

Gender dependence of body composition characteristics in young Bulgarian tennis players

G.S. Nikolova^{a,b*}, A. B. Dimitrova^{c,d}, D.M. Dantchev^{a,b}

^a Institute of Mechanics, Bulgarian Academy of Sciences, Department of Biomechanics, Acad., G. Bonchev Str., Building 4, Sofia 1113, Bulgaria, email: gergana1973@gmail.com

^b Center of Competence for Mechatronics and Clean Technologies "Mechatronics, Innovation, Robotics, Automation and Clean Technologies" - MIRACle, "Acad. G. Bonchev" Str. 4, 1113 Sofia, Bulgaria

^c Institute of Experimental Morphology, Pathology and Anthropology with Museum, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 25

^d National Sports Academy "Vassil Levski", 1700 Sofia, Studentski grad 21, Acad. Stefan Mladenov Str.

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*Corresponding Author

Abstract

Objective: To investigate how the body compositions of girls' and boys' tennis players differ, since assessing these characteristics is essential to improving athletic performance. **Materials and methods:** In the current work, a total of 78 tennis players between 14 and 17 years old had their body composition characteristics measured. The athletes are divided into two groups: 34 girls tennis players and 44 boys tennis players. Body composition components were determined utilising multi-frequency bioelectrical impedance measurements, with the use of an InBody (model: 170) analyser. Every participant had to routinely compete in regional, national, or international competitions and train at least five times a week in order to be eligible. **Results:** We report the mean values and standard deviations of the height (cm), weight (kg), body mass index (BMI) (kg/m²), as well as the corresponding probability distributions of fat mass (%), fat free mass (kg), waist to hip ratio, visceral fat (level) and basal metabolic rate (kcal). **Discussion:** It's apparent how the body composition components of girls and boys tennis players differ from one another. Body fat mass (%) and fat-free mass (kg), which are considerably larger in girls tennis players than in boys tennis players, respectively, reveal the most substantial inter-group differences. **Conclusion:** The body composition profiles of tennis players must be regularly tracked in order to give coaches and athletes the information they need to create effective programs that enhance player performance and reduce the risk of injury.

Keywords: Body composition characteristics, Boys and girls tennis players, Body fat mass and visceral fat

1. Introduction

The body composition of children and adolescents is an important component of their physical traits. Body composition symbolises an individual's ability and state of health. Additionally, it provides accurate details regarding their nutritional status [1,2].

Body fat and lean body mass, the two primary components of body composition, experience substantial changes between childhood and adolescence, as seen by the age- and sex-specificity. Total body weight is calculated by adding the absolute quantities of lean body mass and body fat, both of which are given in kilograms. During childhood and adolescence, as body weight increases, so do the absolute values of lean body mass and body fat, but the ratio of the relative portions of the two components stays mostly unchanged [3,4].

Between childhood and adulthood, adolescence is a time of fast growth in terms of social, psychological, and physiological development. Young people's physical development may be influenced by outside variables, like participating in sports. Body composition has a significant role in the level of physical capacity in childhood and adolescence, as well as in adulthood. Along with an appropriate nutrition plan, tracking body fat and muscle mass is a crucial tool that, when utilised correctly and under the right supervision, may result in significant gains and successes in a variety of sports [5].

The objective of the present study is to examine the body composition profiles of adolescent tennis players by sex and to evaluate these profiles.

2. Methods

The current study evaluates the body composition parameters of 78 tennis players, ages 14 to 17. There are 34 girls tennis players and 44 boys tennis players among the participants. All athletes had to train at least five times a week and constantly compete in regional, national, or international competitions in order to be eligible.

Standard anthropometric equipment and techniques (Martin-Saller's anthropometric method, by employing GPM instruments GmbH, Switzerland) are utilised to measure each subject's body height. An InBody (model: 170) analyser with eight electrodes was used to acquire multi-frequency bioelectrical impedance measurements, which were used to calculate body weight and body composition components. Every athlete volunteered to take part in the current research. Following the principles outlined in the Declaration of Helsinki for Human Studies and Research [6], the study protocol was examined and approved by the Institute of Experimental Morphology, Pathology, and Anthropology with Museum – Bulgarian Academy of Sciences Ethical Committee (Protocol № 3/11.04.2018).

3. Results

3.1. Comparison of average height, weight, BMI, fat mass (%), fat free mass (kg), waist to hip ratio, visceral fat and basal metabolic rate.

Body height is one of the primary and most significant anthropometric measures used to evaluate an individual's physical development during their ontogenetic period, particularly during growth, is body height. It is also a crucial determinant when choosing athletes. Physical activity has less of an impact on an individual's optimal linear growth, which is largely determined by hereditary factors. During the evaluated age period, the body's linear growth grows considerably. The average height for tennis players aged 14–17 is 174.21 [cm] (SD = 7.84), while the average height for female tennis players is 169.06 [cm] (SD = 9.61). Boys are considerably higher than females of the same age throughout the evaluated period ($p \leq 0.003$; this indicates that the assertion is invalid for just 0.3% of the girls).

Body weight is one of the primary anthropometric measures used to evaluate a person's capacity, health, and physical development. Information on body weight can be used to assess each person's nutritional status, body composition, and harmonious body growth. In sports, weight is also a crucial component of successful gameplay. Weight, speed, muscle strength, frequency of arm and leg motions, flexibility, and agility are all closely related. There are no discernible sex-related variations in the mean weight values of tennis players aged 14 to 17 in either of the two evaluated groups / $x \text{ ♂} = 60.34$ [kg] (SD = 8.15), $x \text{ ♀} = 60.54$ [kg] (SD = 7.69).

Body mass index (BMI) is a metric for evaluating children's, adolescents', and adults' nutritional status. The standard method for calculating a person's BMI is to divide their weight by the square of their height. Boys aged 14–17 years had a BMI of 19.83 [kg/m²] (SD = 1.97), whereas girls had a BMI of 20.78 [kg/m²] (SD = 2.94). There were notable disparities between the sexes ($p \leq 0.001$, meaning that this is untrue for only 0.1% of girls).

Fat mass (%) - Fat mass (FM) is a key component of body composition that serves vital functions like energy storage, insulation, and protection of organs. It differs from fat-free mass, which includes muscle, bone, and water. While some fat is essential for life, an excess of fat mass can negatively impact health and performance. Several factors influence an individual's fat mass storage, like sex, age, genes, hormones, physical activity.

Fat free mass (kg) - Fat-free mass (FFM) is the total weight of your body excluding fat, and it includes muscles, bones, organs, water, and minerals. It is calculated by subtracting your body fat from your total body weight. FFM is crucial for health, as it influences your resting metabolic rate and is a key indicator of a person's overall fitness and muscle development. It is a better measure of muscle development for athletes than the standard body mass index (BMI).

Waist to hip ratio (WHR) – Waist-to-hip ratio (WHR) is a measurement that compares your waist circumference to your hip circumference to assess the amount of fat stored around your abdomen. It is calculated by dividing your waist measurement by your hip measurement. A higher WHR is linked to a greater risk of health problems like heart disease, diabetes, and hypertension, with WHO guidelines defining a high-risk ratio as over 0.90 for men and 0.85 for women.

Visceral fat (VF) - (level) - Visceral fat is body fat stored deep inside the abdomen, surrounding internal organs like the liver, stomach, and intestines. While a certain amount is necessary for cushioning organs, too much visceral fat is a serious health risk. Associated health risks include cardiovascular disease, diabetes type 2, dementia, fatty liver disease, cancer and etc.

Basal metabolic rate (BMR) – (kcal) - Basal Metabolic Rate (BMR) is the minimum number of calories your body needs to function at rest for basic life-sustaining processes like breathing, maintaining body temperature, and organ function. Factors such as age, sex, weight, height, body composition (lean mass vs. fat mass), and genetics determine an individual's BMR. BMR accounts for about 60-70% of your total daily energy expenditure.

For each group, we provide the appropriate probability distributions of the following parameters: fat mass (%), fat free mass (kg), waist to hip ratio, visceral fat and basal metabolic rate. Similar types of analyses for the height (cm), weight (kg) and body mass index (BMI) (kg/m²) for the same athlete groups have been reported in detail in [7]. Here, we complement this study with the above-mentioned body composition characteristics.

Data on the average fat mass [%], fat free mass [kg] (together with its minima, maxima, and standard deviation), and waist-to-hip ratio of all participating tennis athletes (34 girls and 44 boys), are shown in Table 1.

Table 1
Average percentage of the fat mass (%), fat free mass (kg), and waist-to-hip ratio of all participating boys and girls tennis players

n	Fat mass (%)			Fat free mass (kg)			Waist to hip ratio		
	Average	Min	Max	Average	Min	Max	Average	Min	Max
Boys 44	11.88 (SD = 4.71)	3.90	24.8	53.03 (SD = 6.51)	36.9	63.9	0.81 (SD = 0.03)	0.76	0.88
Girls 34	23.04 (SD = 7.20)	4.90	32.6	46.49 (SD = 7.44)	36.8	73.7	0.83 (SD = 0.03)	0.76	0.90

All participating boys' and girls' tennis players' average visceral fat [level] and basal metabolic rate [kJ?] (along with their minima, maxima, and standard deviation) are presented in Table 2.

Table 2
Average visceral fat (level) and basal metabolic rate (kcal) of all participating boys and girls tennis players

n	Visceral fat (level)			Basal metabolic rate (kcal)		
	Average	Min	Max	Average	Min	Max
Boys 44	2.43 (SD = 1.55)	1.0	7.0	1515.27 (SD = 140.55)	1168.0	1751.0
Girls 34	5.18 (SD = 2.18)	1.0	9.0	1374.26 (SD = 160.58)	1166.0	1963.0

Inspecting the data in Tables 1 and 2, one can conclude that the most significant difference was observed in visceral fat [kg], where girls had 50.09 % more than boys. Another characteristic where a substantial difference is detected is that of the fat mass [%], where girls had 48.43% more than boys. On the other hand, fat-free mass [kg] is 14.06% bigger in boys than in girls. Boys' waist-to-hip ratios are just 2.40% higher than the girls'. Finally, we found that the basal metabolic rate [kcal] is 10.26 % lower in girls compared to boys.

3.2. Histograms and probability density functions of the data gathered for each investigated group

For each group, we present the histograms, mean value, standard deviation, and probability density function (distribution) for the following body composition contents: fat mass [%], fat free mass [kg], waist-to-hip ratio, visceral fat [level] and basal metabolic rate [kcal].

It is important to note that the article reported the standard deviation σ for all quantities taken into consideration. If the average value is m , all observed values should fall within the interval $(m-\sigma, m+\sigma)$ with a 68.2% confidence level, assuming a normal distribution; 95% in $(m-2\sigma, m+2\sigma)$, and 99.7% in $(m-3\sigma, m+3\sigma)$.

The probability density function (Fig. 1a) and histogram (Fig. 1b) for the boys' percentage of body fat mass are shown in Fig. 1. Histogram results show that the average percentage of the fat mass in boys is 11.88 [%] with a standard deviation of 4.71 [cm]. Additionally, the bin intervals are 4.71 [cm] wide. We find that 50% of the males in the group fall into the 9.52–14.25 [%] range, and 25 [%] fall into the 4.74–9.52 range. The density of the probability distribution of the measured data can be created by dividing the width of the bin by the fraction of dimensions. Conversely, the normal probability distribution (the blue bold curve) with a standard deviation of 4.71 [%] and a calculated mean value of 11.88 [%] can be contrasted to this. We find that our data can be regarded as being normally distributed, with a good approximation.

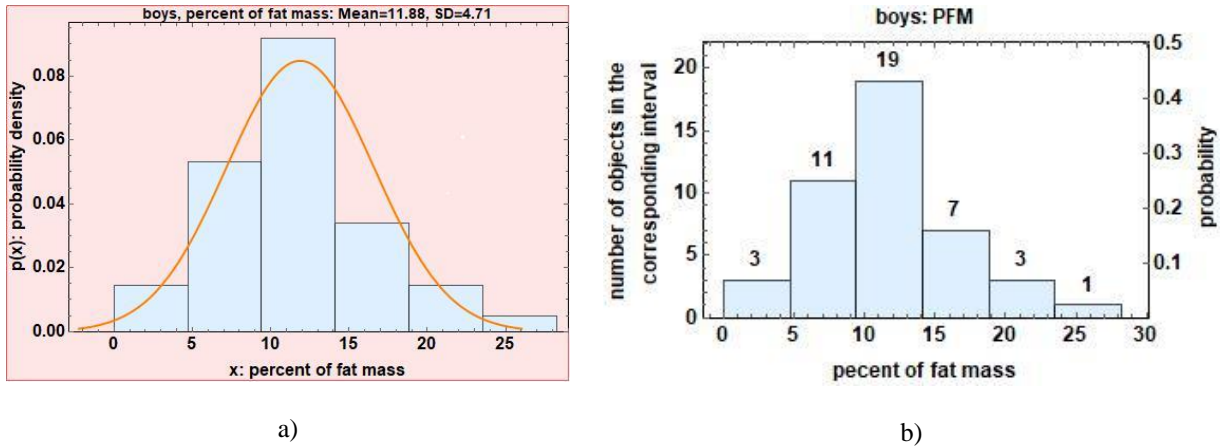


Fig. 1. Probability density function (a) and histogram (b) for the percentage of the fat mass of the boys.

The probability density function (Fig. 2a) and histogram (Fig. 2b) for the percentage of girls' fat mass are shown in Fig. 2. According to Fig. 2b, the average rate of fat mass among the girls in the group is 23.04 [%], with a standard deviation of 7.20 [%].

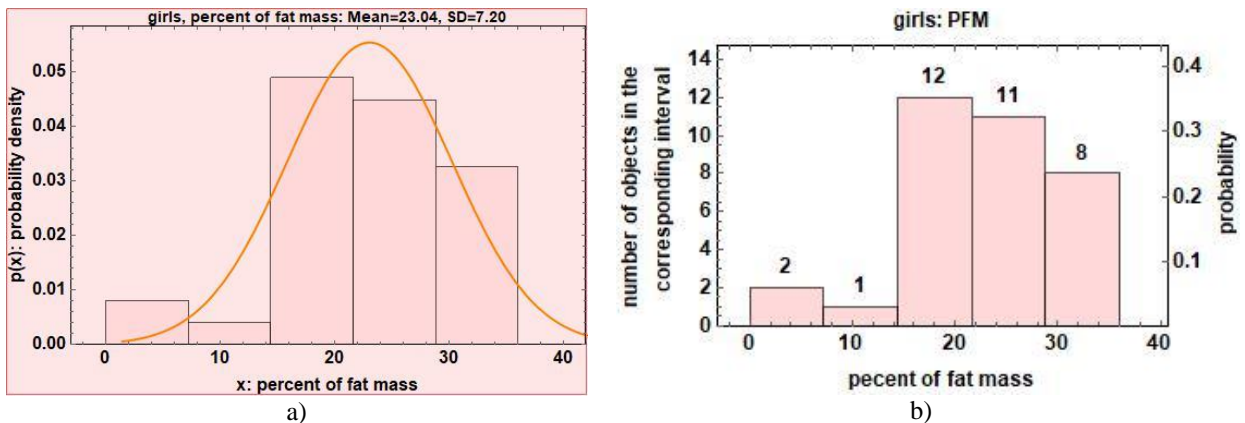


Fig. 2. Probability density function (a) and histogram (b) for the percentage of the fat mass of the girls.

Additionally, the bin intervals' width is 7.20%. About 38.23 % of the girls in the group fall into the 21.7–29.04 [%] range, while 35.29 % fall into the 14.46–21.7 [%] range. The orange bold curve in Figure 2a, which represents the normal probability distribution, is centred around the mean value of 23.04 [%].

Fig. 3 shows the boys' fat-free mass histogram (Fig. 3b) and probability density function (Fig. 3a). The average fat-free mass of the boys in the group is 53.03 [kg], with a standard deviation of 6.51 [kg], as shown in Fig. 3a. Additionally, the bin intervals are 6.51 [kg] wide. Our data illustrates that 40.9% of the boys in the group fall into the 46.74-53.06 [kg] interval, while 27.2% fall into the 53.06 to 59.5 [kg] range. The orange bold curve in Figure 3a, which represents the normal probability distribution, is centered on the mean value of 53.03[kg].

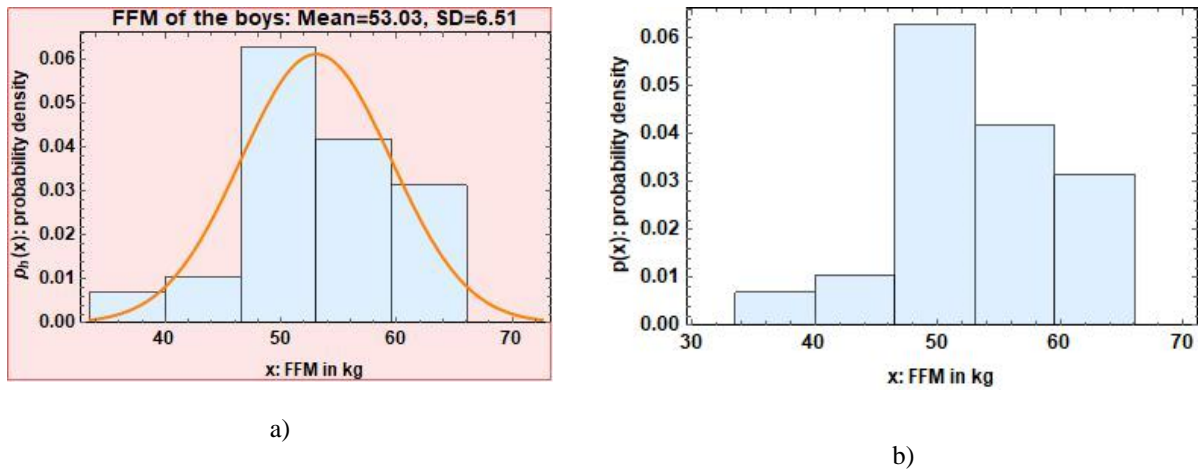


Fig. 3. Probability density function (a) and histogram (b) for the fat free mass of the boys.

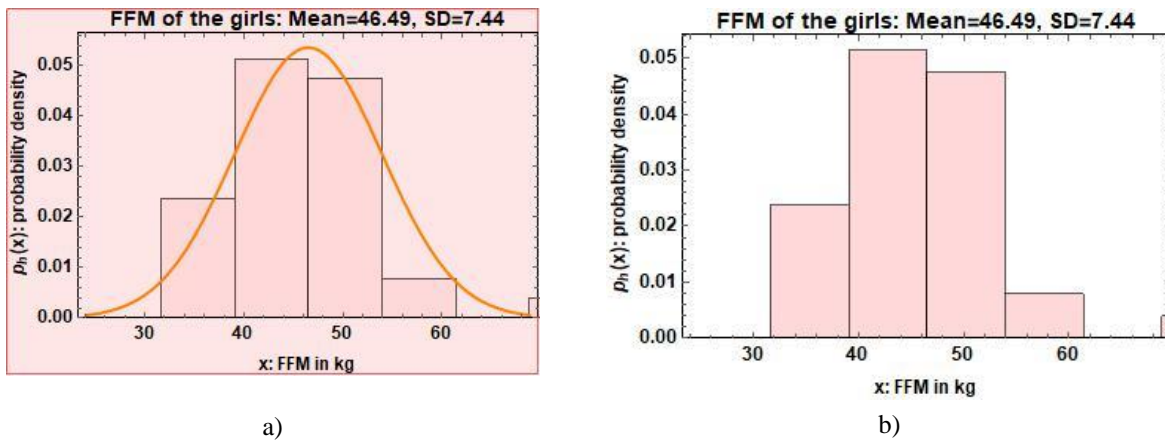


Fig. 4. Probability density function (a) and histogram (b) for the girls' fat free mass.

Fig. 4a presents the probability density function of the girls' fat free mass. The corresponding histogram of the measured data is shown in Fig. 4b. The width of the bin intervals is equal to the standard deviation of 7.44 [kg]. The normal probability distribution (the orange bold curve in Fig. 4a) is centred around the mean value of 46.49 [kg]. In the interval of 39.12 to 46.6 [kg], one observes 38.23% of the measured subjects, while in the interval of 46.6 to 53.94 [kg], they are 32.35%.

In Figure 5a, the probability density function of the boys' WHR is displayed, and in Figure 5b, the corresponding histogram of the measured data. The standard deviation of 0.03 is equivalent to the width of the bin intervals. We find that approximately 45.45% of the males have a WHR between 0.77 and 0.81, while in the interval 0.81 – 0.84, they are 20.25 %. The orange bold curve in Fig. 5a, which represents the normal probability distribution, is centred around the mean value of 0.81.

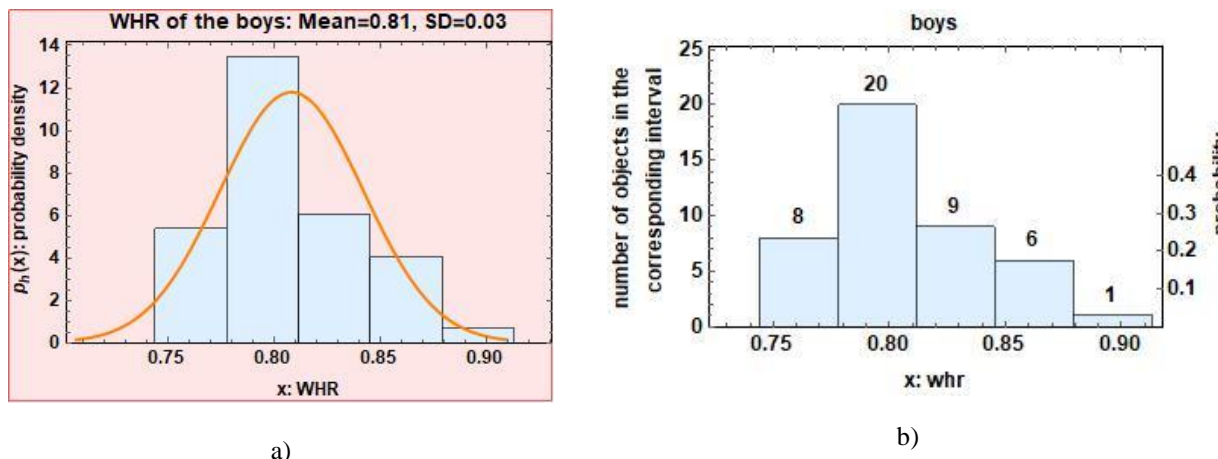


Fig. 5. Probability density function (a) and histogram (b) for the boys' WHR.

The probability density function of the girls' WHR is displayed in Fig. 6a. The corresponding histogram of the measured data is shown in Fig. 6b. The width of the bin intervals is equal to the standard deviation of 0.03, and 0.83 is the mean. A WHR of 0.80 to 0.83 is present in approximately 35.29 % of the girls, whereas a WHR of 0.83 to 0.87 is present in 18.18 %.

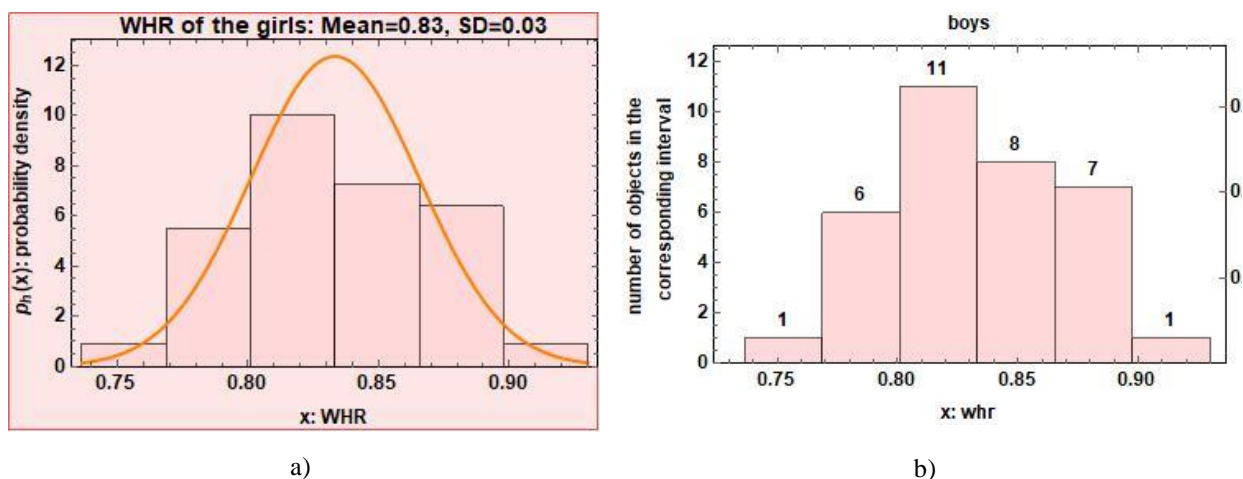


Fig. 6. Probability density function (a) and histogram (b) for the girls' WHR.

Fig. 7 shows the boys' VF histogram (Fig. 7b) and probability density function (Fig. 7a). The boys' bin width is 1.55 [kg]. The mean VF is 2.43 [kg] with a standard deviation (Fig. 7a). Evidently, 45.45% of the boys fall within the interval 1.5 and 3.16 [kg], and 36.36% of the boys fall within 0 and 1.5 [kg]. The normal probability distribution, represented by the orange bold curve in Figure 7a, is centred around the mean value of 2.43 [kg].

The girls' VF histogram (Fig. 8b) and probability density function (Fig. 8a) are presented in Fig. 8. Pursuant to Fig. 8a, the girls have a mean VF of 5.18 [kg] with a standard deviation and a bin width of 2.18 [kg]. Obviously, 47.0 % of the girls' VF are between two intervals, namely 2.2 to 4.4 [kg] and 6.6 to 8.7 [kg], while in the interval 4.4 to 6.6 [kg], one observes 38.23 %. The normal probability distribution is shown by the orange bold curve in Figure 8a, which is centred on the mean value of 2.18 [kg].

The boys' BMR histogram (Fig. 9b) and probability density function (Fig. 9a) are presented in Fig. 9. In accordance with Fig. 9a, the boys have a mean BMR of 1515.27 [kcal] with a standard deviation and a bin width of 140.55 [kcal]. Apparently, 43.18 % of the boys' BMRs are in the interval 1400 to 1550 [kcal] of the measured boys, while in the 1550 to 1688 [kcal] they are 25 %. The normal probability distribution, centred on the mean value of 140.55 [kcal], is illustrated by the orange bold curve in Fig. 9a.

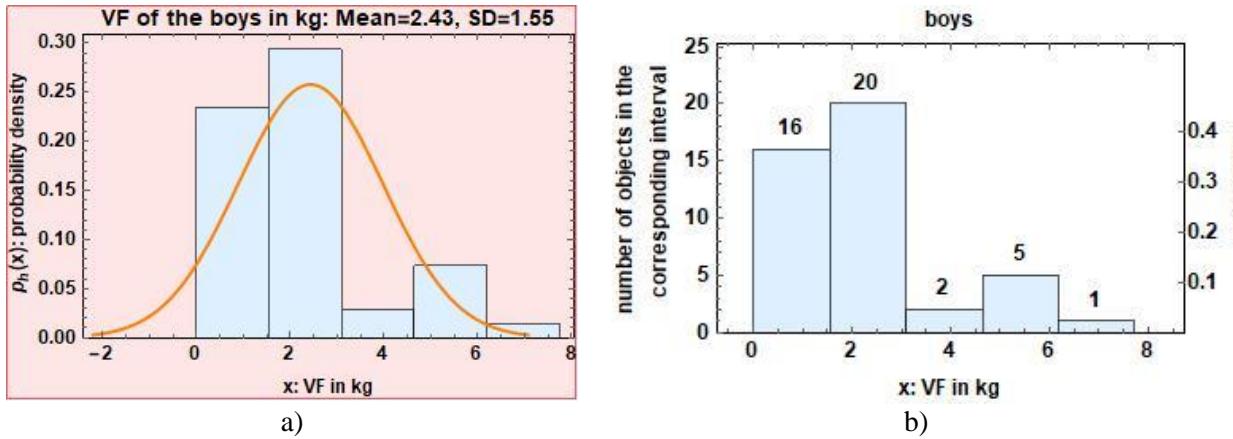


Fig. 7. Probability density function (a) and histogram (b) for the boys' visceral fat (VF).

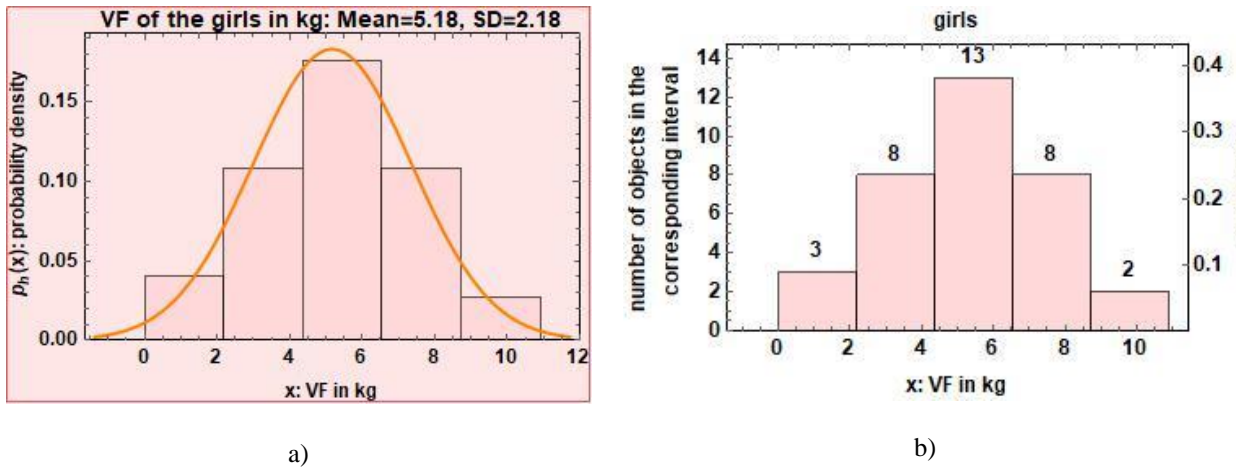


Fig. 8. Probability density function (a) and histogram (b) for the girls' visceral fat (VF).

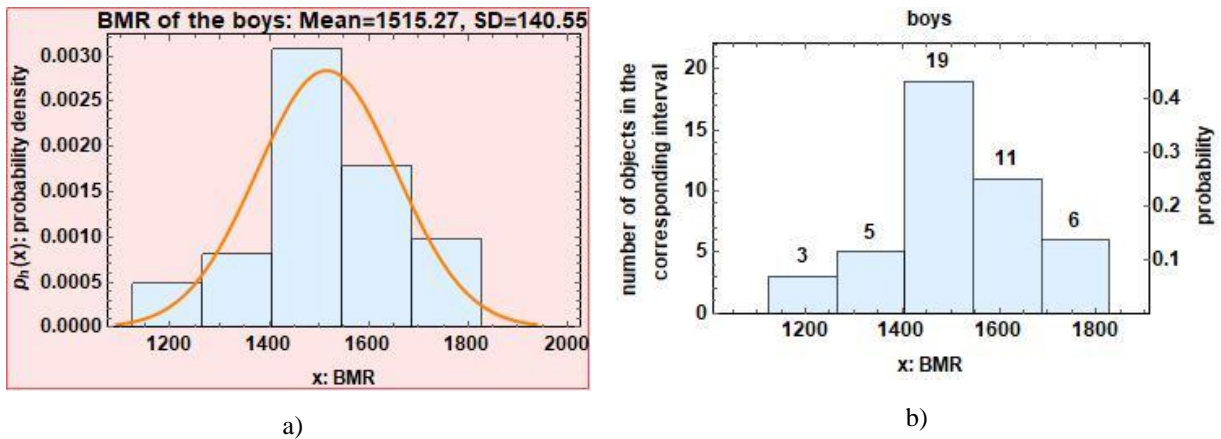


Fig. 9. Probability density function (a) and histogram (b) for the boys' basal metabolic rate (BMR).

The girls' BMR histogram (Fig. 10b) and probability density function (Fig. 10a) are displayed in Fig. 10. Fig. 10b shows that the girls' mean BMR is 1374.26 [kcal], with a bin width and a standard deviation of 160.58 [kg]. The girls' BMR is 26.47% between 1125.0 and 1291.0 [kcal], and 44.11% between 1291.0 and 1609.0 [kcal]. The normal probability distribution is represented via the orange bold curve in Fig. 10a, which is centred on the mean value of 1374.26 [kcal].

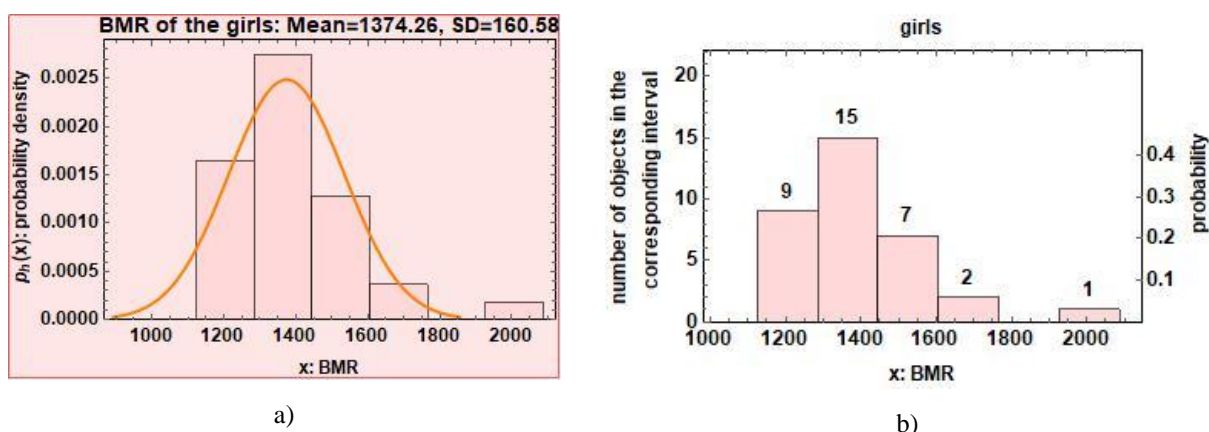


Fig. 10. Probability density function (a) and histogram (b) for the girls' basal metabolic rate (BMR).

4. Discussion and Conclusion

The present paper examines the gender dependence of body composition characteristics of girls and boys tennis players. In addition to the respective probability distributions, we provide the average values of visceral fat, fat mass, fat free mass, waist to hip ratio, and basal metabolic rate for each group.

Numerous instruments and methods, including dual-energy X-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA), and standard anthropometric tools, can be used to measure body composition [8-14]. In the current investigation, we employed BIA to monitor the alterations in young athletes' body composition. This is a prevalent and cutting-edge technique for determining body composition. The approach has been proven to be accurate for assessing the nutritional status of both healthy individuals and patients with various health conditions. Various components of body composition can be identified based on each tissue's resistance and reactance. Each tennis player's measurements were taken at least 12 hours before training and at least two hours after eating to ensure the accuracy of the study.

In sports, and especially in tennis players, the percentage of body fat (% BF) is one of the most significant and extensively researched morphological indicators. The percentage of body fat varies depending on the sport, as stated by [15]. Leading-ranking tennis players between the ages of 14 and 19 have values of 16–22% for males and 21–23% for females, according to Ref. [16]. Boys tennis players between the ages of 11 and 14 had body fat percentages of 14–15%, as determined by [17]. Young tennis players generally have a body fat percentage of 13.0%; with advancing age and improved technical ability, this proportion may diminish to between 8 and 10%. Women have a substantially higher percentage of body fat (19–21%) [18-20]. The body fat percentage of male tennis players is less than 12%; however, female tennis players might have a body fat percentage of up to 23%, as reported by [20]. The research findings of our investigation support the claims made by the other authors mentioned above. The body mass composition of the top 12 tennis players in Spain, ages 16 and under, has been calculated and compared with the outcomes of other tennis players who were below in the rankings (see Ref. [21]). Male athletes' height, weight, and BMI remained unchanged, according to the authors. Nonetheless, they found notable disparities for female athletes, with the top 12 girls in the list having priority and considerably higher muscle mass and lower fat mass values. Once more, significant gender disparities in the proportion of muscle to fat mass have been documented: the percentage of muscle mass for girls is 44–46.2%, whereas the percentage for males is 45.2–46.6% [20]. Similar findings were found for the muscular mass of Bulgarian tennis players aged 14–17: males had considerably larger values (29.6 kg) than females (25.6 kg) of the same age ($p \leq 0.001$). During childhood and adolescence, girls' body fat percentage is considerably higher than boys ($p \leq 0.001$). The biggest disparities between the sexes are observed between the ages of 14 and 17 ($p \leq 0.001$).

In summary, there is a clear distinction between the components of body composition of girls and boys tennis players. The greatest significant inter-group differences are found in visceral fat (kg) and fat mass (kg), which are significantly higher in girls tennis players than in boys tennis players, respectively. To provide athletes and coaches with information that will enable them to develop successful and profitable

programs for improved tennis performance and injury prevention, the body composition traits of tennis players must be regularly researched. Because assessing these characteristics is essential to improving athletic performance, the current study reports the variations in body composition between male and female tennis players. Young tennis players' physical development evolves according to the general tendencies set during adolescence, as seen by the better musculoskeletal development in boys and the more evenly distributed body fat in girls.

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Information about authors

Gergana S. Nikolova - PhD, Associate Professor, Department “Biomechanics”, Institute of Mechanics, Bulgarian Academy of Sciences, Akad. G. Bonchev Str. bl. 4, 1113 Sofia, Bulgaria; gergana1973@gmail.com; ORCID: 0000-0003-2435-6311

Albena B. Dimitrova - PhD, Assistant Professor, Institute of Experimental Morphology, Pathology and Anthropology with Museum, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 25; National Sports Academy “Vassil Levski”, 1700 Sofia, Studentski grad 21, Acad. Stefan Mladenov Str.; albena_84@abv.bg; ORCID: 0000-0002-6941-7133

Daniel M. Dantchev - Prof. D.Sc., Head of Department "Mathematical modeling and numerical simulations", Institute of Mechanics, Bulgarian Academy of Sciences, Akad. G. Bonchev Str. bl. 4, 1113 Sofia, Bulgaria; daniel@imbm.bas.bg; ORCID: 0000-0002-4762-617X