ORIGINAL ARTICLE

Anthropometric characteristics, body composition and somatotype of elite junior tennis players

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Objectives: The aims of this study were to describe the anthropometric characteristics, body composition and somatotype of elite male and female junior tennis players, to compare the anthropometric data, body composition and somatotype of the first 12 elite junior tennis players on the ranking with the lower ranked players, and to establish an anthropometric profile chart for elite junior tennis players.

Methods: A total of 123 (57 males and 66 females) elite junior tennis players participated in this study. The athletes were divided into two groups, the first 12 and the lower ranked players, according to gender. A total of 17 anthropometric variables were recorded of each subject.

Results: There were no significant differences in height and weight between the first 12 and the lower ranked boys, while the first 12 girls were significantly taller than the lower ranked girls ($p=0.009$). Significant differences were found for humeral and femoral breadths between the first 12 and the lower ranked girls ($p=0.000$; $p=0.004$, respectively). The mean (SD) somatotype of elite male junior tennis players could be defined as ectomesomorphic (2.4 (0.7), 5.2 (0.8), 2.9 (0.7)) and the mean (SD) somatotype of elite female junior tennis players evaluated could be defined as endomesomorphic (3.8 (0.9), 4.6 (1.0), 2.4 (1.0)). No significant differences were found in somatotype components between the first 12 and the lower ranked players of both genders.

Conclusions: When comparing the first 12 and the lower ranked elite junior tennis players of both genders, no significant differences were observed in any measured item for the boys. By contrast, significant differences were observed in height and humeral and femoral breadths between the first 12 and the lower ranked girls, whereby the first 12 were taller and had wider humeral and femoral breadths than the lower ranked players. These differences could influence the playing style of junior female players.

The interest in anthropometric characteristics, body composition and somatotype from different competitive sports has increased over the last decades. It has been well described that there are specific physical characteristics in many sports, such as the anthropometric profile, that indicate whether the player would be suitable to compete at the highest level in a specific sport.^{1–8} The quantification of morphological characteristics of elite athletes can be a key point in relating body structure to sports performance.

During the past two decades, great changes have taken place in tennis with respect to technique and tactics, and even more so with respect to the physical performance of the players. Nowadays, tennis is one of the most popular sports in the world and is extensively studied. Most of the scientific literature has focused on physiological^{9–17} and biomechanical variables,^{18–29} physical performance,^{30–33} and prevention and treatment of injuries.^{34–40} At present, there is little data on the physical characteristics of young^{41–44} and adult⁴⁵ tennis players.

Therefore, the purpose of this study was to determine the anthropometric characteristics, body composition and somatotype of elite junior tennis players, in order to use this for training and for the detection and identification of talented players.

METHODS

Subjects

The sample consisted of 123 elite junior tennis players (57 males and 66 females) from 28 national teams that competed at the 2005 and 2006 Davis Junior Cup and Fed Junior Cup (a team competition where the best players in the world from the under 16 category take part). The subjects were grouped according to gender and results; the first 12 players and the

lower ranked players. The latter difference was made in order to separate the sample according to playing level, as even though all the tennis players studied had been training for more than 6 years at 16 h/week (tables 1 and 2), at the international level there are still differences between the best teams and the lower ranked teams in number of training hours per week or number of competitions carried. We aimed to separate the teams at the highest position in the final classification (quarter final, semi-final and final) from the lower ranked players. Therefore, the first 12 subjects studied were a representative sample of the best junior players of the world, and the best in the individual rankings.

The mean (SD) somatotype of elite male junior tennis players evaluated could be defined as ectomesomorphic (2.4 (0.7), 5.2 (0.8), 2.9 (0.7)), ranging from 1.4–3.9 for endomorphy, 3.0–7.5 for mesomorphy and 1.5–5.2 for ectomorphy. The mean (SD) somatotype of elite female junior tennis players evaluated could be defined as endomesomorphic (3.8 (0.9), 4.6 (1.0), 2.4 (1.0)), ranging from 2.4–5.7 for endomorphy, 2.6–6.8 for mesomorphy and 0.7–4.6 for ectomorphy. No significant differences were found in somatotype components between the first 12 and the lower ranked players of both genders. Figures 1 and 2 illustrate the somatotypes for all the studied elite male and female junior tennis players.

Tables 3 and 4 give the anthropometric profile charts of elite male and female junior tennis players. The scores for 17 anthropometric dimensions are located on the chart together with the corresponding percentile values.

Abbreviations: DEXA, dual x ray absorptiometry; ISAK, International Society for the Advancement of Kinanthropometry; TEM, technical error of measurement

Table 1 Descriptive anthropometric characteristics for male junior tennis players (mean (SD) and range), and differences among the first 12 and the lower ranked players

	All male junior tennis players (n = 57)		First 12 players (n = 12)		Lower ranked players (n = 45)		p Value
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	
Age (years)	16.2 (0.4)	14.8–16.7	16.4 (0.2)	16.0–16.7	16.1 (0.4)	14.8–16.7	NS
Height (cm)	176.8 (6.4)	163.2–195.2	176.9 (7.1)	166.3–192.4	176.7 (6.3)	163.2–195.2	NS
Weight (kg)	69.9 (6.8)	51.4–86.3	70.4 (6.1)	60.9–82.3	69.8 (7.0)	51.4–86.3	NS
BMI (kg/m ²)	22.3 (1.4)	19.3–26.0	22.5 (0.8)	21.6–24.1	22.3 (1.5)	19.3–26.0	NS
Breadth (cm)	182.1 (6.7)	165.1–197.6	182.4 (6.6)	174.8–197.6	182.1 (6.8)	165.1–196.5	NS
Triceps skinfold (mm)	9.5 (2.7)	5.3–15.9	8.8 (1.9)	6.1–12.3	9.6 (2.9)	5.3–15.9	NS
Biceps skinfold (mm)	4.3 (1.2)	2.8–7.9	4.0 (0.7)	3.0–5.5	4.4 (1.3)	2.8–7.9	NS
Subscapular skinfold (mm)	8.3 (1.7)	5.4–14.1	7.7 (1.1)	6.5–10.5	8.5 (1.8)	5.4–14.1	NS
Suprailiac skinfold (mm)	12.9 (4.5)	6.4–24.6	12.4 (3.1)	7.5–18.0	13.0 (4.9)	6.4–24.6	NS
Supraspinal skinfold (mm)	7.6 (2.7)	4.5–16.6	7.1 (1.0)	5.3–9.3	7.9 (2.9)	4.5–16.6	NS
Abdominal skinfold (mm)	11.3 (4.5)	5.8–25.2	9.8 (1.7)	6.9–12.6	11.7 (4.9)	5.8–25.2	NS
Thigh skinfold (mm)	10.7 (2.7)	6.6–17.3	10.1 (2.0)	7.5–13.4	10.9 (2.8)	6.6–17.3	NS
Calf skinfold (mm)	8.2 (2.3)	5.1–17.0	7.9 (1.9)	5.5–10.9	8.3 (2.4)	5.1–17.0	NS
Upper arm girth (cm) †	28.7 (1.7)	23.9–32.1	28.9 (1.0)	27.3–30.5	28.7 (1.8)	23.9–32.1	NS
Upper arm girth (cm) ††	30.7 (1.8)	26.9–34.4	30.6 (0.9)	29.4–32.6	30.7 (1.9)	26.9–34.4	NS
Thigh girth (cm)	51.2 (2.5)	44.0–56.3	51.9 (2.0)	49.1–56.3	51.0 (2.6)	44.0–56.1	NS
Calf girth (maximum) (cm)	37.3 (1.8)	33.0–41.3	37.6 (1.7)	34.8–40.8	37.2 (1.8)	33.0–41.3	NS
Humeral breadth (cm)	7.2 (0.4)	6.4–8.0	7.2 (0.4)	6.4–7.9	7.2 (0.3)	6.6–8.0	NS
Femoral breadth (cm)	10.4 (0.5)	9.4–11.7	10.4 (0.6)	9.4–11.5	10.4 (0.5)	9.7–11.7	NS
Sum of 3 skinfolds (mm)	30.6 (8.0)	17.5–47.8	28.9 (5.3)	21.1–39.2	31.1 (8.6)	17.5–47.8	NS
Sum of 6 skinfolds (mm)	65.6 (18.0)	36.7–111.2	61.2 (9.5)	47.3–81.1	66.8 (19.5)	36.7–111.2	NS
Sum of 8 skinfolds (mm)	78.1 (20.3)	45.0–125.9	73.0 (10.9)	56.0–96.1	79.4 (22.0)	45.0–125.9	NS
% Body fat ⁴⁸	15.8 (3.6)	8.9–22.2	15.2 (2.4)	11.1–19.8	16.0 (3.9)	8.9–22.2	NS
% Muscle mass ⁵⁰	46.7 (1.9)	42.0–51.9	47.0 (1.7)	44.3–49.2	46.6 (2.0)	42.0–51.9	NS
Endomorphy	2.4 (0.7)	1.4–3.9	2.2 (0.4)	1.7–2.9	2.5 (0.7)	1.4–3.9	NS
Mesomorphy	5.2 (0.8)	3.0–7.5	5.3 (0.4)	4.6–5.8	5.2 (0.9)	3.0–7.5	NS
Ectomorphy	2.9 (0.7)	1.5–5.2	2.8 (0.6)	1.6–3.8	2.9 (0.8)	1.5–5.2	NS
Total years playing tennis	7.9 (1.6)	7.0–9.0	8.3 (0.9)	7.0–9.0	7.5 (1.4)	7.0–9.0	NS
Training (h/week)	23.2 (3.4)	18.0–27.0	25.6 (2.1)	23.0–27.0	22.1 (3.9)	18.0–25.0	NS

*p<0.05, **p<0.001, ***p<0.0001. NS, not significant.

†Relaxed; ††flexed and tensed.

Figure 1 Somatotype distribution of elite male junior tennis players ($n=57$). ○: mean somatotype = 2.4–5.2–2.9.

The study was approved by the Review Committee for Research Involving Human Subjects of the University of Granada, and oral as well as written information was given. Before measurement, written informed consent was obtained from each participant and coach.

Data collection

Measurements were performed following the standardised techniques adopted by the International Society for the Advancement of Kinanthropometry (ISAK).⁴⁷ All measurements were taken by the same investigator, an anthropometrist accredited by the ISAK. The technical error of measurement (TEM) was lower than 5% for skinfolds and lower than 1% for the other measurements. The instruments were calibrated prior to use and all measurements were taken on the subject's right side. Anthropometric variables included body mass, height, breadth, eight skinfolds (biceps, triceps, subscapular, suprailiac, supraspinal, abdominal, thigh and medial calf), four girths (upper arm relaxed, upper arm flexed and tensed, thigh and maximum calf), and two breadths (humeral and femoral). Height was measured on a stadiometer (GPM, Seritex, Inc., Carlstadt, New Jersey) to the nearest 0.1 cm, and the weight was recorded on a portable scale (model 707, Seca Corporation, Columbia, Maryland) to the nearest 0.1 kg. Skinfolds were taken using a calliper (Holtain Ltd, Crymych, UK) to the nearest 0.2 mm, and the girths were performed with a flexible metallic tape measure (Holtain Ltd). Skinfolds were taken three times and the average was employed in further calculations. The sum of three skinfolds (triceps, subscapular, supraspinal), six skinfolds (sum of three and suprailiac, abdominal and thigh), and eight skinfolds (sum of six and biceps and medial calf) were also calculated. BMI was calculated as weight/height² where weight was expressed in kilograms (kg) and height in metres (m). Body density was estimated using the method of Durnin and Womersley.⁴⁸ Density was transformed to percentage of body fat (%BF) by the Siri's equation.⁴⁹ Percentage of muscle mass (% MM) was determined using the method of Poortmans *et al.*⁵⁰ Somatotype was determined according to the equations of Carter and Heath.⁵¹

Statistical analysis

Standard descriptive statistics (mean, SD and range) were used to present the characteristics of the subjects for all variables. A

Figure 2 Somatotype distribution of elite female junior tennis players ($n=66$). ○: mean somatotype = 3.8–4.6–2.4.

non-parametric Mann–Whitney U test was used to compare the anthropometric data between the first 12 and the lower ranked players groups of both genders. The 5% level of probability was chosen to represent statistical significance. A profile chart with norms, using percentiles (p values of 5, 10, 25, 50, 75, 90, 95) was constructed. The statistical analysis using a statistical package was carried out (V.14.0; SPSS, Inc, Chicago, Illinois, USA).

RESULTS

Tables 1 and 2 gives the mean, SD, and ranges for the age, anthropometric characteristics, body composition, somatotype, total years playing tennis and hours of training per week for the elite male and female junior tennis players. In addition, the results of the statistical analysis for the differences between the first 12 and the lower ranked players of both genders are presented. There were no significant differences in height and weight between the first 12 and the lower ranked boys, while the first 12 girls were significantly taller than the lower ranked girls ($p=0.009$). No significant differences were observed in breadth, body mass index (BMI), skinfold thickness, girth, body composition, or somatotype between the first 12 players and the lower ranked boys, while significant differences were found for humeral and femoral breadths between the first 12 and the lower ranked girls ($p=0.000$; $p=0.004$, respectively).

DISCUSSION

A few studies have examined physical characteristics related to playing tennis.^{41–45} Our study attempts to describe the anthropometric characteristics, body composition and somatotype in a homogeneous sample (according to performance) of elite junior tennis players.

Elliot *et al.*⁴² tested a sample of male and female tennis players (age range 10–12 years) who regularly attained a semi-final position in the Western Australian Lawn Tennis Association sanctioned tournaments biannually over a 5 year period. He compared them with another sample who regularly or occasionally attended a quarter final position in the same tournaments and with non-competitive performers. In the present study, elite male and female junior tennis players were taller and heavier than those in the study by Elliot *et al.*⁴² (mean (SD) 176.8 (6.4) cm vs 169.6 (8.3) cm; 69.9 (6.8) kg vs 54.0

Table 2 Descriptive anthropometric characteristics for female junior tennis players (mean (SD and range), and differences among the first 12 and the lower ranked players

	All female junior tennis players (n = 57)			First 12 players (n = 12)			Lower ranked players (n = 45)			p Value
	Mean (SD)	Range		Mean (SD)	Range		Mean (SD)	Range		
Age (years)	15.9 (0.6)	14.2–16.7		16.1 (0.5)	14.8–16.6		15.9 (0.6)	14.2–16.7		NS
Height (cm)	165.4 (6.3)	149.7–180.0		170.0 (6.9)	156.6–180.0		164.3 (5.8)	149.7–177.3		0.009*
Weight (kg)	59.9 (6.2)	45.1–77.6		62.0 (4.4)	55.6–68.7		59.4 (6.5)	45.1–77.6		NS
BMI (kg/m ²)	21.9 (1.7)	18.7–25.4		21.5 (1.9)	19.0–24.6		22.0 (1.7)	18.7–25.4		NS
Breadth (cm)	167.9 (6.9)	153.6–186.1		170.9 (7.5)	156.5–183.2		167.3 (6.6)	153.6–186.1		NS
Triceps skinfold (mm)	16.3 (4.0)	9.3–26.1		15.8 (4.1)	11.1–25.7		16.4 (4.0)	9.3–26.1		NS
Biceps skinfold (mm)	7.4 (2.6)	3.3–17.1		7.8 (2.7)	4.9–13.1		7.3 (2.6)	3.3–17.1		NS
Subscapular skinfold (mm)	9.3 (2.4)	5.9–17.3		9.6 (2.6)	6.5–15.5		9.2 (2.4)	5.9–17.3		NS
Suprailiac skinfold (mm)	19.1 (6.0)	8.6–33.9		19.5 (7.0)	9.9–31.5		19.1 (5.9)	8.6–33.9		NS
Supraspinal skinfold (mm)	10.8 (3.7)	5.6–22.5		11.2 (4.2)	6.5–20.5		10.7 (3.6)	5.6–22.5		NS
Abdominal skinfold (mm)	17.7 (5.9)	6.9–30.3		19.0 (6.4)	9.8–28.3		17.4 (5.8)	6.9–30.3		NS
Thigh skinfold (mm)	20.4 (4.5)	10.9–31.7		18.9 (3.7)	13.1–26.7		20.8 (4.6)	10.9–31.7		NS
Calf skinfold (mm)	14.3 (3.9)	7.9–24.0		14.3 (3.1)	11.1–20.7		14.3 (4.1)	14.3–41		NS
Upper arm girth (cm) †	27.0 (1.8)	22.9–31.5		27.2 (1.5)	25.1–30.4		26.9 (1.8)	22.9–31.5		NS
Upper arm girth (cm) ††	27.9 (1.7)	24.4–31.9		28.1 (1.6)	26.0–31.1		27.9 (1.7)	24.4–31.9		NS
Thigh girth (cm)	49.7 (2.9)	43.1–57.4		49.3 (2.5)	45.3–53.9		49.8 (3.0)	43.1–57.4		NS
Calf girth (maximum) (cm)	35.7 (2.1)	31.6–40.0		36.5 (2.2)	33.4–39.1		35.6 (2.0)	31.6–40.0		NS
Humeral breadth (cm)	6.3 (0.3)	5.3–6.9		6.6 (0.2)	6.3–6.9		6.2 (0.3)	5.3–6.9		0.000**
Femoral breadth (cm)	9.8 (0.6)	8.8–11.4		10.1 (0.5)	9.3–10.8		9.7 (0.6)	8.8–11.4		0.004*
Sum of 3 skinfolds (mm)	44.7 (10.9)	25.9–67.6		44.9 (12.0)	29.4–65.0		44.7 (10.7)	25.9–67.6		NS
Sum of 6 skinfolds (mm)	102.0 (24.2)	58.7–155.5		102.2 (27.3)	64.9–147.8		102.0 (23.8)	58.7–155.5		NS
Sum of 8 skinfolds (mm)	123.7 (28.8)	73.1–190.0		124.3 (31.5)	83.5–180.9		123.6 (28.5)	73.1–190.0		NS
% body fat ⁴⁸	28.5 (3.7)	21.1–34.7		28.6 (3.9)	23.2–34.7		28.5 (3.6)	21.1–34.7		NS
% muscle mass ⁵⁰	45.2 (1.5)	41.6–49.3		44.9 (1.5)	41.6–46.6		45.3 (1.5)	42.9–49.3		NS
Endomorphy	3.8 (0.9)	2.4–5.7		3.7 (1.0)	2.6–5.5		3.8 (0.9)	2.4–5.7		NS
Mesomorphy	4.6 (1.0)	2.6–6.8		4.6 (1.2)	3.1–6.5		4.6 (0.9)	2.6–6.8		NS
Ectomorphy	2.4 (1.0)	0.7–4.6		2.9 (1.2)	0.8–4.6		2.3 (0.9)	0.7–4.2		NS
Total years playing tennis	7.2 (0.9)	6.0–8.0		8.1 (0.7)	7.0–8.0		6.9 (1.2)	6.0–8.0		NS
Training (h/week)	21.4 (2.9)	16.0–25.0		23.2 (2.3)	22.0–25.0		20.4 (2.6)	16.0–26.0		NS

*p<0.05, **p<0.001, ***p<0.0001. NS, not significant.

†Relaxed; ††flexed and tensed.

Table 3 Anthropometric profile chart for the total male junior tennis players (n = 57)

	Percentiles						
	5	10	25	50	75	90	95
Height (cm)	166.3	166.8	173.0	177.3	179.9	184.5	190.2
Weight (kg)	56.1	61.6	66.3	69.2	73.7	79.6	82.5
Breadth (cm)	172.2	174.1	177.4	182.3	186.6	190.8	193.0
Triceps skinfold (mm)	5.7	6.0	7.1	9.2	11.5	14.0	14.2
Biceps skinfold (mm)	3.0	3.1	3.2	4.1	4.9	5.7	7.0
Subscapular skinfold (mm)	5.8	6.5	7.1	8.1	9.2	10.9	11.1
Suprailiac skinfold (mm)	6.6	7.5	9.4	12.2	15.9	20.2	21.8
Supraspinal skinfold (mm)	4.7	5.2	5.8	7.1	8.4	11.1	14.7
Abdominal skinfold (mm)	5.8	6.0	8.4	10.5	13.1	16.4	22.4
Thigh skinfold (mm)	6.9	7.3	8.5	11.0	12.2	15.0	16.5
Calf skinfold (mm)	5.4	5.7	6.6	7.8	9.7	11.0	11.9
Upper arm relaxed girth (cm)	25.5	26.1	27.6	29.1	29.6	30.6	31.5
Upper arm flexed and tensed girth (cm)	27.2	27.9	29.7	30.8	31.8	32.8	33.6
Thigh girth (cm)	47.2	48.2	49.6	51.4	52.8	54.1	55.9
Maximum calf girth (cm)	34.2	34.8	36.3	37.0	38.4	39.8	40.6
Humeral breadth (cm)	6.6	6.7	7.0	7.2	7.4	7.8	7.9
Femoral breadth (cm)	9.7	9.8	10.0	10.2	10.7	11.1	11.3
Body fat (%)	9.6	10.8	13.5	15.4	18.6	21.5	22.1
Muscle mass (%)	43.9	44.6	45.2	46.6	48.0	48.9	50.8

(8.8) kg for male and 165.4 (6.3) cm vs 164.5 (7.5) cm; 59.9 (6.2) kg vs 54.2 (6.8) kg for female; respectively). In 1982, Powers and Walker⁴⁴ compiled anthropometric data of 10 women top 15 at a Louisiana Tennis Association. In agreement with the results of Power and Walker,⁴⁴ the elite junior tennis players in the present study were smaller and heavier than those (165.4 (6.3) cm vs 168.7 (2.35); 59.9 (6.2) kg vs 57.99 (2.59), respectively).

In relation to skinfolds, our results indicated that biceps and triceps skinfolds values found in our female tennis players are higher than those data reported by Powers and Walker⁴⁴ (mean (SD) 7.4 (2.6) mm vs 6.55 (1.38) mm and 16.3 (4.0) vs 13.2 (2.34), respectively). Also, the upper arm girth of our female tennis players was greater than those found by Power and Walker.⁴⁴

In our study, elite male and female junior tennis players tended to show a greater mesomorphic component and a lower ectomorphic component than those in the study by Elliot *et al*⁴²

(5.2 (0.8) vs 3.90 (0.99) and 2.9 (0.76) vs 4.46 (1.07) for male; 4.6 (1.0) vs 3.2 (0.97) and 2.4 (1.0) vs 3.4 (1.17) for female; respectively). Similar results were found in respect to the somatotype components observed in the study of Elliot *et al*,⁴³ who analysed a total of 866 leading junior tennis players (516 males and 350 females), aged 10–17 years.

Leone and Larivière⁴⁶ studied 35 male regional level tennis players, aged 12–17 years (14.5 (1.5) years), but they did not discriminate by age group. Our male subjects were taller (176.8 (6.3) cm vs 165.6 (11.5) cm) and heavier (69.9 (6.8) cm vs 54.8 (11.0) cm). Also, our males showed greater upper arm (28.7 (1.7) cm vs 26.5 (3.0) cm) and calf (37.3 (1.8) cm vs 34.4 (2.6) cm) girth than those studied by Leone and Larivière.⁴⁶

Leone *et al*⁴¹ identified the anthropometric and biomotor variables of 15 regional level female tennis players aged 13.9 (1.3) years. Our female subjects were taller (165.4 (6.3) cm vs 161.0 (96.0) cm) and heavier (59.9 (6.2) kg vs 50.6 (8.3) kg). Also, our females showed greater upper arm (27.0 (1.8) cm vs

Table 4 Anthropometric profile chart for the total female junior tennis players (n = 66)

	Percentiles						
	5	10	25	50	75	90	95
Height (cm)	153.4	157.0	161.6	165.4	168.9	174.6	178.0
Weight (kg)	48.6	51.8	55.8	60.0	64.3	66.7	68.4
Breadth (cm)	155.3	158.3	163.3	168.2	172.4	176.6	178.8
Triceps skinfold (mm)	10.4	11.1	13.5	15.5	19.7	21.5	24.9
Biceps skinfold (mm)	4.1	4.5	5.4	7.2	8.9	11.2	12.9
Subscapular skinfold (mm)	6.2	6.6	7.5	8.8	10.7	12.9	14.0
Suprailiac skinfold (mm)	10.7	11.3	13.9	18.9	23.4	26.7	30.6
Supraspinal skinfold (mm)	6.1	6.6	8.1	10.1	12.4	16.2	19.4
Abdominal skinfold (mm)	8.4	9.7	13.3	17.2	22.8	26.5	28.3
Thigh skinfold (mm)	12.8	13.8	17.6	20.6	23.0	25.8	28.1
Calf skinfold (mm)	9.2	9.8	11.1	13.5	17.3	20.1	22.5
Upper arm relaxed girth (cm)	23.5	24.8	25.8	27.0	28.0	29.0	30.3
Upper arm flexed and tensed girth (cm)	24.9	25.7	26.7	28.0	29.0	30.1	31.2
Thigh girth (cm)	44.2	45.5	47.6	50.0	51.6	53.7	54.2
Maximum calf girth (cm)	32.0	33.1	34.4	35.8	37.2	38.6	39.1
Humeral breadth (cm)	5.8	6.0	6.1	6.3	6.5	6.7	6.9
Femoral breadth (cm)	8.8	9.0	9.3	9.7	10.1	10.7	10.8
Body fat (%)	22.2	23.2	25.0	28.9	31.5	33.1	34.4
Muscle mass (%)	42.9	43.6	44.0	45.3	46.2	46.7	48.7

What is already known on this topic

- The interest in anthropometric characteristics, body composition and somatotype from different competitive sports has been increasing in recent years.
- It is well documented that for many sports there are specific physical characteristics that indicate suitability to compete in that sport at the highest level, the anthropometric profile being an important selective factor for success in sport.
- Quantification of the physiques of top athletes is a reference point in relating body structure and sports performance, and at present there is little data on the physical characteristics of junior and senior tennis players at the highest level.

What this study adds

- Our study consists of a greater sample size (123 elite junior tennis players of the best teams: 57 males and 66 females) than other similar studies.
- The sample source is important as the subjects were the best junior players in the world at the time of study.
- The best players were compared with lower ranks to ascertain if any key point could be found with regard to anthropometric variables.
- The study was carried out during the most important competitions in the world for junior category (the Davis Cup and Fed Cup), so all the players should be in top physical shape.
- The somatotype for this category has never been elucidated previously.

25.5 (2.8) cm) and calf (35.7 (2.1) cm vs 34.0 (2.8) cm) girth than those studied by Leone *et al.*⁴¹

The different characteristics of the best female junior tennis players of our study—taller, heavier, and with wider humeral and femoral breadths—compared with the lower ranked players, suggest this could nowadays influence playing style in this category for this gender. This style is more aggressive, as increased height is an advantage when serving or when trying to reach the balls in emergency situations. By contrast, the profile in male junior tennis players is more homogeneous than in the female players.

Sanchis-Moysi *et al.*⁴⁵ studied body composition of professional tennis players by using DEXA (dual x ray absorptiometry) measurement, which is not comparable with the anthropometric method generally used.

With respect to the anthropometric data observed in studies of others racquet sports, the elite male junior tennis players of our study were taller and heavier than the Asian elite squash players⁵² aged 20.7 (2.5) years (176.8 (6.4) cm vs 172.6 (4.3) cm and 69.9 (6.8) kg vs 67.7 (6.9) kg, respectively) and than male badminton players⁵³ of national level aged 24.3 (4.1) years (176.8 (6.4) cm vs 175.4 (5.4) cm and 69.9 (6.8) kg vs 64.8 (6.9) kg, respectively). Finally, when comparing the tennis players of the present study with the top class senior squash players evaluated by Jaski and Bale,⁵⁴ our athletes were smaller and heavier than those, and showed smaller girths,

greater skinfold thicknesses, and similar somatotype components.

The main limitation of this kind of study is that the results have to be taken into account as a point of reference, but should not be taken as an obligatory model for better performance. In this way, the results presented can be used as a standard reference, but should be interpreted with caution according to individual characteristics and necessities.

A longitudinal follow-up study of these characteristics and variables is recommended. Even though the DEXA method would be more accurate than anthropometrical measurements, using DEXA would not be feasible for this size of sample under competition circumstances because of the high costs and the limited availability of the subjects. We do think the large sample size (123 elite junior tennis players of the best teams) is an asset of this study compared to the other studies found in the literature. In addition, the sample source was important as the subjects were the best junior players in the world at the time of testing. Furthermore, at the time of the study, the players were competing in the most important junior competitions in the world (the junior Davis Cup and Fed Cup), and were therefore in optimal shape.

CONCLUSIONS

There were no significant differences in any of the variables studied when comparing the first 12 and the lower ranked elite male junior tennis players. However, significant differences were observed in height and humeral and femoral breadth when comparing the first 12 and the lower ranked female players, whereby the first 12 players were significantly taller than the lower ranked players, and had wider humeral and femoral breadth. These differences could influence the playing pattern in junior women, allowing a more attacking playing style.

This study provides reference values of anthropometric characteristics, body composition and somatotype of elite male and female junior tennis players. This information provides a reference frame for coaches to control the training process in order to help improve athletes' performance, and to improve talent detection and identification in tennis.

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