arm -relax -right	24.78±2.18	26.05±2.57	0.342
	Upper arm -relax -left	24.57±1.83	25.41±2.72	0.398
	Upper arm -flex- right	27.43±2.47	28.01±3.01	0.725
	Upper arm -flex- left	27.33±2.05	28.14±2.95	0.549
	Chest-relax	86.08±5.53	86.66±5.57	0.805
	Chest-breath	91.15±4.48	91.32±4.96	1.000
	Waist	70.95±2.52	70.50±5.09	0.438
	Hip	90.28±3.69	87.81±3.74	0.159
	Thigh-right	45.38±3.49	47.64±3.61	0.130
	Thigh -left	44.03±3.04	47.71±2.87	0.014
Diameters (cm)	Calf-right	34.24±2.28	35.00±4.92	0.673
	Calf-left	34.67±2.54	33.95±2.75	0.418
	Humerus-right	6.57±0.16	6.62±0.60	0.719
	Humerus-left	6.63±0.24	6.41±0.49	0.287
	Femur-right	9.18±0.56	9.26±0.42	0.524
	Femur-left	9.16±0.50	9.25±0.46	0.647
	Biacromial	42.35±2.19	42.11±3.45	0.360
	Bitrochanteric	34.91±1.06	33.84±1.94	0.129

^aMann Whitney U Test; * Significant differences between groups ($P < 0.01$); M=Mean SD=Standard Deviation; MEC=Medalist in the European Championships.

DISCUSSION

This study aimed to determine anthropometric and body composition characteristics of the medalist and non-medalist male taekwondo athletes competing at the European championship level. In addition, the morphological characteristics of Turkish national team taekwondo players are presented in detail.

The main finding in this study was that the above mentioned performances and parameters of the are similar for these groups of athletes. To the best of our knowledge, this is the first study that has morphological characteristics of the medalist and non-medal elite taekwondo athletes at the European championship level.

Anthropometric characteristics (Formalioni *et al.*, 2020), body fat percentage, and body fat mass are used as basic data to, directly and indirectly, evaluate the performance of athletes (Kim *et al.*, 2015). Taekwondo is also a weight division game: the physical characteristics of athletes are a critical factor of winning or losing (Kim *et al.*). Therefore, in the present study, besides the technical levels of our athletes, they were also evaluated in terms of anthropometric characteristics (length, diameter, circumference measurements) and body composition components (percent body fat, total body fat, fat-free mass, fat mass index, fat-free mass index) which are important performance factors. Considering all anthropometric characteristics and body composition components, our study revealed that there is no significant difference between medalist and non-medalist elite taekwondo players. These results are in line with other research in taekwondo, in which it was determined that there was no difference in anthropometric measurements between selected and unselected athletes for the 2008 Beijing Olympic games, and that height, body mass, and lean body mass may not be the determinant of Olympic selection in a relatively homogeneous sample of athletes (Wheeler *et al.*, 2012).

Concerning body height, while lengths between 170 cm and 183 cm for adult male elite athletes are reported, they are accompanied by relatively high standard deviations. Body weight ranges significantly between 60 and 75 kg in adult male athletes. This large variability is at least partially related to the weight categories in taekwondo; however, within a weight category, athletes of different lengths can excel. BMI around 21 kg/m² for males appears to be associated with elite Taekwondo player's performance (Bridge *et al.*). The mean values of body height, body mass, and BMI recorded in the present study corroborate the values reported by previous studies and that are

recommended to facilitate performance and maintain good health status (Bridge *et al.*).

Optimal body features of athletes are required according to the demands of different sports. Although reference values for body weight, height, and BMI (Kazemi *et al.*, 2006, 2010, 2013) as well as body composition measurements are frequently reported in the literature, especially in young and adult Olympic-level elite taekwondo players, there is scant research in the current literature (Ghorbanzadeh *et al.*, 2011) about anthropometric characteristics (length, circumference, diameter, etc.) for elite-level taekwondo athletes.

In addition to body composition components, we researched circumference, diameter, and length measurements for the upper and lower limbs of elite taekwondo players. Since our research methods were different from those of the study by Ghorbanzadeh *et al.*, a clear comparison could not be made. These detailed data are an important source of information that can improve the performance of taekwondo players, help to determine their physical preparation for competition and to monitor the effects of training and dietary interventions on anthropometric and body composition status.

Physical structure variables (for example, athletes' weight, height, and body circumference) are related to the sport and affect the skinfold thickness and muscle mass of the athletes (Kim *et al.*). In our study, the total skinfold thickness (triceps, biceps, subscapula, suprailiac, abdominal, and calf) values taken from six areas, values of elite taekwondo players with medalist (41.9 mm) and non-medalist (43.9 mm) were compared to the results of Olympic-level taekwondo players (44.7 mm) and were found to have similar values. However, although the values were higher (36.14 mm) than those of elite American taekwondo players (Pieter, 1991), they were in line with studies reporting lower TKD skinfold values (Formalioni *et al.*).

Our findings showed that medalists and non-medalists had similar percentages of body fat. Similarly, other reports found that internationally successful and less successful female taekwondo athletes have a similar percentage of body fat (Markovic *et al.*, 2008). The body fat percentage of taekwondo athletes may differ according to age group, athlete level, sex, and nutritional habits (Mathunjwa *et al.*, 2015) as well as the measurement method. Bridge *et al.* reported the percentage of body fat for taekwondo athletes from different countries, using the skinfold caliper method, but with different formulas for athletes at an international level according to various ages.

In this review study, they reported that the percentage of body fat of elite taekwondo players was between 7-18 (Bridge *et al.*). The percentage of body fat of the elite male athletes with and without medals competing in the 54-74 kg weight category constituting our study group were determined by Bridge *et al.* and are located within the lower limits of the wide range they reveal. Although different formulas or methods from those of our research were used, our results support the consensus, namely that elite taekwondo players have a low body fat percentage (Markovic *et al.*; Bridge *et al.*). Furthermore, our results are slightly lower than the previously reported values of 12.8 % (Khayyat *et al.*, 2020) and 11.8 % (Ghorbanzadeh *et al.*) in elite Turkish national team taekwondo players. While it is not possible to make a recommendation on the ideal body fat percentage for a taekwondo athlete, a low body fat percentage is desired for good performance in competitions (Bridge *et al.*; da Silva Santos *et al.*, 2018). Particularly in taekwondo, high body fat content is associated with poor performance in fast successive maximum-effort for kicks. Accordingly, one should aim to keep the amount of body fat low to maintain or improve performance (da Silva Santos *et al.*). The low percentage of body fat of our participating athletes may provide an advantage in improving their performance as well as agility and endurance (Noh *et al.*, 2013) as they participate in multiple fights in the same day.

The FFM values of the medalist (54.67 kg) and non-medalist (53.85 kg) elite athletes in our study were akin to those of the Croatian (47.6-60.2 kg) and Turkish (58.4 kg) taekwondo players with a bodyweight of 55-74 kg. Moreover, our FFMI (17.04-17.18) values were lower than the FFMI values reported for Olympic (Reale *et al.*, 2020) and national level (Dopsaj *et al.*, 2017) boxers (19.5 kg), judoka (20.8 kg) wrestlers (19.8 kg) and karate players (22.6 kg). However, Our FFMI values have also been shown to be similar to taekwondo players (17.9 kg). Our FMI values were lower than those of judo (3.9), wrestling (3.3), and karate (2.74) athletes; however, it is seen that they have similar values to taekwondo and boxers' players (2.1) (Dopsaj *et al.*; Reale *et al.*). As movement speed and coordination are essential components of successful TKD performance (Boraczyn'ski *et al.*, 2017), low BM, %BF, and adipose tissue may provide an important advantage in demonstrating technical skills (Markovic *et al.*). From this point of view, low-fat mass index, fat-free mass index and total body fat, and high fat-free mass, as well as the low percentage of body fat values demonstrate that our athletes have the appropriate athletic body composition for their sport.

Although this study has important findings, it also has some limitations. Since the sample included only elite

male taekwondo athletes in the 54-74 kg category, the results of this investigation should not be generalized to both sexes and individuals outside of the sample category. In future research, normative values for other age groups and weight categories of taekwondo competitors should be determined, and somatotype should be calculated according to weight category.

CONCLUSIONS

This study demonstrated that medalist and non-medalist elite taekwondo athletes in the European championships do not differ in terms of anthropometric and body composition components and have a similar profile. Anthropometric and body composition characteristics are not distinguishing features for elite male taekwondo athletes with and without medals in European championships. We believe our research results will help in eliminating deficiency in anthropometric, and body composition profiles, which are notably insufficient in the literature regarding elite-level taekwondo athletes with different level. Our results provide important practical applications for definition of the success-related fitness profile structure in taekwondo for the sport and the strength and conditioning of coaches, athletes, physical educators, and other individuals.

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RESUMEN: Este estudio tuvo como objetivo determinar las posibles diferencias antropométricas y perfiles de composición corporal de los peleadores de taekwondo de élite, con o sin medallas en campeonatos europeos. Veintiún atletas de taekwondo de élite de cinturón negro ($17,4 \pm 1,2$ años) del equipo nacional turco se dividieron en dos grupos, medallistas (MEC; $n = 11$) y no medallistas (NmEC; $n = 10$). Se tomaron veintiocho medidas antropométricas incluyendo altura, masa corporal, longitud, circunferencias, ancho y pliegues cutáneos siguiendo las técnicas estándar sugeridas por la Sociedad Internacional para el Avance de la Cineantropometría (ISAK). Las variables de composición corporal se evaluaron mediante mediciones del grosor de los pliegues cutáneos. Los resultados demostraron que las variables antropométricas y de composición corporal no difirieron significativamente entre los jugadores de taekwondo medallistas y no medallistas ($p > 0,01$). Nuestros deportistas tienen un bajo porcentaje de grasa corporal y un alto perfil de masa muscular. Los medallistas y no medallistas de taekwondo turcos de élite en los campeonatos europeos no difieren en términos de componentes

antropométricos y de composición corporal. Tienen un perfil de composición corporal similar adecuado para peleadores de taekwondo y dentro de rangos saludables aceptables. El presente estudio ayuda a los entrenadores en la formulación de programas de entrenamiento apropiados que apunten al desarrollo para manejar el estado de la composición corporal de los peleadores, lo que se asociará con un rendimiento de alto nivel en taekwondo. Los estudios futuros deben incluir la inspección de la composición corporal y el perfil del somatotipo en todas las categorías de peso.

PALABRAS CLAVE: Antropometría; Composición corporal; Taekwondo.

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Corresponding author:

Ani Agopyan

Goksu Mah. Cuma Yolu Cad. No:1

Marmara Universitesi

Anadoluhisari Yerleskesi Spor Bilimleri Fakultesi

PK. 34815 – Beykoz

Istanbul

TURKEY

E-mail: aniagopyan@marmara.edu.tr

ORCID: 0000-0001-6407-4648