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Comparison of Body Fat, Body Mass Index and Somatotype in Racquet Players

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Abstract
The aim of this study was to compare body fat, body mass index and somatotypes in racquet players. 36 young racquet players (n=15 badminton, n=9 tennis, n=12 table tennis) with at least 5 years of experience in their current discipline participated in the research voluntarily. The Heath & Carter method was used to determine the somatotypes of the participants, and the Siri formula was used to calculate the body fat. Descriptive statistics of body profile & somatotype characteristics of racquet players and hypothesis tests used for intergroup comparisons (One Way Anova test for parametric data, Kruskal Wallis test for nonparametric data) were carried out using SigmaPlot software. Tennis players have higher body height, body weight, and lower body fat; table tennis players have the highest body fat, body mass index, endomorphy & mesomorphy score and lowest ectomorphy scores; badminton players have higher ectomorphy scores and lowest body weight, and body mass index. However, these differences were not statistically significant between the groups. In addition, badminton and tennis players have ectomorphic mesomorph (2-4-3) and table tennis players have endomorphic mesomorph (3-5-2) somatotype. As a result , although the racquet athletes included in the study show similarities in terms of body fat percentage, body mass index and somatotype, the emergence of minimal differences is an indicator that should be considered in terms of racquet sports. Research findings can be supported by increasing the number of participants in future studies.

Keywords: *Badminton, Body Fat, Somatotype, Table Tennis, Tennis*

Raket Sporcularında Vücut Yağ Yüzdesi, Vücut Kütle İndeksi ve Somatotipin Karşılaştırılması

Özet
Bu çalışmanın amacı raket sporcularının vücut yağ yüzdesi, vücut kütle indeksi ve somatotiplerinin karşılaştırılmasıdır. Çalışmaya mevcut branşında en az 5 yıl deneyime sahip 36 genç raket sporcusu (n=15 badminton, n=9 tenis, n=12 masa tenisi) gönüllü olarak katılmıştır. Katılımcıların somatotiplerinin belirlenmesinde Heath & Carter metodu, vücut yağ yüzdelerinin hesaplanmasında Siri formülü kullanılmıştır. Raket sporcularının vücut profili & somatotip özelliklerinin tanımlayıcı istatistikleri ve gruplar arası karşılaştırmalar için kullanılan hipotez testleri (parametrik veriler için One Way Anova testi, nonparametrik veriler için Kruskal Wallis test) SigmaPlot yazılımı aracılığı ile yürütülmüştür. Tenis sporcuları daha yüksek boy uzunluğu, vücut ağırlığı, vücut kütle indeksi ve daha düşük vücut yağ yüzdesine; masa tenisi sporcuları en yüksek vücut yağ yüzdesi, endomorfi & mezomorfi skoru ve en düşük ektomorfi skoruna; badminton sporcuları

ise daha yüksek ektomorfi skoru ve en düşük vücut ağırlığı ile vücut kütle indeksine sahiptir. Buna rağmen bu farklılıklar istatistiksel olarak gruplar arası anlamlı bulunmamıştır. Buna ek olarak badminton ve tenis sporcuları ektomorfik mezomorf (2-4-3) ve masa tenisi sporcuları endomorfik mezomorf (3-5-2) somatotipe sahiptir. Sonuç olarak, araştırmaya dâhil edilen raket sporcuları vücut yağ yüzdesi, vücut kütle indeksi ve somatotip bakımından benzerlik göstermekle birlikte tespit edilen minimal farkların ortaya çıkması, raket sporları açısından dikkate alınması gereken bir göstergedir. İleriki araştırmalarda katılımcı sayılarının artması ile araştırma bulguları desteklenebilir.

Anahtar kelimeler: *Badminton, Vücut yağ yüzdesi, Somatotip, Masa tenisi, Tenis*

Introduction

Evaluation of the anthropometric profiles of the athletes is important in terms of determining the morphological needs of each sport discipline (Granados et al., 2008; Silva et al., 2010; Ubago-guisado et al., 2017). In racquet sports, physical demands and sportive performance are directly related to anthropometric characteristics and body type characteristics (Robertson et al., 2018; Willem et al., 2021). In addition, determining the optimal somatotype, body fat and body mass index of athletes is an important tool for achieving optimal performance and good health (Dimitrova & Ivanova-Pandourska, 2022). Since the competitions in racquet sports include explosive strength, agility skills and there are high-intensity intervals, examining the anthropometric features by scoring them according to body type can contribute to the evaluation of the effect of the athlete's body structure on sportive performance (Bourgois et al., 2000; Lees, 2003; Paswan, 2020; Weatherwax-Fall, 2011). Selection of athletes with proper body structure and afterwards reaching a high level of performance with planned training practices can contribute to the increase in success in these sports disciplines in the following years (Poyraz & Demirkan, 2011). Besides that, with such anthropometric evaluations, it is possible to determine the current status of the athletes throughout the season and provides convenience to compare with other disciplines (Martinez-Rodriguez et al., 2015).

In previous studies, it is seen that the body compositions of badminton, tennis and table tennis disciplines were examined in pairs or separately (Ayuningtyas et al., 2021; Luna-Villouta et al., 2021; Paswan, 2020). It has been reported that the somatotype, body fat and body mass index of racquet players are closer in badminton and tennis disciplines (Korkmaz, 1996; Şenel et al., 1998; Söğüt et al., 2004). Due to differences in racket weight, court size, rally and competition times in badminton, tennis and table tennis disciplines, the anthropometric components that athletes must have and the up-to-dateness of these components are a matter of curiosity (Cenan, 2022; Çoban & Marangoz, 2018; Eyüboğlu, 2006; Zagatto et al., 2018). In

this way, it will be possible to compare somatotype and other anthropometric variables in the past. Body composition is usually quantified by laboratory (e.g. dual-energy X-ray absorptiometry [DXA], air displacement plethysmography [ADP]) and field methods (e.g. skinfold measurement, bioelectrical impedance analysis [BIA]) all of which have their own advantages and disadvantages (Sansone et al., 2022). Body composition and somatic profiles play a critical role in athlete's health and sports performance (Fields et al., 2018). In fact, somatic parameters and body composition directly affect some motoric test results of athletes (Gryko et al., 2018). In addition, routine monitoring of body composition in athletes is important to make necessary adjustments to the diet or training program (Fields et al., 2018; Karagöz, 2023). To the best of authors' knowledge, there was no research compares of anthropometric characteristics of these three racquet sports (badminton, tennis, and table tennis) in the same study and indicates the distinctive anthropometric features of these disciplines. Therefore, the aim of this current study was to compare body fat, body mass index and somatotypes in badminton, tennis and table tennis athletes.

Materials and Methods

Research Model

A comparative cross-sectional study design was implemented in this current research.

Participants

Thirty-six young racquet players (n=15 badminton players, 5 female and 10 male; n=9 tennis players, 4 female and 5 male; n=12 table tennis players, 7 female and 5 male) participated in the study voluntarily. Voluntary participation form was obtained from the 18-year-old athletes and informed consent was obtained from the athletes' parent under the age of 18. The inclusion criteria in the research were (a) participating in competitions in the youth category between the ages of 16-18 and (b) being an active athlete for at least five years. Athletes who have had any physical injury or operation in the last six months and have regularly trained in another sport discipline in the last 5 years were excluded.

Study Protocol

Athletes were informed about the research before the measurement. All measurements were taken during the competition season, before warming up and when the athlete was at rest. The measurement of an athlete took about 10 minutes.

Body height and body weight

The body height of the athletes was adjusted to touch the apex point of the head via a stadiometer (SECA 213, Germany), which shows the height of the athletes with 1 mm precision, in the standing upright position, barefoot, and the caliper sliding on the scale was recorded in cm. A weighing scale measuring body weight with an accuracy of 0.1 kg was used (SECA Colorata 760, Germany). The participants stepped on the device with bare feet wearing shorts and t-shirts, and the data were recorded in kg.

Body fat and somatotype

In the determination of body fat and somatotype, a skinfold caliper (Holtain, UK) applying pressure of 10 g/mm^2 with a sensitivity level of skinfold thickness of 0.2 mm, a sliding caliper (Holtain, UK) with a diameter measurement of 1 mm at each interval (Holtain, UK) and gullick tape (SECA 201, Hamburg, Germany) was used for circumference measurements. All measurements were taken by the same researcher from the right side of the body while the athlete was standing (only the femoral diameter was taken in the sitting position). Skinfold thickness was measured from eight regions of the body (triceps, chest, midaxillar, abdominal, subscapula, suprailiac, thigh, calf), circumference measurement from two regions (flexed biceps, calf) and diameter measurement from two regions (femur, humerus). The somatotype of the athletes was calculated by the Heath & Carter method (Heath & Carter, 1967), the body fat was calculated by the Siri's equation (Siri, 1961), and the body density (BD) was calculated by the Jackson and Pollock (Jackson & Pollock, 1978) formula.

Jackson and Pollock's (1978) formula:

BD (female)= 1.0970-0.00046971(sum of seven skinfold thicknesses)+0.00000056 (sum of seven skinfold thicknesses)^2-0.00012828 x age

BD (male)= 1.112-0.00043499 (sum of seven skinfold thicknesses)+0.00000055 (sum of seven skinfold thicknesses)^2 – 0.00028826 x age

Siri' equation (1961):

%Body fat = [(4.95/body density) - 4.50] x 100

Heath & Carter method (1967):

Endomorphy = −0.7182 + (0.1451 × X) – (0.00068 × X2) + (0.0000014 × X3), where X = (sum of triceps, subscapular, and supraspinal) × (170.18/height).

Mesomorphy = (0.858 × humerus breadth) + (0.601× femur breadth) + (0.188 × corrected arm girth) + (0.161 × corrected calf girth) − (height × 0.131) + 4.5, where corrected arm and calf circumferences are the respective limb circumferences minus the triceps and medial calf skinfolds.

Ectomorphy was calculated via three equations according to the height weight ratio (HWR): If HWR is ≥40.75, then ectomorphy =(0.732 × HWR) − 28.58; if HWR is less than 40.75 but greater than 38.25, then ectomorphy = (0.463 ×HWR) − 17.63; if HWR ≤38.25, and ectomorphy= 0.1.

Data Analysis

The descriptive statistics of the body profile and somatotype characteristics of the racquet players and the hypothesis tests used for intergroup comparisons (One Way analysis of variance for parametric data, Kruskal Wallis test for non-parametric data) were carried out using SigmaPlot 11.0 software (Systat Software, Inc, San Jose California USA). All pairwise multiple comparison procedures (Dunn's Method) was used to determine between which groups the differences occurred. Data are presented as mean, standard deviation (SD), and 95% confidence intervals (CI). Significant level was set at 5%.

Ethics of Research

The study was carried out according to the latest form of the Declaration of Helsinki and was approved by the University Ethics Committee with the code numbered 2022-118 on 30.01.2022.

Results

Table 1. The characteristics of badminton, tennis and table tennis players

		Badminton				Tennis				Table Tennis				
		n	mean	SD	95% CI	n	mean	SD	95% CI	n	mean	SD	95% CI	p
Age (year)	F	5	16.4	0.5	16.0-16.8	4	16.8	1.0	15.8-17.8	7	17.6	0.5	17.2-18.0	-
	M	10	16.9	1.0	16.3-17.5	5	16.4	0.6	15.9-16.9	5	17.3	1.0	16.4-18.2	-
	T	15	16.7	0.9	16.2-17.2	9	16.6	0.7	16.1-17.1	12	17.5	0.7	17.1-17.9	-
Age of Experience (year)	F	5	8.0	1.2	6.9-9.1	4	8.8	2.1	6.7-10.9	7	7.9	2.4	6.1-9.7	-
	M	10	8.3	2.2	6.9-9.7	5	9.4	2.6	7.1-11.7	5	9.4	2.1	7.6-11.2	-
	T	15	8.2	1.9	7.2-9.2	9	9.1	2.3	7.6-10.6	12	8.5	2.3	7.2-9.8	-
Body weight (kg)	F	5	60.4	5.3	55.8-65.0	4	67.0	4.1	63.0-71.0	7	60.0	12.7	50.6-69.4	.117
	M	10	63.7	6.5	59.7-67.7	5	65.2	4.5	61.3-69.1	5	69.2	8.0	62.2-76.2	.327
	T	15	62.6	6.1	59.5-65.7	9	66.0	4.2	63.3-68.7	12	63.9	11.6	57.3-70.5	.610
Body height (cm)	F	5	167.1	4.6	163.1-171.1	4	169.3	3.0	166.4-172.2	7	163.2	4.4	159.4-166.5	.054
	M	10	175.2	4.0	172.2-177.7	5	177.2	9.6	168.8-185.6	5	173.1	3.6	169.4-176.3	.549
	T	15	172.5	5.6	169.7-175.3	9	172.9	7.4	168.1-177.7	12	167.3	6.5	163.6-171.0	.074

Data are presented as mean, standard deviation (SD) and 95% confidence interval (CI). F: female, M: male, T: Total. $p<0.05$

Among racquet players, the highest body weight was tennis (66.0±4.2 kg) and the lowest was badminton (62.6±6.1 kg). The highest body height was tennis (172.9±7.4 cm) and the lowest was table tennis (167.3±6.5 cm). Despite these quantitative differences, the body height and body weight of racquet players did not differ significantly between groups ($p>0.05$, Table 1).

Table 2. BMI and body fat of badminton, tennis and table tennis players

		Badminton				Tennis				Table Tennis				
		n	mean	SD	95% CI	n	mean	SD	95% CI	n	mean	SD	95% CI	p
Body fat (%)	F	5	15.6	2.7	13.2-18.0	4	12.7	2.5	10.3-15.2	7	14.3	5.7	10.1-18.5	.265
	M	10	7.3	3.2	5.3-9.3	5	4.9	1.0	4.0-5.8	5	6.8	2.8	4.3-9.3	.134
	T	15	9.5	4.8	7.1-11.9	9	8.3	4.5	5.4-11.2	12	11.2	6.0	7.8-14.6	.455
BMI (kg/m^2)	F	5	21.6	1.5	20.3-22.9	4	23.5	0.9	22.6-24.4	7	22.5	4.8	18.9-26.1	.235
	M	10	20.9	1.2	20.2-21.6	5	21.0	1.0	20.1-21.9	5	23.2	3.3	20.3-26.1	.438
	T	15	21.1	1.3	20.4-21.8	9	22.1	1.6	21.1-23.1	12	22.8	4.0	20.5-25.1	.397

Data are presented as mean, standard deviation (SD) and 95% confidence interval (CI). F: female, M: male, T: Total, BMI: body mass index. $p<0.05$.

It was determined that table tennis players have the highest body mass index (BMI, 22.8±4.0 kg/m^2) and badminton players have the lowest (21.1±1.3 kg/m^2). The highest body fat belongs to table tennis players (11.2±6.0%) and tennis players have the lowest (8.3±4.5%). Although there are quantitative differences between BMI and body fat in racquet players, these differences are not statistically significant (p>0.05, Table, 2).

Table 3. Somatotype scores of badminton, tennis and table tennis players

		Badminton				Tennis				Table tennis				
		n	mean	SD	95% CI	n	mean	SD	95% CI	n	mean	SD	95% CI	p
Endomorphy (a.u.)	F	5	2.7	.5	2.3-3.1	4	2.4	.7	1.7-3.1	7	3.1	1.3	2.1-4.1	.569
	M	10	1.8	.4	1.6-2.0	5	1.7	.3	1.4-2.0	5	2.2	.7	1.6-2.8	.276
	T	15	2.1	.6	1.8-2.4	9	2.1	.6	1.7-2.5	12	2.7	1.1	2.1-3.3	.231
Mesomorphy (a.u.)	F	5	3.9	1.0	3.0-4.8	4	4.7	.5	4.2-5.2	7	4.3	1.4	3.3-5.3	.510
	M	10	4.4	.8	3.9-4.9	5	3.6	.9	2.8-4.4	5	4.7	1.5	3.4-6.0	.296
	T	15	4.2	.9	3.7-4.7	9	4.2	.9	3.6-4.8	12	4.5	1.4	3.7-5.3	.782
Ectomorphy (a.u.)	F	5	2.6	.7	2.0-3.2	4	2.0	.5	1.5-2.5	7	2.3	1.4	1.3-3.3	.688
	M	10	3.6	.6	3.2-4.0	5	3.6	1.0	2.7-4.5	5	2.4	1.6	1.0-3.8	.124
	T	15	3.3	.8	2.9-3.7	9	2.8	1.1	2.1-3.5	12	2.4	1.4	1.6-3.2	.138

Data are presented as mean, standart deviation (SD) and 95% confidence interval (CI). F: female, M: male, T: Total, a.u: arbitrary unit. p<0.05.

Table tennis players have the highest endomorphy (2.1±3.3) & mesomorphy score (3.7±5.3) and the lowest ectomorphy score (1.6±3.2), while badminton players have the highest ectomorphy score (3.3±0.8). It was determined that badminton and tennis players had similar endomorphy and mesomorphy scores (in total). However, these differences were not statistically significant between the groups (p>0.05, Table 3).

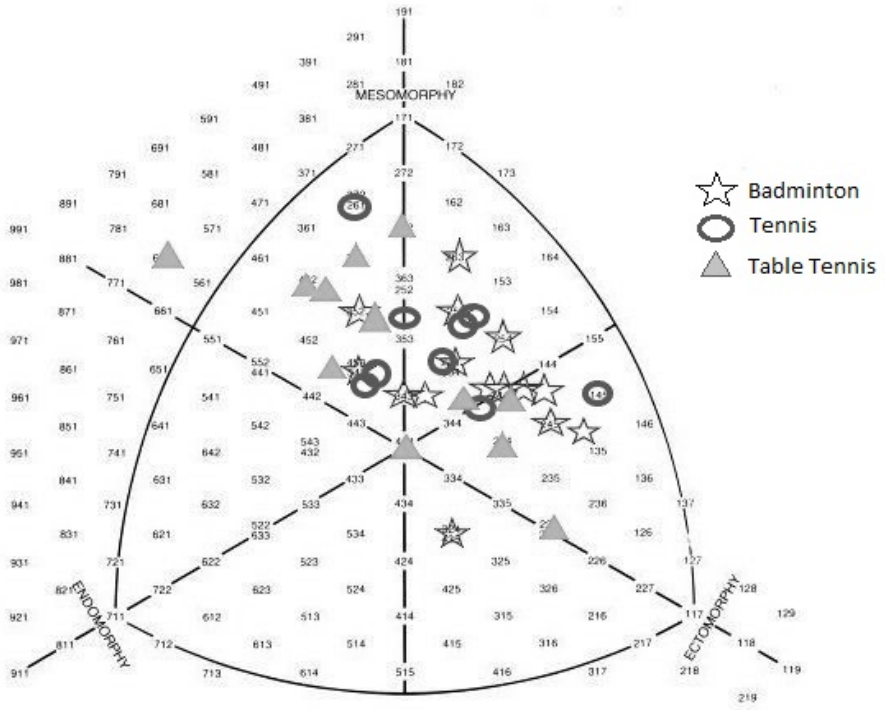

Figure 1. Distribution of somatotypes of badminton, tennis and table tennis players in somatochart

In addition, badminton and tennis players have ectomorphic mesomorph (2-4-3) and table tennis players have endomorphic mesomorph (3-5-2) somatotype (Figure 1).

Discussion and Conclusion

In this current study, it was aimed to compare body fat, BMI and somatotypes of badminton, tennis and table tennis players. There was no significant difference in body fat, BMI and somatotype among racquet players. Badminton players have the lowest BMI (21.1±1.3 kg/m^2) and table tennis players have the highest (22.8±4.0 kg/m^2). While tennis players have the lowest body fat (8.3%), table tennis players have the highest (11.2%). This data shows that table tennis players have about 35% higher body fat than tennis player.

Table 4. A summary of scientific researches about body fat, BMI and characteristics of the racquet players

Author(s) (Year)	Sports Discipline	Age (year)	Body height (cm)		Body weight (kg)		BMI ($kg.m^{-2}$)		Body fat (%)	
			F	M	F	M	F	M	F	M
Akdoğan et al. (2022)	Badminton	16-17	164	177.4	54	55	20.4	20.1	25.4	14.2
Ayuningtyas et al. (2021)	Badminton	13-19	160	166	54	55	21.1	20.0	24.3	13.9
Luna-Villouta et al.	Tennis	14-16	165	174	50	64	18.4	21.1	19.3	16.6
Paswan (2020)	Badminton	21.8	171.9		64.6		21.8		17.8	
	Tennis	22.3	171.8		69.1		23.4		19.1	
Pradas et al. (2021)	Table tennis	15-17	162	172	57	67	21.3	21.8	23.0	12.6
Yaprak (2020)	Badminton	20.3	171.4		64.7		21.9		17.6	
	Tennis	19.5	171.6		62.2		20.9		13.9	
Zaferanieh et al. (2020)	Table tennis	24	-	175	-	74	-	23.	-	12

Note: F: female, M: male. Gender was not specified in Paswan's study (2020) and Yaprak (2020) presented female and male athletes with a single average data in her research.

The summary of body fat, BMI and characteristics of racquet athletes competing in the senior and junior categories in recent years is given in Table 4. In previous research, body fat and BMI differ quantitatively among racquet athletes. These findings support our research (Akdoğan et al., 2022; Ayuningtyas et al., 2021; Luna-Villouta et al., 2021; Paswan, 2020; Pradas et al., 2021; Yaprak, 2020; Zaferanieh et al., 2020).

Table 5. A summary of scientific researches about somatotype scores of the racquet players

Author(s) (Year)	Sports Discipline	Age (year)	Endomorphy (a.u.)		Mesomorphy (a.u.)		Ectomorphy (a.u.)	
			F	M	F	M	F	M
Ayuningtyas et al. (2021)	Badminton	13-19	5.7	3.5	4.3	3.5	2.5	3.6
Luna-Villouta et al. (2021)	Tennis	14-16	3.3	3.2	3.9	4.0	3.3	4.4
Martinez-Rodriguez et al. (2015)	Tennis	21-23	-	3.3	-	4.3	-	2.5
Pradas et al. (2021)	Table	15-17	4.2	3.2	3.7	4.3	2.7	3.0
Söğüt ve Altunsoy (2019)	Tennis	15-18	4.1	-	3.4	-	2.6	-

Note: F: female, M: male, a.u.: arbitrary unit

In our study, somatotype scores of racquet players were not significantly different. In addition, badminton and tennis players have ectomorphic mesomorph (2-4-3) and table tennis players have endomorphic mesomorph (3-5-2) somatotype. Considering recent studies, many of them support our results and show that the dominant somatotype in athletes is mesomorphy (Table 5) (Ayuningtyas et al., 2021; Luna-Villouta et al., 2021; Martinez-Rodriguez et al., 2015; Pradas et al., 2021; Söğüt & Altunsoy, 2019).

Although the disciplines examined in this study are within the scope of racquet sports, it is predicted that body composition and somatotype will differ depending on the differences in game characteristics such as racquet weight, rally time, size of the playing field and the training age of the athletes, the number of weekly training sessions, and the optimum application of the technique (Söğüt & Altunsoy, 2019). As a result, in this study in which body fat percentage, BMI and somatotype of racquet players were compared, it was determined that racquet players showed similar characteristics and table tennis differed in terms of somatotype.

In this study, it is aimed to compare the body fat, BMI and somatotypes of racquet players. There is no significant difference in body fat, BMI and somatotype among racquet players. Although there is no statistically significant difference between badminton, tennis and table tennis players in terms of body mass, the highest body mass in female belongs to tennis, the lowest is table tennis players, and the highest body mass in male belongs to table tennis and the lowest is badminton players. The body height of tennis players is higher (in female, male and in total) than other racquet players in our study, and table tennis players have the lowest body height. Tennis players have the lowest body fat in female, male and total data. Badminton players have the lowest BMI, and table tennis players have the highest.

Female players are endomorphic mesomorphs in all racquet sports (badminton: 2.7-3.9-2.6, tennis: 2.4-4.7-2.0, table tennis: 3.1-4.3-2.3). In male players, except tennis players (1.7-3.6-3.6, mesomorph-ectomorph), other male racquet players have ectomorphic-mesomorph (badminton=1.8-4.4-3.6, table tennis=2.2-4.7-2.4) somatotype. In our study, somatotype scores (in total data) were determined as ectomorphic mesomorph in badminton and tennis players, and endomorphic mesomorph in table tennis players.

Tennis players have higher body height, body weight, and lower body fat; table tennis players have the highest body fat, body mass index, endomorphy & mesomorphy score and lowest ectomorphy scores; badminton players have higher ectomorphy scores and lowest body weight, and body mass index. However, these differences were not statistically significant between the groups. In addition, badminton and tennis players have ectomorphic mesomorph (2-4-3) and table tennis players have endomorphic mesomorph (3-5-2) somatotype. Although the biggest limitation of the study is the sample size, our research provides important data in the literature due to the few studies in which racquet sports are evaluated together in recent years. It is thought that the findings obtained with the increase in the number of participants in future studies will benefit the coaches in the talent selection stage. It is recommended that a

similar study be applied to different age groups and other racquet sports such as paddle tennis, ball badminton, and squash.

Ethics Committee Permission Information

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Statement of Researchers Contribution Rates

All authors contributed equally to all stages of the research.

Conflict Statement

The authors do not have a conflict statement regarding the research.

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