Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXIII, ISSUE 1, 2023, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

**Science, Movement and Health, Vol. XXIII, ISSUE 1, 2023**
**January 2023, 23 (1): 35-38**
**Original article**

# COMPARISON OF BODY COMPOSITION, BONE MINERAL CONTENT AND MUSCLE STRENGTH VARIABLES BETWEEN ELITE TAEKWONDO AND SWIMMING ATHLETES

**HAYRIYE ÇAKIR-ATABEK[1], CIHAN AYGÜN[1], BIRCAN DOKUMACI[1]**

**Abstract**

This study aimed to compare the body composition, bone mineral contents, and isokinetic muscle strength variables (maximum strength and muscular endurance) between young elite taekwondo and swimming athletes.

Twelve taekwondo athletes (age 16.66±2.46 years, height 167.90±7.89 cm, body mass 57.31±5.63 kg, and BMI 20.34±1.68 kg/m$^2$), and 7 swimmers (age 14.00±1.00 years, height 170.95±5.97 cm, body mass 59.98±7.76 kg, and BMI 20.44±1.53 kg/m$^2$) volunteered to participate in this study. All athletes were well trained and engaged approximately more than 8 years to the specific training (mean training experience: 8.23 ± 1.75 years). The body composition and bone mineral content were evaluated with DXA (Lunar Prodigy Pro; GE, Healthcare, Madison, WI, USA). The concentric isokinetic maximum muscle strength of the knee extensors and flexors was evaluated at angular velocity of 180$^0$/sec for 5 repetitions, and muscular endurance was evaluated at angular velocity of 180$^0$/sec for 30 repetitions using the CSMI-Humac/Norm TM – 770 model (HumacNorm Testing & Rehabilitation System) device.

Statistical analysis was done using the Univariate-ANOVA using SPSS-23.0 program, and $p<0.05$ value was taken as the significance level. The findings of the current study show that the body fat (%) was significantly higher in taekwondo athletes, consequently tissue lean (%) was significantly higher in swimmers ($p<0.05$). The bone mineral density (g/cm$^2$) was recorded significantly higher in taekwondo athletes ($p<0.05$), therefore, the bone mineral content (g) and Z-score were not significantly different between groups. The comparison of maximum torque values of knee extensors and flexors were not significantly different between groups ($p>0.05$).

On the other hand, the muscular endurance evaluated with the fatigue index was significantly different between groups: higher fatigue index values were calculated for taekwondo athletes ($p<0.05$). In consequence, body composition differs according to the sport training, and this reflects to the maximum strength and muscular endurance performance.

*Keywords:* body composition, bone mineral density, strength, isokinetic, fatigue index.

## Introduction

One group of sports which has received relatively little investigation is Olympic combat sports, including boxing, taekwondo, judo and wrestling (Reale et al., 2020). As taekwondo was incorporated in the 2000 Olympic Games as a medal sport, the zeal among participants, national governments and scientists has gained momentum (Kazemi & Pieter, 2004; Khayyat et al., 2020). Taekwondo is famous for its high and fast kicks. Competitors must have the ability to move with high velocity, speed, and power (Kazemi et al., 2006; Khayyat et al., 2020). For this reason, they must develop aerobic and anaerobic strength, muscular strength, muscular endurance, speed, and flexibility (Agopyan et al., 2022; Bridge et al., 2014). On the other hand, for swimming an athlete makes purposeful movements to cover a certain distance in the water. Water is not a natural environment for humans, for this reason, in order to pass through the water, it is essential to learn to be comfortable and to support natural floating ability. Additionally, it is essential to bring the body to its maximum swimming position with minimum effort, faster than the face (Guzman, 2007).

The strength is one the most important determinant of sportive performance which can be evaluated with many different methods. Isokinetic dynamometry tests are considered as reliable and validated methods of testing athletic strength variables. Isokinetic testing allows for isolation of dynamic ranges of motion while focusing on the function movement of the segment or limb (Jiang et al., 2013). Another important determinant of sportive performance is the body composition. Body composition testing among athletes has been performed using a variety of different methods such as skinfold testing (SKF), hydrostatic weighing (HW), and bioelectrical impedance (BIA) (Lohman & Chen, 2005). Perhaps the most promising and practical means of testing body composition is dual energy X-ray absorptiometry (DXA) (Borgard, 2010). Scanning athletes using a DXA machine allows practitioners to obtain a reliable estimate of three compartments of the athlete's mass; bone mineral content, lean mass and fat mass (Nana et al., 2012)

To determine an individual athlete's optimal body composition profile for training and competition performance, accurate assessment of body composition throughout the season is key (Mitchell et al., 2020). Additionally, endurance is the ability of an organism to perform physical effort with specific intensity and efficiency, at the same time maintaining increased resistance to fatigue. Muscle fatigue denotes a state of changing ability of a muscle to maintain a specific force level or a static body position (Danek et al., 2019). Hence, the purposes of the current study were to compare the body

[1]Department of Coaching Education, Faculty of Sports Science, Eskişehir Technical University.

composition, bone mineral content, and isokinetic muscle strength variables (maximum strength and muscular endurance) between young elite taekwondo and swimming athletes.

**Methods**

Twelve taekwondo athletes (age 16.66 ± 2.5 years, height 167.90 ± 7.9 cm, body mass 57.31 ± 5.6 kg, and BMI 20.34 ± 1.7 kg/m$^2$), and 7 swimmers (age 14.00±1.0 years, height 170.95 ± 6.0 cm, body mass 59.98 ± 7.8 kg, and BMI 20.44 ± 1.5 kg/m$^2$) volunteered to participate in this study. All athletes who compete in national and international competitions were well trained and engaged approximately more than 8 years to the specific training (mean training experience of taekwondo athletes: 8.17 ± 1.8 years; mean training experience of swimmers: 8.29 ± 1.7 years). The primary inclusion criteria were participants in good health without any medical, cardiovascular, metabolic and/or respiratory disorders. An athlete with any neuromuscular injury or impairment was excluded. Participants were asked to avoid exhaustive exercise for 24 hours before testing and were told to refrain from eating or drinking for 3 hours before testing. All participants were informed at the beginning of the study about the experimental risks and their right to withdraw from the study at any time without negative consequences, then the written consent forms were obtained from them or their parents. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Institutional Ethics Committee (protocol number: 56261). The study was conducted in the Laboratory of Human Performance of the Faculty of Sports Science at Eskişehir Technical University in Eskişehir, Turkey, and supported by University' Research Fund (Project number: 22-ADP-082).

**Body composition and bone mineral content measurements**

The body composition and bone mineral content were assessed following anthropometric measurements (height and body mass) using DXA machine (Lunar Prodigy Pro; GE, Healthcare, Madison, WI, USA). DXA scans were performed in the morning with participants presenting in a rested state (no exercise 24 h prior) and fasted for at least 3 h prior to the scan. Participants wore minimal clothing (underwear/swimwear) during the DXA scan.

**Isokinetic testing: maximum strength and muscular endurance**

Concentric isokinetic maximum strength of the knee extensors and flexors was measured using the CSMI Humac/ Norm TM -770 model (Humac Norm Testing and Rehabilitation System, USA). The dynamometer was calibrated prior to the testing session according to the procedures prescribed by the manufacturer. A 5 min warm-up consisting of cycling (Monark) preceded the actual test. Knee extension and flexion were performed with the subjects in the seated position, with their hands gripping the sides of the dynamometer chair. Stabilizing straps were placed around the thorax, pelvis and the thigh. The resistance shin pad was placed at a level just above the medial malleolus. The subjects were positioned so that the axis of rotation of the lever arm of the device coincided with the line passing transversely through the femoral condyles. The range of motion for the knee was from 90◦ to 0◦ (full extension). Five submaximal effort at angular velocity of 180$^0$/sec was performed for familiarization and warm-up purpose. After 3 min of rest the athlete performed 5 repetitions of maximal knee extensions/flexions at 180$^0$/sec. The best maximal peak torque for knee extension and flexion (out of the 5 repetitions) was calculated automatically by the Humac /2004 via computer (4.5.5 version, CSMI, USA) and served as the outcome measure. Following the maximum test performance an athlete rested for 3 min and then performed 30 repetitions at angular velocity of 180$^0$/sec for muscular endurance which was calculated through a fatigue index (work performed last 5 repetitions/work performed first five repetitions x 100) (Pincivero et al., 2001).

**Statistical analyses**

The results are expressed as the mean ± standard deviation (SD), unless otherwise stated. All data were assessed for normality of distribution with the Shapiro-Wilk test. Statistical analysis was done using the Univariate-ANOVA using SPSS-23.0 program, and $p<0.05$ value was accepted as statistically significant. A power analysis (1-β) was performed, and the effect sizes were calculated as the partial eta-squared (ηp2).

**Results**

The mean values of body composition and bone mineral content are presented in Table 1. The findings show that BFP (%) was significantly higher in taekwondo athletes ($p<0.05$). Therefore, the tissue lean (%) was significantly higher in swimmers ($p<0.05$). For the bone mineral content only, the BMD (g/cm$^2$) variable was significantly different between groups: the taekwondo athletes have higher BMD level than swimmers ($p<0.05$).

The mean values of isokinetic concentric muscle strength variables are presented in Table 2 and 3. The Table 2 shows the maximum strength values; no significant differences were observed between groups for right and left maximum strength of extensors and flexors. The Table 3 shows the muscular endurance values; the fatigue index values were significantly lower in swimmers which show that the swimmers' muscular endurance levels were higher than taekwondo athletes ($p<0.05$).

Table 1. The mean values of body composition and bone mineral content of athletes (Mean ± SD).

| | Taekwondo Gr. | Swimming Gr. | p | F | $\eta p^2$ | 1-β |
|---|---|---|---|---|---|---|
| BFP (%) | 25.39 ± 4.88 | 20.14 ± 4.47* | 0.033 | 5.413 | 0.242 | 0.593 |
| Fat (Kg) | 13.86 ± 2.86 | 11.73 ± 2.89 | 0.137 | 2.430 | 0.125 | 0.313 |
| Lean (Kg) | 40.95 ± 6.01 | 46.36 ± 6.43 | 0.083 | 3.404 | 0.167 | 0.413 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tissue lean (%) | 71.39 ± 4.47 | 76.82 ± 4.32* | 0.019 | 6.672 | 0.282 | 0.683 |
| BMC (g) | 2.44 ± 0.35 | 2.29 ± 0.29 | 0.379 | 0.817 | 0.046 | 0.137 |
| BMD (g/cm$^2$) | 1.15 ± 0.71 | 1.02 ± 0.10** | 0.005 | 10.660 | 0.385 | 0.868 |
| Z score | 1.01 ± 0.67 | 0.37 ± 0.84 | 0.085 | 3.342 | 0.164 | 0.407 |

BFP: Body fat percentage; BMC: Bone mineral content; BMD: Bone mineral density; **p<0.01 and *p<0.05 significantly different.

Table 2. The mean values of maximum isokinetic muscle strength of athletes (Mean ± SD; in Nm).

| | Taekwondo Gr. | Swimming Gr. | p | F | $\eta p^2$ | 1-β |
|---|---|---|---|---|---|---|
| Max.IS.R.Ext. | 98.25 ± 26.83 | 113.14 ± 20.01 | 0.221 | 1.615 | 0.087 | 0.224 |
| Max.IS.R.Flex. | 83.42 ± 18.55 | 75.714 ± 12.07 | 0.342 | 0.957 | 0.053 | 0.152 |
| Max.IS.L Ext. | 105.25 ± 26.76 | 111.71 ± 22.09 | 0.597 | 0.291 | 0.017 | 0.080 |
| Max.IS.L.Flex. | 84.08 ± 18.49 | 72.57 ± 15.93 | 0.188 | 1.885 | 0.100 | 0.254 |

Max.IS.R.Ext.: Maximum isokinetic strength of right extension; Max.IS.R.Flex.: Maximum isokinetic strength of right flexion; Max.IS.L.Ext.: Maximum isokinetic strength of left extension; Max.IS.L.Flex.: Maximum isokinetic strength of left flexion. No significant differences were observed.

Table 3. The mean values of muscular endurance evaluated by fatigue index of athletes (Mean ± SD; in %).

| | Taekwondo Gr. | Swimming Gr. | p | F | $\eta p^2$ | 1-β |
|---|---|---|---|---|---|---|
| ME.R.Ext. | 39.53 ± 6.33 | 22.59 ± 2.93** | 0.000 | 43.785 | 0.720 | 1.000 |
| ME.R.Flex. | 27.03 ± 8.71 | 12.95 ± 8.97** | 0.004 | 11.309 | 0.399 | 0.886 |
| ME.L.Ext. | 35.25 ± 5.83 | 17.11 ± 7.00** | 0.000 | 36.986 | 0.685 | 1.000 |
| ME.L.Flex. | 24.07 ± 7.23 | 15.63 ± 9.98* | 0.047 | 4.569 | 0.212 | 0.522 |

ME.R.Ext.: Muscular endurance for right extension; ME.R.Flex.: Muscular endurance for right flexion; ME.L.Ext.: Muscular endurance for left extension; ME.L.Flex.: Muscular endurance for left flexion; **p<0.01 and *p<0.05 significantly different.

**Discussion**

The purposes of the current study were to compare the body composition, bone mineral content, and isokinetic muscle strength variables (maximum strength and muscular endurance) between young elite taekwondo and swimming athletes. It is important to maintain a certain amount of body weight in taekwondo because it is a weight division game (sport). From this point of view, there is no such situation in swimming, but swimmers also try to maintain the optimum body composition in order to improve their performance. Body composition can impact swimming performance through numerous mechanisms including increasing total mass, which will cause a decrease in acceleration resulting from propulsive forces. Additionally, increasing total mass will increase the swimmer's surface area which will increase skin-friction drag, slowing the swimmer's velocity for the same propulsive force (Mitchell et al., 2020; Pendergast et al., 2005). The main findings of the present study determined that BFP was significantly higher in taekwondo athletes. This may be explained with the higher mean age value (16.66 ± 2.5 vs. 14.00±1.0 years) for taekwondo athletes. Significant differences in body measurements occur with age, and puberty, which may change body composition.

In a study conducted on taekwondo athletes divided into two groups according to their competitive results achieved at the European Championships (medalist and non- medalist), it has been shown that there was no significant differences between two groups for mean age (16.8 vs 18.00, respectively), BMI (19.1 vs. 19.4, respectively), and body composition components such as BFP (10.8 vs 11.4, respectively), and FFM (54.7 vs. 53.9, respectively) (Agopyan et al., 2022). Similar findings are reported by Makovic et al (2008) who compared internationally successful and less successful female taekwondo athletes and indicated that these two groups have a similar PBF values (Markovic et al., 2008). BFP may not differ between athletes with different levels of success in the same sport branch, but it may differ as a result of comparing different sports branches.

In another study body composition and bone mineral contents were compared between runners and swimmers (Borgard, 2010). Consistent with previous findings the runners had significantly greater total body BMD (p<0.05) and the swimmers had significantly greater total BFP (%) (Borgard, 2010). Findings reported that the BMD values of the male and female swimmers from a wide variety of age groups were not significantly different than age-matched, nonathlete controls, on the other hand they displayed significantly lower BMD than runners and weight-bearing athletes (Borgard, 2010). Carbuhn et al. (2010) reported similar findings in a study conducted on 67 women collegiate athletes from 5 sports (softball: n = 17; basketball: n = 10; volleyball: n = 7; swimming: n = 16; and track jumpers and sprinters: n = 17) who were scanned using DXA at 3 seasonal periods. At preseason all bone measurements (BMC and BMD) in swimmers were significantly less compared with all other athletes (Carbuhn et al., 2010). Consistent with these findings the current study shows that swimmers had significantly lower BMD values than taekwondo athletes ($p<0.05$; Table 1).

In the current study isokinetic maximum strength was measured at an angular velocity of $180^0$/sec. Theoretically, as the speed of muscle contraction increases, the force output of the muscle is reduced, indicating an inverted relationship between force and velocity during a concentric movement (Jiang et al., 2013). The speed is important for kick in taekwondo also in sprint swimming performance, that's the reason why the $180^0$/sec angular velocity was used in the current study. The findings of the present study show that the isokinetic maximum strength was not significant different between groups. On the other hand, the fatigue index which was used to interpret muscular endurance was significantly higher in taekwondo athletes, means that less resistance to fatigue.

Although this study has important findings, it also has some limitations. Since the sample included only well-trained athletes, the results of this investigation should not be generalized to individuals outside of the sample category. Future research conducted with larger athlete sample sizes may possibly be able to determine what other physiological factors (age, hormonal and metabolic variations, muscular contractions, etc.) have the most influence on such differences in body composition (Borgard, 2010).

**Conclusion**

Consequently, the body composition, bone mineral density, and isokinetic strength variables differ between the swimmer and taekwondo athletes. This reflects adaptation to sport-specific training.

**References**

Agopyan, A., Yesilcimen, T., Gocmez, H. B., Ozturk, B., Gulesce, S., Bulut, T., Gungor, K. C., Ucar, D. H., Ulucan, Y., & Cumbur, C. (2022). Comparison of Kinanthropometric Profiles of Elite Turkish Taekwondo Players With or Without Medals in European Championships. *International Journal of Morphology*, *40*(1).

Borgard, C. P. (2010). Assessing Body Composition Among Male Collegiate Runners and Swimmers Using Dual-Energy X-ray Absorptiometry (DXA). *Master's Theses and Project Reports*, 250.

Bridge, C. A., Ferreira da Silva Santos, J., Chaabene, H., Pieter, W., & Franchini, E. (2014). Physical and physiological profiles of taekwondo athletes. *Sports medicine*, *44*(6), 713-733.

Carbuhn, A. F., Fernandez, T. E., Bragg, A. F., Green, J. S., & Crouse, S. F. (2010). Sport and training influence bone and body composition in women collegiate athletes. *The Journal of Strength & Conditioning Research*, *24*(7), 1710-1717.

Danek, J., Wojtasik, W., & Szulc, A. (2019). Measurement of maximal isometric torque and muscle fatigue index of the knee muscles in male athletes. *Acta of Bioengineering and Biomechanics*, *21*(3).

Guzman, R. J. (2007). *The swimming drill book*. New World Library.

Jiang, C., Olson, M. W., & Li, L. (2013). Determination of biomechanical differences between elite and novice San Shou female athletes. *Journal of Exercise Science & Fitness*, *11*(1), 25-28.

Kazemi, M., & Pieter, W. (2004). Injuries at a Canadian National Taekwondo Championships: a prospective study. *BMC musculoskeletal disorders*, *5*(1), 1-8.

Kazemi, M., Waalen, J., Morgan, C., & White, A. R. (2006). A profile of Olympic taekwondo competitors. *Journal of sports science & medicine*, *5*(CSSI), 114.

Khayyat, H. N., Sağır, S. G., Hataş, Ö., Smolarczyk, M., & Akalan, C. (2020). Physical, physiological and psychological profiles of elite Turkish taekwondo athletes. *Biomedical Human Kinetics*, *12*(1), 187-196.

Markovic, G., Vucetic, V., & Cardinale, M. (2008). Heart rate and lactate responses to taekwondo fight in elite women performers. *Biology of Sport*, *25*(2), 135.

Mitchell, L. J., Morris, K. S., Bolam, K. A., Pritchard-Peschek, K. R., Skinner, T. L., & Shephard, M. E. (2020). The non-linear relationship between sum of 7 skinfolds and fat and lean mass in elite swimmers. *Journal of Sports Sciences*, *38*(20), 2307-2313.

Nana, A., Slater, G. J., Hopkins, W. G., & Burke, L. M. (2012). Techniques for undertaking dual-energy X-ray absorptiometry whole-body scans to estimate body composition in tall and/or broad subjects. *International Journal of Sport Nutrition and Exercise Metabolism*, *22*(5), 313-322.

Pendergast, D., Mollendorf, J., Zamparo, P., Termin 2nd, A., Bushnell, D., & Paschke, D. (2005). The influence of drag on human locomotion in water. *Undersea Hyperb Med*, *32*(1), 45-57.

Pincivero, D. M., Gear, W. S., & Sterner, R. L. (2001). Assessment of the reliability of high-intensity quadriceps femoris muscle fatigue. *Medicine and science in sports and exercise*, *33*(2), 334-338.

Reale, R., Burke, L. M., Cox, G. R., & Slater, G. (2020). Body composition of elite Olympic combat sport athletes. *European journal of sport science*, *20*(2), 147-156.