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Original Article

Anthropometric characteristics of young Italian tennis players

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ABSTRACT

Purpose. Aim of our study is to observe specific body differences induced by training in young agonist tennis players at pre-pubertal and pubertal age, using anthropometry. Method. We analyzed 101 tennis players (27 females and 74 males) coming from South Italy, aged 8-14, which played tennis from at least 1 year. Anthropometric measurements like wrist, mid-thigh, mid-arm circumferences and arms length were compared between dominant and not dominant side of the body. Results. The mean Z-score for females was 0.9627, corresponding to the 83.22th centile of Italian growth chart, the mean Z-score for males was 1.0157, corresponding to 84.51th centile of Italian growth chart. For weight the mean Z-score for females was 0.2394 (59.46th centile) and the mean Z-score for males was 0.4032 (65.66th centile). The mean Z-score for females Body Mass Index was -0.1451 (44.23th centile), instead the mean Z-score for males was -0.0768 (46.94th centile). The Wilcoxon test reported a statistically significant difference between dominant and not dominant wrist circumferences regardless of sex (p-value=1.87e-10). Conclusions. Our study revealed that playing tennis starting from childhood may be useful for a regular growth. Analysis of wrist circumference and height may confirm the osteogenic potential of the sport. **Key words:** ANTHROPOMETRY, TENNIS, GROWTH, EXERCISE, CHILDREN, BONE.

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INTRODUCTION

The positive role of physical exercise for health promotion is well established and concerns the prevention of aging and pathologies related to sedentary lifestyles (Nelson et al., 2007), such as obesity, diabetes and cardiovascular diseases (Sparling et al, 2015). On this topic, the American College of Sports Medicine (ACSM) has recently published recommendations concerning physical activity. These have been incorporated into the current edition of the *ACSM's Guidelines for Exercise Testing and Prescription* (Lippincott Williams &Wilkins, 2010). The scientific evidences proves that healthy adults may have beneficial effects from regular activity that includes cardiorespiratory benefits, resistance, flexibility, and neuro-motor improvement[4]. The ACSM suggests that most adults should engage in moderate-intensity cardio-respiratory training for ≥ at least 30 minutes for 5 days a week, so that the total time of moderate intensity training amounts to ≥150 minutes a week, and a high-intensity cardio-respiratory training for at least 20 minutes daily or 30 minutes for three days a week (a total of ≥75 minutes a week). Almost two session of resistance exercises for each of the major muscle groups and neuron-motor exercise for 30 minutes contribute to perform balance, agility, and coordination in adults (Garber et al., 2011). Tennis is considered the third most popular sport in the world and is played by millions of people. A large majority of the people who play tennis during childhood and adolescence maintains continue practicing this sport throughout their life. Tennis involves both intermittent, high-intensity efforts and low-intensity activity (Fernandez-Fernandez et al., 2009). Throughout matches and practice sessions, players are constantly required to execute precise explosive actions. Power and high-level neuron-motor skills are achieved and represent a determinant key of success and improvement in this sport (Fernandez-Fernandez et al., 2009; Reid et al., 2007). Due to the characteristics of the game, several evidences show that tennis has specific physiological adaptation to exercise like osteogenic potential (Calbet et al., 1998; Kannus et al., 1995; Kontulainer et al 2002). A recent study conducted on over 80000 Scottish and English subjects had highlight that racquet sports are associated to benefits for public health like a significant reduction in cardiovascular disease associated mortality risk (Oja et al., 2016). Since it is an asymmetric sport, previous studies focused on analysis of the adaptations in tennis players and some of them reported differences between the dominant and the non-dominant side of the body of professional tennis players who had begun tennis practice before puberty (Calbet et al., 1998; Olmedillas et al., 2010; Sanchis-Moysi et al., 2010). Individual weight, height and some circumferences are important body dimensions, and have been object of studies and investigations related to population's health and nutrition, growth and development of infants, children and adolescents obtained without invasive practices. The main aim of our study is to observe specific body differences induced by training in young agonist tennis players at in pre-pubertal and pubertal age, using anthropometric measurements.

MATERIALS AND METHODOLOGY

Subjects

101 tennis players (27 female and 74 male) coming from South Italy (regions of Campania, Basilicata and Puglia) aged 8-14 were enrolled in the study (table 1). Subjects and their parents provided informed consent to participate to the study. The inclusion criteria were attending tennis competitions, training at least three hours a week and being healthy. Tennis experience was determined by starting age, years of tennis playing and upper limb dominance. The exclusion criteria were presence of pathological state (acute and/or chronic), pharmacological treatments, history of injury.

Table 1. General characteristics of 101 young tennis players analyzed in this study

All male tennis players		**All female tennis players**	
N=74		N=27	
Total			
N=101			
Age (years)	**Male**	**Female**	**Total**
8	N=7	N=3	N=10
9	N=14	N=3	N=17
10	N=12	N=3	N=15
11	N=15	N=3	N=18
12	N=10	N=3	N=13
13	N=9	N=8	N=17
14	N=4	N=7	N=11

Anthropometric measurements

Anthropometric measurements were collected in triplicate as follow. Body height was measured with a fixed stadiometer (±0,1 centimeters, Holtain Ltd., Crosswell, UK). Every subject was measured three times according to Cameron et al., 1993. Subjects stood straight, with feet placed together and flat on the ground, and heels, buttocks and scapulae against the vertical bar. Arms were loosed and relaxed with the palms facing medially. Head was carefully positioned in the Frankfurt plane, with the lower margins of the orbit in the same horizontal plane as the upper margin of the external auditory meatus. Body weight, expressed in kilograms (kg), was measured at fasting state in the morning with a mechanical balance (SECA 700, Hamburg DE). Body Mass Index (BMI) was calculated as body weight divided by height squared (kg/m^2). The BMI of each individual was converted using Italian reference tables by smooth age-specific curves called L, M and S to a standard deviation score for the child's age (Cacciari et al., 2006). Wrist circumference (dominant and not dominant) was measured immediately proximal to the ulnar and radial epicondyles to the nearest 0,5 cm using a flexible meter. Arm length was taken using a flexible meter. Mid upper arm circumferences (biceps circumference) was measured at the halfway point between the acromion and olecranon process of the dependent right and left upper arms with the forearm held at a right angle. Mid-thigh circumferences (quadriceps femoris circumference) were obtained by measuring tape (cm). Circumferences were measured at the half-distance between the greater tuberosity and the lateral condyle of the femur. For all measurements, the tape was held to the limb, without compressing any underlying soft tissues (Son et al., 2016). The mean calculated for triplicates was considered for statistical analysis. The number of weekly training was reported for all subjects.

Statistical analysis

All frequencies were analyzed using Barnard's test, that is a more powerful test than Fisher's test even if it is computationally more complex, when cells data are lower than 5, otherwise Fisher's test was used. Binomial distribution was used to assess frequencies too. All ordinal groups of data were analyzed using Lilliefors' test for normality. If samples were normally distributed, differences in variances were assessed using the Fisher-Snedecor F-test and differences in means were assessed using unpaired or paired Student's t-test; if samples were not normally distributes, differences in median were assessed using Mann-Whitney-Wilcoxon for unpaired samples or Wilcoxon test for paired samples.

RESULTS

Table 2. Anthropometric data (mean ± standard deviation) of the 101 young tennis players.

	Males	**Females**	**Total**
Age (years)	10,83±1,8	11,48±2,02	11±1,87
Height (m)	1,50±0,13	1,53±0,11	1,51±0,12
Weight (kg)	43,87±12	45,01±7,99	44,18±11,53
BMI (kg/ m^2)	18,97±3,17	19,03±1,64	18,99±2,83
Left dominant arm	12	4	16
Right dominant arm	62	23	85
Left wrist circ. (cm)	15,15±1,80	14,53±1,15	14,85±1,63
Right wrist circ. (cm)	15,23±1,23	14,87±1,11	15,27±1,24
Left arm length (cm)	52,5 [11] *	53,25±5,96	53,53±5,72
Right arm length (cm)	52,75 [11] *	52,92±6,42	53,5±5,86
Left mid upper arm (cm)	23 [7,5] *	24,07±2,51	23,56±3,14
Right mid upper arm (cm)	23 [7,5] *	24,29±2,54	23,67±3,23
Left mid thigh circ. (cm)	45,47±5,71	46,98±4,28	45,87±5,39
Right mid thigh circ. (cm)	45,19±5,46	46,51±4,49	45,54±5,23
Hours of weekly training	3,59±1,16	3,55±1,18	3,38±1,16
Years playing	3,06±1,74	2,29±1,78	3,03±1,74

Circumference is abbreviated in "circ." Asterisk indicates data not normally distributed which are expressed in median and interquartile range.

We analyzed anthropometric characteristics of 101 young tennis players aged 8-14 years (mean age 11.00±1.87 years). Females were 27 (26.70%) and males were 74 (73.26%). Table 1 shows the numerosity of each subgroup stratified for age and table 2 reports the main anthropometric characteristic of subjects included in the study. Males had a mean height of 1.50±0.13 m. Females had a mean height of 1.53±0.11 m. The mean weight for males was 43.87 ±12.62 kg, the mean weight for female was 45.01±7.99 kg. The BMI, based on height and weight, was 18.97±2,83 kg/m^2, 18.97±3.17 kg/m^2 for males and 19.03±1.64 kg/m^2 for females. 85 subjects (84%) were right handed, the remaining 16% (n=16) was left handed. Barnard test did not show statistical significant differences for left-handedness between males and females (p-value=0.938854), however, in our study we found that frequency of left handed subjects respect to the general population in female group was 16.2% versus 6.69% of general population (Fisher test p-value =0.0052181205) and in male group was 14.8% versus 8.52%of general population (Fisher test p-value = 0.0330042161; MacManus et al., 1993). This result is compatible with a recent study by Loffing et al., 2014, in which is reported that cross-sectional studies found significantly enhanced frequencies of left handed people among elite athletes in interactive sports such as baseball, cricket and tennis. Lilliefors test showed that wrist circumferences are not normally distributed (p-value=0.02 for dominant wrists of females, p-value=0.0011 for not dominant wrists of females; p-value=0.0201 for dominant wrists of males; p-value=0.0017 for not dominant wrists of males). The Wilcoxon test reported a statistically significant difference between dominant wrist and not dominant wrist circumferences regardless of sex (p-value=1.87e-10). The median of the differences estimated via Hodges-Lehmann estimator is 0.75 cm (I.C. 95% 1.00 - 0.75). The dominant and not dominant arms length and dominant and not dominant biceps circumferences did not show significant differences according to Mann-Whitney-Wilcoxon test. The dominant and not dominant quadriceps circumferences were analyzed via Fisher-Snedecor test, which reported the same variances. Data had to be unified via t-Student test for not paired data, which did not show statistically significant differences between the circumferences of the quadriceps regardless of gender (p-value=0.94018). The average difference is 0.0104 cm (I.C. 95% -1.9736 - 1.9944). Height, weight and BMI of young tennis players were compared between males and females and in relationship with Italian growth charts for height, weight and BMI of 2 to 20 years subjects. Height measurements for males and females were normally distributed. The mean Z-score for females was 0.9627, corresponding to the 83.22th centile of Italian growth chart, the mean Z-score for males was 1.0157, corresponding to 84.51th centile of Italian growth chart. Weight measurements were normally distributed and the mean Z-score analysis revealed a slight difference from control population, in fact the mean Z-score for females was 0.2394 (59.46th centile) and the mean Z-score for males was 0.4032 (65.66th centile). Finally, we considered the BMI distributions for females and males. The mean Z-score for females BMI was -0.1451 (44.23th centile), instead the mean Z-score for males was -0.0768 (46.94th centile).

DISCUSSION

This study furthers our understanding of sport specific impact of tennis on growth during childhood and adolescence. In this work, we have focused on a specific age group with the purpose to analyze variations of specific anthropometric parameters in relation to growth and training of tennis. For this reason we have included in the study children who practiced the sport for at least a year for at least three hours a week. In particular, our young tennis players had a current training volume of 3.58±1.16 hours a week and the mean years of playing tennis were 3.06±1.74 years. The 73.26% of them had at least 3 hours a week of training. The resting 26.74% had a weekly training greater than or equal to 5 hours. Because of the asymmetrical nature of this sport, other authors described differences between dominant and not dominant side of the body in professional tennis players who began practicing before puberty. For this reason, our study focused on analysis of anthropometric parameters in children and adolescents playing tennis continuatively for at least 1 year. In particular, Sanchis-Moysi et al., 2010, found a lean mass in the dominant arm 10-15% greater compared to the non dominant arm of professional tennis players who started tennis before puberty. Other evidences, like cross sectional studies by Kannus et al., 1995, show that in female tennis and squash players the effect of biological age (such as age of playing relative to the age of menarche) at which tennis or squash playing was started had a relevant impact on the difference in bone mineral content between the dominant and not dominant arms. Our data do not show sex-related differences between circumferences and lengths of the dominant and not dominant limbs, except for wrist circumference (table 3). We have recorded a statistically significant difference between the circumferences of the dominant and non-dominant wrists independent of gender (p-value = 1.87e-10). The median of the differences estimated via Hodges-Lehmann estimator is 0.75 cm (I.C. 95% 1.00 - 0.75). This result, combined with the analysis of the height of the 101 subject studied, may confirm the osteogenic potential of the sport. Wrist circumference is, in fact, an important indicator of bone mass and bone metabolism. It represents an easy-to-detect measure of skeletal frame size and is in relation with cross-sectional area of bone, regardless of the quantity of body fat (Capizzi et al., 1995). The osteogenic effect of tennis training on our young tennis players was supported by height measurements. In our study both males and females are higher than the 83.22th centile of Italian growth chart and BMI is 44.23th centile for females and 46.94th centile for males. This observation may be relevant in order to plan multidisciplinary strategies of approach to motor practice at early age for the maintenance of normal weight and body composition. Currently the goal of the training methodology of the young tennis player relies is characterized by the use of strategies to ensure harmonious somatic and motor development, proposing a series of activities that will allow at the same time to consolidate the basic motor patterns, restructure sense and perceptive functions, encouraging the technical and tactical learning processes, without affecting the physiological development of the human body with special reference to morphological aspects. A guided process of growth and physical and psychological maturity, implemented through the organized practice of appropriate physical exercises, improves' physical efficiency to achieve maximum athletic performance. For the childhood and adolescent age group a very important multilateral work, which consists of a set of rationally structured exercises that promote mental and physical growth, has an impact especially on the musculoskeletal system. Proper training determines: i) correct posture, ii) improved joint mobility, iii) increases in tone of the muscles. The methods of improving coordination skills and multilateral development of tennis can be summarized as follows: i) bodyweight exercises (specific coordination of arms and legs in relation to the technical aspects of the game, to the spaces and reaction times), ii) addition of complex movements to the basic exercise, iii) execution of the exercises in unusual environmental conditions (largest workout on the competition course or smaller than the standard size), iv) specular execution of movements on both sides of the body, v) execution of movements from different positions of the body, vi) changes in the executive rhythm, vii) changing technical tool size. Despite this point regarding tennis methodologies of training, a recent study conducted on 7 prepubescent males showed that tennis has an impact on the asymmetry of core musculature, detectable with magnetic resonance imaging (MRI). The exercise seems to induce a selective hypertrophy of the core musculature and exaggerates the degree of asymmetry of quadratus lumborum and rectus abdominis, compared to untrained boys (Sanchis-Moysi et al., 2016). No more data concerning the asymmetry of the body in children or prepubescent tennis players is available in literature.

Table 3. Anthropometric data (mean ± standard deviation) registered for dominant and not dominant side of the body for the 101 young tennis players.

	Males	**Females**	**Total**
Dominant wrist circ. (cm)	15,37±1,27	15,00±1,12	15,27±1,24*
Not dominant wrist circ. (cm)	15,02±1,76	14,40±1,09	14,85±1,63
Dominant arm length (cm)	53,75±5,58	52,98±6,41	53,54±5,82
Not dominant arm length (cm)	53,60±5,71	53,20±6,98	53,49±5,82
Dominant mid upper arm (cm)	45,39±5,68	46,55±4,46	45,70±5,39
Not dominant mid upper arm (cm)	45,27±5,49	46,94±4,31	45,71±5,23
Dominant mid thigh circ. (cm)	23,44±3,43	24,20±2,52	23,66±3,26
Not dominant mid thigh circ. (cm)	23,35±3,28	24,16±2,53	23,57±3,11

The asterisk indicates statistically significant differences between the two measures (Wilcoxon test, p-value=1.87e-10). Circumference is abbreviated in "circ."

CONCLUSION

We presented for the first-time data regarding the impact of tennis in 101 young Italian players during growth, by using a noninvasive, easy and not expensive method. No data is currently available about this age group and in relation to the Italian population in the literature. The training administered to our children would seem to favor the maintenance of a normal weight and a high development in the height in relation to age, although this finding should be confirmed through further follow-up. Further studies will be useful to assess the impact of tennis training during pubertal and post pubertal age. According to the results, we suggest that the collection of anthropometric parameters may be useful for monitoring the progress of the growth of our children and to confirm the correct training methodology applied.

PRACTICAL IMPLICATIONS

The study focused on a particular age group playing tennis continuatively for at least one year. Using east to detect and not expensive methods it was possible to analyze the effect on the growth of the sport. After one year of playing tennis for at least three hours a week children showed a normal BMI and an harmonious growth. Further studies may be useful to confirm the osteogenic potential observed in our work.

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