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Sexual Dimorphism in Physical Fitness Parameters of Competitive Adolescent Taekwondo Athletes

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ABSTRACT The aim of this study was to determine gender-related differences in physical fitness parameters of adolescent competitive taekwondo athletes. Subjects were members of the National Taekwondo Team of Turkey (23 men and 19 women). Men taekwondo athletes' $MaxVO_2$ level was greater than women (54.13±3.47 versus 43.58±5.37 $ml.min^{-1}kg^{-1}$). Men taekwondo athletes' anaerobic power performance was greater than women (101.90 ±15.73 versus 73.69±12.13 kg.m/sec). Men have a better 30-meter sprint time than women (4.31±0.18 versus 4.98±0.21sec). Also, men jumped higher than women (37.17±3.43 versus 26.74±3.39 cm). The medicine ball throw distance was higher for men than women (8.51 ± 1.79 versus 6.11 ± 1.09 m). Men had a greater handgrip force than women in both hands (right and left: 45.35±9.03 kg and 32.27±5.99 kg in men; right and left: 43.08±10.44 kg and 30.24±5.64 kg, in women). In conclusion, sexual dimorphism in aerobic, anaerobic power, vertical jump performance, 30-meter sprint and muscle strength performance except for body mass index was found in adolescent competitive taekwondo athletes.

INTRODUCTION

Taekwondo is a martial art originating from Korea to train combat fighting skills of armies and individual warriors (Shirley and Gabriel 2011; Kim 2015). The martial art originated as a national Korean sport in 1971, and in 1972, Kukkiwon became the headquarters of taekwondo. Today, taekwondo, as the representative sport of Korea, and is performed by millions of practitioners in 188 countries around the world (Kim 2015). Originally, taekwondo was taught for warfare, self-defence and physical fitness (Kazemi et al. 2006). Taekwondo in the Olympics consist of 3x2-minute bouts with a 1-minute rest period between each bout. Points are given in a taekwondo competition for punches and kicks to the torso and kicks to head. A match can be won with a knock-out or points (Ball et al. 2011). Taekwondo competitions include very short periods of bursty high intensity actions that are rare, and thus athletes use anaerobic energy pathways, mainly phosphagen and lactic acid systems to generate energy for defense and attack (Shirley and Gabriel 2011).

Taekwondo is known for its high and fast kicks (Kazemi et al. 2006) since it athletes have highly explosive leg power, aerobic endurance and flexibility (Ball et al. 2011). It has been established that taekwondo's top-level performers require a high fitness level (Lin et al. 2006; Ball et al. 2011; Heller et al. 2011; Singh et al. 2015). Aiwa and Pieter (2007) reported that men and women are suggested to differ in physical characteristics believed to be related to sport performance. This phenomenon is termed "sexual dimorphism" (Laskowski 2010). Sexual dimorphism is a more important factor in physical education and sports. The gender-related functional differences ensure equal opportunity for men and women to obtain high scores or make it impossible for women to join in some sport branches (Laskowski 2010).

The aim of this study was to determine gender-related dimorphic differences in body mass index score (BMI), anaerobic power, muscle strength and cardio-respiratory fitness levels of adolescent competitive taekwonda athletes. The researchers hypothesized that there could be gender-related differences in BMI, anaerobic power, muscle strength and cardio-respiratory fitness levels of adolescent competitive taekwonda athletes.

METHODOLOGY

Subjects

Forty-two adolescent competitive taekwondo athletes were recruited for this study. Subjects signed an informed consent form before participating in the study. The mean ± standard

deviation (SD) for age, height, and weight for the 23 men were 20.04± 3.16 years, 179.35±6.50 cm, and 73.08±10.63 kg, respectively. The mean ± standard deviation for age, height and weight for the 19 women were 18.95±3.45 years, 169.48±7.24 cm, and 62.26±10.33 kg, respectively. All the subjects have participated in an international competition at least once. Also, the procedure of this study was completed during a camp, which was held for preparing for an international tournament. The subjects were assessed for their BMI, 30-meter sprint, aerobic power ($MaxVO_2$), handgrip strength (right and left), vertical jump test (VJ) test, and medicine ball throw test in terms of gender.

Procedures

Height (cm) and Weight (kg) Measurements: The height was measured to the nearest 0.1 cm by using a stadiometer. Weight was measured to the nearest 0.1 kg on an electronic scale (Seca-Corp, Birmingham, United Kingdom).

BMI (Body Mass Index): BMI was measured as body mass in kilograms divided by height in meters squared (kg/m^2) (WHO 2014).

30-meter Sprint: The 30-meter sprint test was used to measure sprint performance. The sprint time for 30 meters was measured using a photocell (Newtest 300 Series Powertimer, Finland). The faster time was saved for additional analysis (Imai et al. 2014).

Aerobic Power ($MaxVO_2$): The 20-meter shuttle run test followed previously explained protocols where participants ran back and forth between two lines set 20 meters apart. The test started with 8.5 $km \cdot h^{-1}$. The tempo was arranged by an audio signal sent from a disc. Subjects were given a caveat if they did not run the line in time with the audio signal, and the test was finished if the participant could not run the line for two successive shuttles or if the participant finished voluntarily. Completed shuttles were converted to total distance covered and velocity at exhaustion for statistical analysis. According the results from the study, the value of max VO_2 was found to be $ml/kg/min^{-1}$ (Leger et al. 1982).

Handgrip Strength: The handgrip strength of the dominant hands was evaluated using a handgrip dynamometer (Takei, Tokya, Japon). The test was carried out twice for both hands. 30-second resting intervals were ensured between measurements and the highest score was saved (ACSM 2000).

Vertical Jump Test: Subjects jumped using the countermovement jump technique. The jumps were performed on a jumping platform (Newtest, Oulu, Finland) where flight and touching the floor periods were determined. Every athlete jumped thrice and the highest records were used to analyze the jumping performance (Gelen et al. 2008).

Anaerobic power was calculated using the Lewis formula (Tamer 2000; Zorba and Saygin 2009), which is:

$P=(\sqrt{}\ 4.9 \times \text{body mass (kg)} \times \sqrt{}\text{Vertical jump})$

Where,

P = Anaerobic power (kg-m/sec)

D = Vertical jump (cm)

Medicine Ball Throw: The total body power was assessed by using the medicine ball throw test (McMillian et al. 2005). The participants sat on the floor with their backs against a wall and were instructed to toss the ball as far as they could with both hands. Before each throw, the ball was covered with magnesium carbonate so that when the ball landed on the floor it left apparent signs that allowed for an exact measurement. The movement pattern for the medicine ball throw (4 kg in weight) was a backward overhead toss (Faigenbaum et al. 2006).

Statistical Analysis

Statistical measurements were carried out using the SPSS program (Version 16.0). The normal distribution was seen for all parameters. Hence, an independent t-test was used for comparing physical parameters of men and women. The significance level was accepted as $p<0.05$.

RESULTS

As it is shown in Table 1, there was no difference in ages of the men (20.04 ± 3.16 years) and women (18.95±3.45 years ($p>0.05$). However, the men were taller (179.35±6.50 cm versus 169.48±7.24 cm) than women ($p<0.001$) and heavier (73.08±10.63 kg versus 62.26±10.33 kg) than the women ($p<0.05$). There was no difference in the BMI value for men and women ($p>0.05$). There was a significant difference in max VO_2, vertical jump performance, anaerobic power, 30-meter sprint time, medicine ball throw distance and handgrip strength (both right and left hand) values for men and women ($p<0.001$). The values of

Table 1: Physical and performance characteristics of the subjects

	Gender	*N*	*Mean ± SD*	*t*	*p*
Age(years)	Men	23	20.04 ± 3.16	-1.071	0.29
	Women	19	18.95± 3.45		
Height(cm)	Men	23	179.35± 6.50	-4.64	0.000*
	Women	19	169.48± 7.24		
Body mass (kg)	Men	23	73.08±10.63	-3.325	0.002*
	Women	19	62.26±10.33		
Body Mass Index(kg/m²)	Men	23	22.76± 2.60	-1.251	0.218
	Women	19	21.73± 2.74		
MaxVO₂(ml/kg/dk)	Men	23	54.13± 3.47	-7.678	0.000*
	Women	19	43.58± 5.37		
Vertical Jump(cm)	Men	23	37.17± 3.43	-9.853	0.000*
	Women	19	26.74± 3.39		
Anaerobic Power(kg.m/sec)	Men	23	101.90±15.73	-6.397	0.000*
	Women	19	73.69±12.13		
30 m Sprint Time(sec)	Men	23	4.31± 0.18	10.688	0.000*
	Women	19	4.98± 0.21		
Medicine Ball Throw(m)	Men	23	8.51± 1.79	-5.076	0.000*
	Women	19	6.11± 1.09		
Handgrip-Right(kg)	Men	23	45.35± 9.03	-5.368	0.000*
	Women	19	32.27± 5.99		
Handgrip-Left(kg)	Men	23	43.08±10.44	-4.803	0.000*
	Women	19	30.24± 5.64		

*$p<0.05$

max VO_2, vertical jump performance, anaerobic power, 30-meter sprint time, medicine ball throw distance and handgrip strength (both right and left hand) of men taekwondo players were found to be higher as compared with women taekwondo players.

DISCUSSION

Physical fitness is the foundation of taekwondo movement, and physical deficiencies in taekwondo severely restrict technical and tactical level of play. With the improvement in the taekwondo competition level, the change in rules, as well as more attention and investment from other countries, competitions in taekwondo, which put forward higher requirements on the taekwondo athlete's fitness level, are facing increasingly fierce antagonism (Lv 2015). In this study, the researchers concluded that there are gender-related differences in anaerobic power, muscle strength and cardio-respiratory fitness levels except for BMI of adolescent competetive taekwondo athletes (Table 1). Chan et al. (2003) argued that physical characteristics are suggested to contribute to performance in many sports. Kazemi et al. (2006) informed that BMI is a reliable method to measure total body fat. However, it may overrate body fat in athletes and others who have a muscular built. Similar to this result of the study, Noor and Pieter (2007) and Noorul et al. (2008) reported that there was no difference in BMI scores of recreational adolescent Taekwondo athletes. According to Laskowski (2010), body constitution of male and female athletes performing the same sport becomes increasingly similar as female athletes are characterised by rather male silhouttes. Training promotes the development of the male type of body composition in both genders, through adipose tissue decrease and muscular development.

There are some studies in literature, which were shown in Table 2 on taekwondo and the other martial arts that compare the body mass index, performance of max VO_2, vertical jump, anaerobic power, 30-meter sprint time, medicine ball throw, handgrip strength for right and left hands between male and female.

Markovic et al. (2005) argued that taekwondo and karate use similar movement patterns and activate similar energy systems, and fitness components that are relevant to success in taekwondo that might also be of importance for performance in karate. It has been known that MaxVO_2 was widely used by the researchers to indicate the cardiovascular functional capacity (Shirley and Gabriel 2011). There are contradictory results about gender-related differences in max VO_2 char-

Table 2: Data on physical fitness parameters in martial arts athletes (For literature section)

Variables	*Researches*	*Male*	*Female*
Body Mass Index(kg/m²)	Top Caucasian taekwondo athletes (Mazic et al. 2015)	22.55± 2.53*	
	Elite Iran female Taekwondo players (aged 18-22 years) (Nazarali et al. 2015)	-	22.33 ± 1.15
	Polish National ITF Women's Taekwon-do Team (Poliszczuk et al. 2015)	-	21.04 ± 1.86
	Greek national team karate athletes (Margaritopoulos et al. 2015)	22.3± 1.9	20.1± 0.8
MaxVO₂(ml.min⁻¹kg⁻¹)	Recreational adolescent taekwondo athletes (Noorul et al. 2008)	42.18 ± 7.86	42.18 ± 7.86
	North Brazilian Mixed Martial Artists (MMA) (Oliveira et al. 2015)	44.22 ± 6.7	-
	Korean female collegiate taekwondo athletes (Kim et al. 2015)	-	45.2± 3.69
	Korean Collegiate Taekwondo athletes 20 m multistage endurance run performance (n) (Seo et al. 2015)	107.7± 9.56	77.6± 11.21
	Crotian top-quality female taekwondo competitors (Markovic et al. 2005)	-	49.6± 3.3
	Elite taekwondo athletes from the Australian National Olympic team (Ball et al. 2011)	53.29	
	Australian Olimpic Taekwondo team (Wheeler et al. 2012)	52.4 ± 6.0	
Vertical Jump (cm)	Recreational adolescent taekwondo athletes (Noorul et al. 2008)	52.07 ± 11.07	52.07 ± 11.07
	Indian elite national level male Taekwondo players (Singh et al. 2015)	36 ± 5	-
	Korean Taekwondo male club students (Yoon et al. 2015)	57.0± 12.4	
	Crotian top-quality female taekwondo competitors (Markovic et al. 2005)		32.8± 3.9
	National Tunisian Taekwondo team (Tabben et al. 2014)	43.2± 5.2	
Anaerobic Power(kg.m/sec)	Korean Collegiate Taekwondo athletes Wingate test score (Relative peak power (w/kg) (Seo et al. 2015)	10.2± 1.31	8.7± 0.61
30 m. Sprint Time (sec)	Crotian top-quality female taekwondo competitors- 20m sprint performance (Markovic et al. 2005)	-	3.6± 0.2
	Highly qualified Belgium Karate male athletes (Pion et al. 2014)	5.05 ± 0.54	-
	Highly qualified Belgium Judo male athletes (Pion et al. 2014)	4.59 ± 0.27	-
	Highly qualified Belgium Taekwondo athletes (Pion et al. 2014)	4.54± 0.29	-
	National Tunisian Judo team (Tabben et al. 2014)	4.38± 0.18	-
	National Tunisian Karate team (Tabben et al. 2014)	4.41± 0.17	
	National Tunisian Taekwondo team (Tabben et al. 2014)	4.33± 0.11	
	Elite Polish male taekwondo competitors (Sadowski et al. 2012)	5.37± 0.39	
Medicine Ball Throw (m)	Elite Polish male taekwondo competitors (Sadowski et al. 2012)	8.69± 1.71	-
Handgrip-Right(kg)	North Brazilian Mixed Martial Artists (MMA) (Oliveira et al. 2015)	4 5.9 ± 8.9	-
	Korean female collegiate taekwondo athletes (Kim et al.2015)	-	25.9± 6.63
	Korean Taekwondo male club students (Yoon et al. 2015)	39.3± 7.1	
Handgrip-Left (kg)	North Brazilian Mixed Martial Artists (MMA) (Oliveira et al. 2015)	45.8 ± 8.5	-
	Korean Taekwondo male club students (Yoon et al. 2015)	39.0± 7.9	-

acteristics of men and women athletes (Noorul et al. 2008; Shirley and Gabriel 2011; Chaabene et al. 2012). Although Doria et al. (2009) reported that there was no difference in MaxVO_2 value of top-level women and men, Karetekas and Noorul et al. (2008) reported that recreational men taekwondo players had greater aerobic endurance than women but the effect was small. The study conducted by Saygin (2014) on lightweight wrestlers (age mean: 15.29 ± .84), found handgrip strength (31.44± 5.54), max VO_2 (47.16± 4.74), and 30-meter sprint (5.09± .37) performance and body fat (%) (5.13± 2.37).

As the researchers previously mentioned, taekwondo is characterized with high intensity alactic anaerobic activity interspersed with submaximal aerobic work (Ball et al. 2011; Shirley and Gabriel 2011). Anaerobic power is an important criterion for the sportive performance sports in which short-term explosive efforts are made (Arslan 2005). In the present study, the VJ test, 30-meter sprint test and medicine ball throw test were used to evaluate the lower body power and total body power (Sands et al. 2004; Arslan 2005; McMillian et al. 2006). The results of three tests showed that there was gender related difference in the lower body and total body power of men and women taekwondo athletes, similar with results by Noorul et al. (2008).

In the present study, the isometric grip strength was assessed using the handgrip test. A study conducted with 13 male taekwondo players (mean age: 20.10±1.60 years) in South Korea by Yoon et al. (2015) found righthand strength (39.3 ±7.1 kg), lefthand strength (39.0±7.9) and vertical jump performance (57.0±12.4 cm). Ivanovic and Dopsaj (2012) suggested that handgrip strength also presents an indicator for valid evaluation of the overall body strength. In this study, men had shown greater grip force than women for hands (p=0.000). However, the researchers could not reach any study during researching literature, which would explain gender-related difference in grip force of well-trained athletes. Davies et al. (1988) and Dopsaj et al. (2007) reported that there are gender-related differences in force grip of physically active subjects.

CONCLUSION

In the present results of the study, the researchers concluded that there are gender-related differences in anaerobic power, muscle strength and cardio-respiratory fitness level except for the BMI of adolescent competetive taekwondo athletes. For effective performance and success, great importance should be given to monitor pyhsical fitness parameters at regular intervals for planning training programs by coaches. These will help athletes have information about their performance and give feedback about their individual changes in physique and physical fitness.

RECOMMENDATIONS

More comprehensive studies can be completed to examine different physical, physiological and motor parameters with a greater simple size in the future. The researchers have used BMI for evaluating body composition. In future research one can use the Bioelectrical Impedance Analysis **(**BIA) or Dual Energy X-ray Absorptiometry (DEXA) for evaluating body composition.

REFERENCES

Aiwa N, Pieter W 2007. Sexual dimorphism in body composition indices in martial arts athletes. *Brazilian Journal of Biomotricity*, 1(3): 56-63.

Arslan C 2005. Relationship between the 30-second wingate test and characteristics of isometric and explosive leg strength in young subjects. *Journal of Strength and Conditioning Research*, 19(3): 658-666.

Ball N, Nolan E, Wheeler K 2011. Anthropometrical, physiological, and tracked power profile of elite taekwondo athletes 9 weeks before the Olympic competition phase. *Journal of Strength and Conditioning Research*, 25(10): 2752-2763.

Chaabene H, Hachana Y, Franchini E, Mkaouer B, Chamari K 2012. Physical and physiological profile of elite karate athletes. *Sports Medicine*, 42(10): 829-843.

Chan K, Pieter W, Moloney K 2003. Kinathropometric profile of recreational taekwondo athletes. *Biology of Sport*, 20(3): 175-179.

Davies BN, Greenwood EJ, Jones SR 1988. Gender difference in the relationship of performance in the handgrip and standing long jump tests to lean limb volume in young adults. *European Journal of Applied Physiology and Occupational Physiology*, 58: 315-320.

De Oliveira SN, Follmer B, de Moraes MA, dos Santos JOL, de Souza Bezerra E et al. 2015. Physiological profiles of north Brazilian mixed martial artists (MMA). *Journal of Exercise Physiology Online*, 18(1): 56-61.

Yoon SD, Sung DH, Park GD 2015. The effect of active core exercise on fitness and foot pressure in Taekwondo club students. *Journal of Physical Therapy Science*, 27(2): 509.

Dopsaj M, Koropanovski N,Vuckovic G, Blagojevic M, Marinkovic B et al. 2007. Maximal isometric hand grip force in well-trained university students in Serbia: Descriptive, functional and sexual dimorphic model. *Serbian Journal of Sports Sciences*, 1(4): 138-147.

Doria C, Veicsteinas A, Limonta E, Maggioni MA, Aschieri P et al. 2009. Energetics of karate (kata and kumite techniques) in top-level athletes. *European Journal of Applied Physiology*, 107: 603-610.

Faigenbaum AD, Kang J, McFarland J, Bloom JM, Magnatta J et al. 2006. Acute effects of different warm-up protocols on anaerobic performance in teenage athletes. *Pediatric Exercise Science*, 18(1): 64.

Gelen E, Saygin O, Karacabey K, Kilinc F 2008. Acute effects of static stretching on vertical jump performance in children. *International Journal of Human Sciences [Online]*, 5(1): 2-10.

Heller J, Peric T, Dlouha R, Kohlikova E, Melichna J et al. 2011. Physiological profiles of male and female taekwon-do (ITF) black blets. *Journal of Sports Sciences*, 16(3): 243-249.

Imai A, Kaneoka K, Okubo Y, Shiraki H 2014. Effects of two types of trunk exercises on balance and athletic performance in youth soccer players. *International Journal of Sports Physical Therapy*, 9(1): 47-57.

Ivanovic J, Dopsaj M 2012. Functional dimorphism and characteristics of maximal hand grip force in top level female athletes.*Collegium Antropologicum*, 36(4): 1231-1240.

Kazemi M, Waalen J, Morgan C, White RA 2006. A profile of Olympic taekwondo compotitors. *Journal of Sports Science and Medicine*, 2: 114-121.

Kim Y 2015. The effect of regular Taekwondo exercise on Brain-derived neurotrophic factor and Stroop test in undergraduate student. *Journal of Exercise Nutrition and Biochemistry*, 19(2): 73.

Kim HB, Jung HC, Song JK, Chai JH, Lee EJ 2015. A follow-up study on the physique, body composition, physical fitness, and isokinetic strength of female collegiate Taekwondo athletes. *Journal of Exercise Rehabilitation*, 11(1): 57-64.

Laskowski R 2010. Symptoms of sexual dimorphism in judoists. *Journal of Combat Sports and Martial Arts*, 1(2): 45-52.

Leger L, Lambert J 1982. A maximal multistage 20-m shuttle run test to predict VO2max. *Eur J Appl PhysiolOccup Physiol*, 49: 1-12.

Lin WL, Yen KT, Lu Doris CY, Huang YH, Chang CK 2006. Anaerobic capacity of elite Taiwanese taekwondo athletes. *Science and Sports*, 21: 291-293.

Lv Q 2015. Research on the physical fatigue recovery and training method of taekwondo athletes. *International Symposium on Social Science*, 29-30 August, 2015, Wuhan/China: Atlantis Press.

Margaritopoulos S, Theodorou A, Methenitis S, Zaras N, Donti O, Tsolakis C 2015. The effect of plyometric exercises on repeated strength and power performance in elite karate athletes. *Journal of Physical Education and Sport*, 15(2): 310-318.

Markovic G, Misigoj-Durakovic M, Trinic S 2005. Fitness profile of elite Croatian female taekwondo athletes. *Collegium Antropologicum*, 29(1): 93-99.

Mazic S, Lazovic B, Djelic M, Suzic-Lazic J, Djordjevic-Saranovic S et al. 2015. Respiratory parameters in elite athletes- does sport have an influence? *Revista Portuguesa de Pneumologia (English Edition)*, 21(4): 192-197.

MCMillian DJ, Moore JH, Hatler BS, Taylor DC 2006. Dynamic vs static-stretching warm-up: The effect on power and agility performance. *Journal of Strength and Conditioning Research*, 20(3): 492-499.

Nazarali P, Pormphamadi A, Hanachi P 2015. Effect of six weeks of resistance training (rt) and silymarin supplement on the changes in the inflammation marker interleukin 6 and psychological profile in elite female taekwondo players in Alborz Province. *International Journal of Sport Studies*, 5(1): 57-61.

Noorul HR, Pieter W, Erie ZZ 2008. Physical fitness of recreational adolescent taekwondo athletes. *Brazilian Journal of Biomotricity*, 2(4): 230-240.

Pion J, Fransen J, Lenoir M, Segers V 2014. The value of non-sport-specific characteristics for talent orientation in young male judo, karate and taekwondo athletes. *Archives of Budo*, 10: 147-152.

Poliszczuk T, Jankowska1 E, Mankowska1 M, Poliszczuk D, Omiecinskal I 2015. Profile of an ITF taekwon-do female champion team in terms of somatotype and body composition. *Archives of Budo, Science of Martial Arts*, 11: 173-185.

Sadowski J, Gierczuk D, Miller J, Cieslinski I, Buszta M 2012. Success factors in male WTF taekwondo juniors. *J Combat Sports Martial Arts*, 1: 47-51.

Sands WA, McNeal JR, Ochi MT, Urbanek TL, Jemni M et al. 2004. Comparison of the wingate and Bosco anaerobic tests. *Journal of Strength and Conditioning Research*, 18(4): 810-815.

Saygin O 2014. Examination of some physical, hematological parameters and iron status of greco-roman wrestlers in the age category of cadets by weight classes. *Anthropologist*, 18(2): 325-334.

Seo MW, Jung HC, Song JK, Kim HB 2015. Effect of 8 weeks of pre-season training on body composition, physical fitness, anaerobic capacity, and isokinetic muscle strength in male and female collegiate taekwondo athletes. *Journal of Exercise Rehabilitation*, 11(2): 101-107.

Shirley SMF, Gabriel YF 2011. Does Taekwondo training improve physical fitness? *Physical Theraphy in Sport*, 12: 100-106.

Singh A, Boyat AV, Sandhu JS 2015. Effect of a 6 week plyometric training pro-gram on agility, vertical jump height and peak torque ratio of Indian Tae-kwondo players. *Sport Exerc Med Open J*, 1(2): 42-46.

Tabben M, Chaouachi A, Mahfoudhi MH, Aloui A, Habacha H et al. 2014. Physical and physiological characteristics of high-level combat sport athletes. *Journal of Combat Sports and Martial Arts*, 1(2): 1-5.

Tamer K 2000. *Sporda Fiziksel-Fizyolojik Performansin Olculmesi ve Degerlendirilmesi*. Ankara: Bagirgan Yayimevi.

Yoon SD, Sung DH, Park GD 2015. The effect of active core exercise on fitness and foot pressure in Taekwondo club students. *Journal of Physical Therapy Science*, 27(2): 509-511.

Wheeler K, Nolan E, Ball N 2012. Can anthropometric and physiological performance measures differentiate between Olympic selected and non-selected taekwondo athletes? *International Journal of Sports Science and Engin*eering, 6(3): 175-183.

WHO 2012. From <http://www.who.int/mediacentre/factsheets/fs311/en/index.html> (Retrieved on 28 February 2014).

Zorba E, Saygin O 2009. *Fiziksel Aktivite ve Uygunluk.* Ankara: Inceler Ofset.

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