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Anthropometric and Physical Profile Among the Different Age Groups of Tunisian Tennis Players

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Abstract

Background: The popularity of Tunisian tennis is on the rise, due to emerging players gaining global recognition, leading to growth and evolution in the sport. In order to optimize training and performance, coaches need valuable information on physical fitness and player profiling.
Objectives: The study aimed to investigate the physical profile of Tunisian tennis players in different age groups ranging from 7 to 17 years.
Methods: One hundred and one tennis players from the same team were assigned to six age groups (U9-U18); U9 (7.89 ± 0.32), U10 (8.88 ± 0.34), U11 (9.78 ± 0.43), U12 (10.81 ± 0.4), U14 (12.3 ± 0.73), and U18 (14.69 ± 0.95) and were assessed for standing long jump (SLJ), countermovement jump, medicine ball throw (MBT), various sprint distances, agility drills, 20m Shuttle run (20mSRT), and Sit and reach tests.
Results: The results showed that U14 and U18 age groups demonstrated better performance than U9 and U10 in jump tests, while U18 and U14 outperformed only U9 in the MBT test. U11 showed better performance than U9 and U10 in sprints, sideways shuffle, and spider drill tests. U9 and U10 had lower performance than U12 in SLJ, 20m sprint, sideways shuffle, and zigzag tests, and U11 outperformed U9 in the SLJ test. U18 and U14 had higher VO_2max than U10 and U11, while U12 was higher than U11 only. No difference in flexibility was reported. The centile estimates of physical performances among Tunisian tennis players provide a means to compare individual player test results with the standard performance levels of the group.
Conclusions: In conclusion, this study found that 11–17-year-old players exhibited greater physical performance than 7–10-year-old players. However, no age effect was found for flexibility.

Keywords: Tennis, Physical Profile, Anthropometric, Age

1. Background

To achieve optimal performance in tennis, skill is a key factor, and the sport requires the intricate interplay of various physical components such as strength and agility (1). The intermittent nature of the game places demands on the energy supply, which suggests that a combination of the aerobic and anaerobic energy systems is utilized to meet these demands (1-3). Additionally, physical fitness development is crucial for tennis players. Physical fitness development is crucial for tennis players, and encompasses power, speed, and agility (4, 5). These physical traits have been found to have a positive correlation with performance on the court (5, 6). Power is the result of combining strength and velocity with upper body power utilized for fastballs and lower body power for explosive movements during gameplay (5, 7, 8). Moreover, since tennis matches can last up to five hours and rallies involve sprints of 8 - 15 m and 3 - 4 changes of direction (2, 9), tennis-specific endurance, speed, and agility are essential. Typically, rallies last less than 3 - 10 seconds to score a point (4, 10). Functional tests are considered the most useful for tennis players, with a measurement of power preferred over a measurement of strength (11). Knowledge of anthropometric and physical performance levels, and the relationship between various physical characteristics, including speed, agility, flexibility, endurance, upper and lower body power, relevant to tennis performance can help identify such measures.

To optimize individual performance and training efficiency, it is crucial to define goals and content based on the specific workload for each age group, as well as the technical and physical requirements of the competition level (1). Conducting adequate fundamental and representative research is essential to provide general guidelines for players and coaches, enabling them to obtain objective information on the players' physical performance. This information helps to make adjustments to short-term and long-term training programs that are beneficial and motivating for both players and coaches (12).

Tennis in Tunisia is experiencing constant growth and evolution according to the latest international results. The emergence of Tunisian tennis players who have achieved international recognition, such as Malek Jaziri and Ons Jabeur, has contributed to this progress. They have made significant strides on the Association of Tennis Professionals (ATP) and Women Tennis Association (WTA) tours. Therefore, evaluating the physical fitness characteristics and profiling of Tunisian tennis players can provide valuable information for coaches and trainers to optimize their training and performance. However, previous research has not adequately examined the profiling and physical fitness characteristics of Tunisian tennis players.

2. Objectives

This study aimed to address the limited research on the profiling of Tunisian tennis players by evaluating their physical fitness characteristics in different age categories. The physical fitness characteristics of the tennis players were measured using basic tests for upper and lower body power, namely the Medicine-ball throw (MBT) test, standing long jump (SLJ), and countermovement jump (CMJ) tests. Linear sprints of 5, 10, and 20m were also conducted, and the endurance ability was assessed using the 20m shuttle run test (20mSRT). Additionally, tennis-specific agility tests such as the sideway shuffle, spider drill, and Zig-zag tests were used to assess agility. Lastly, the Sit-and-Reach test was used to evaluate flexibility ability.

3. Methods

3.1. Participants

The sample for this study consisted of 101 Tunisian tennis players, including 71 boys and 30 girls, who belonged to the same team and volunteered to participate. Table 1 presents the general characteristics of the participants. All participants were recruited from a tennis-training club in Sfax city, Tunisia, and were engaged in weekly physical education sessions at school for approximately 50 minutes. Additionally, they participated in five sessions of tennis training per week, with each session lasting around 90 minutes. This training regimen was maintained for a minimum of two years, with an average duration of 2.5 ± 0.5 years. Prior to their involvement in the study, all participants received both verbal and written instructions explaining the procedures and potential risks involved. They were also informed of their right to withdraw from the trial at any point. The study was approved by the ethics committee of Farhat Hached Hospital in Sousse, Tunisia, and adhered to the guidelines set forth in the declaration of Helsinki prior to commencing the assessments.

None of the participants exhibited any observable symptoms of dysfunction in their musculoskeletal or cardio-pulmonary systems. They were specifically instructed to refrain from consuming any antioxidants (e.g., vitamins E, A, C) or anti-inflammatory medication from one month before the experimentation. Also, they were asked to avoid participating in any high intensity sessions prior to the experimentation period.

3.2. Procedures

The testing procedure for this study took place at the start of the season, and all participants were introduced to the overall setting and testing protocols during the orientation phase. The tests were conducted over the course of three different days. On the first day, height and body mass measurements were recorded, along with flexibility assessments using the Sit-and-Reach test (SAR), the medicine ball throw test, and the 20m shuttle run test (Luc Leger Test). The following day, participants performed the jump tests (Countermovement jump (CMJ) and standing long jump (SLJ)), as well as the sprint tests (5, 10, and 20 m) on an outdoor tennis court. There was a 15-minute break between the two sets of tests. On the final day, players completed the spider drill, sideway shuffle, and Zig-zag tests in the same sequence, all conducted on an outdoor tennis court.

Table 1. The Anthropometric Characteristics of Tunisian Tennis Players in Different Age Groups [a]

	U9 (n = 18)	U10 (n = 17)	U11 (n = 14)	U12 (n = 16)	U14 (n = 20)	U18 (n = 16)
Age, y	7.89 ± 0.32 [7 - 8]	8.88 ± 0.34 [8 - 9]	9.78 ± 0.43 [9 - 10]	10.81 ± 0.4 [10 - 11]	12.3 ± 0.73 [11 - 13]	14.69 ± 0.95 [14 - 17]
Height, m	1.28 ± 0.06 [1.18 - 1.38]	1.34 ± 0.06 [1.25 - 1.48]	1.39 ± 0.06 [1.3 - 1.49]	1.44 ± 0.04 [1.37 - 1.51]	1.53 ± 0.09 [1.32 - 1.65]	1.69 ± 0.09 [1.5 - 1.81]
Body mass, kg	26.39 ± 4.76 [20.3 - 36.5]	28.71 ± 5.04 [20 - 40.3]	31.64 ± 3.38 [25.6 - 38.6]	34.37 ± 4.29 [27.6 - 43.7]	46.16 ± 10.38 [26.9 - 60.2]	56.28 ± 7.49 [45.6 - 69.8]
BMI, kg/m^2	16.1 ± 2.12 [12.3 - 20.9]	15.83 ± 2.23 [12.6 - 21.8]	16.46 ± 1.68 [13.4 - 20.2]	16.67 ± 1.82 [14.1 - 21.4]	19.61 ± 3.08 [13.7 - 24.7]	19.78 ± 2.01 [16.9 - 24.4]

Abbreviation: BMI, body mass index.
[a] Values are expressed as mean ± SD.

3.3. Testing Procedures

Anthropometrics: Anthropometric measurements were taken using a portable stadiometer (Seca Model 225, Hanover, MD) and a digital scale (Tanita, Tokyo, Japan). Participants were measured in stocking feet and underwear, with height rounded to the nearest 5 mm and body mass to the nearest 100 g. The body mass index (BMI), a measure of body composition, was calculated by dividing the body mass (in kilograms) by the square of the height (in meters). The BMI values were then used to assess the participants' weight status based on established BMI categories.

Countermovement-Jump (CMJ): The Countermovement Jump (CMJ) test was conducted using an infrared jump system (Optojump Microgate—Italy) connected to a computer. Participants stood between two infrared sensor bars and executed a rapid downward movement, followed by an upward jump, keeping their hands on their iliac crests. Three trials were performed with a 2-minute rest period between each trial, and the highest jump height was used for analysis.

Standing long jump (SLJ): The Standing Long Jump (SLJ) test was performed according to Ab Rahman (13). Participants started from a standing position, swung their arms, and jumped with both feet. The distance between the take-off line and the heel of the closest foot at landing was measured in centimeters. Three trials were conducted with a 2-minute rest period between each trial, and the best jump distance was recorded.

Medicine Ball Throw Test (MBT): The overhead medicine ball throw test was conducted by having participants stand behind a designated line. They used a 1-kg or 2-kg medicine ball, depending on their assigned group. The ball was brought back behind the head using both hands and then released as far as possible without any foot movement or crossing the line. The distance from the starting line to the ball's landing point was measured. Each participant completed two repetitions, and the best performance was recorded.

Sprint Tests: Running performance was evaluated over a 20-meter distance, with intermediate phases at 0 - 5 meters and 0-10 meters. After a standardized warm-up period, participants performed two maximal sprints with a 3-minute rest interval between each sprint. The best time from the two sprints was used for analysis. The sprints were timed using three infrared photoelectric cells (Cell Kit Speed Brower, USA) placed at 0.4 meters above the ground at the start line and at 5-, 10-, and 20-meter marks.

Sideway Shuffle Test: The Sideway Shuffle Test involved participants shuffling along the center service line at the T, starting with one foot on each side of the line and facing the net. They shuffled to touch the doubles sideline and then shuffled to the opposite doubles sideline before returning to the center. Crossover steps were not allowed during the test. The trial time was recorded using a stopwatch.

Zig-Zag Test: The Zig-zag sprint test involved participants starting from point A and finishing at point F, while cutting around markers without running over them. Participants were instructed to complete the test as quickly as possible. Sprint times were recorded using two infrared photoelectric cells (Cell Kit Speed Brower, USA) placed at 0.4 meters above the ground at the start point (A) and the finish point (F) (Figure 1).

Spider Drill Test: The Spider Drill test involved participants breaking the beam of the timing gates to officially start the assessment. They then performed sprints in a specific pattern, starting with a sprint to the right and progressing anticlockwise. The distances covered varied for each sprint. After completing the last sprint, participants turned right 90° and sprinted through the timing gates to finish the test. Sprint times were recorded using an infrared photoelectric cell (Cell Kit Speed Brower, USA) placed at 0.4 meters above the ground at the start line (Figure 2).

Aerobic maximal power: The maximum oxygen uptake (VO_2max) was estimated using the 20-meter shuttle run test. The VO_2max is a measure of the maximum amount of oxygen that an individual can consume during exercise and is often used as an indicator of aerobic fitness. To estimate the VO_2max, the equations formulated by Leger et al. were utilized (14).

Sit and reach test (SAR): The Sit and Reach test was conducted according to Ayala et al. (15). Participants sat

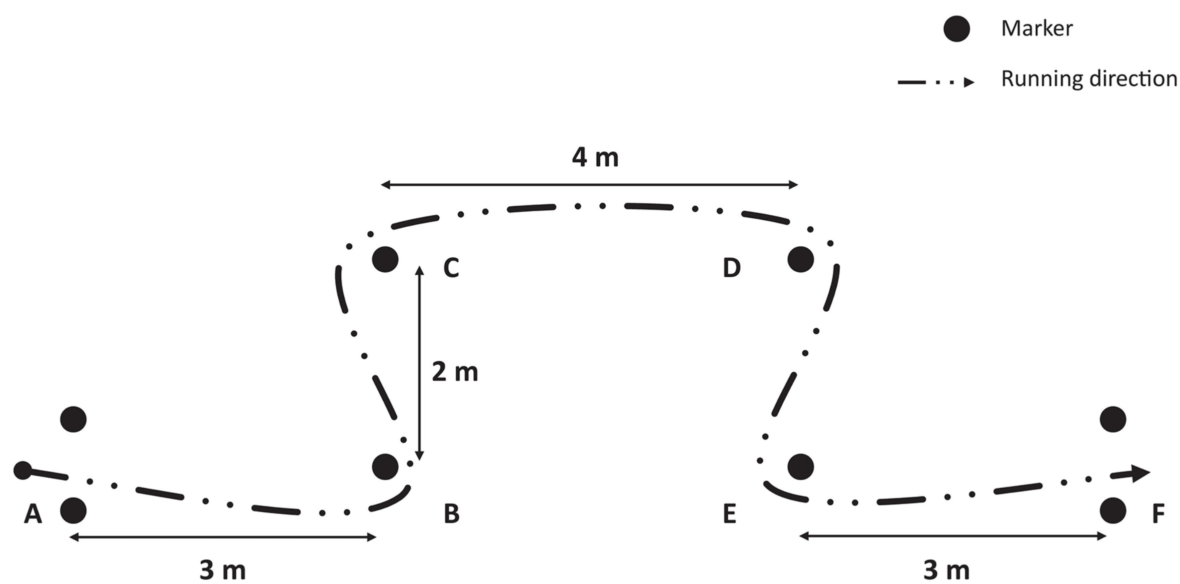

Figure 1. Schematic of the Zig-zag Test.

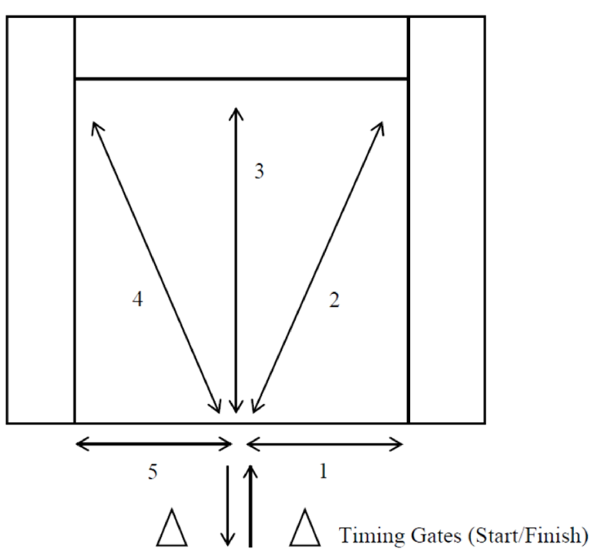

Figure 2. Schematic of the Spider Drill Test.

on the floor with their legs together, knees extended, and the soles of their feet against the edge of the box. With arms extended forward and palms down, they reached as far as possible along the measuring scale without bending their knees. The position of the heel and knee extension was monitored throughout the test to ensure proper technique and accurate measurement.

3.4. Statistical Analyses

The R programming language (version 4.2.1, R Foundation for Statistical Computing, Vienna, Austria) was used for all statistical analyses. Descriptive statistics were presented as Mean ± standard deviation (SD) for parametric data and Median (25th; 75th percentiles) for nonparametric data. The normality of data sets was checked using the Shapiro-Wilk test and confirmed for all data sets. One-way analysis of variance (ANOVA) was performed using the "afex" package (version 1.2-0) for normally distributed data, and post-hoc pairwise comparisons with the Bonferroni adjustment were conducted using the "emmeans" package (version 1.8.4-1) to determine differences between age groups. For non-normally distributed data, the Kruskal-Wallis test was performed, followed by the Dunn's test with the Bonferroni adjustment, using the "rstatix" package (version 0.7.0). The effect size statistic (η_p^2) was used to evaluate the magnitude of difference between age groups, with a small effect size defined as 0.01, a moderate effect size as 0.06, and a large effect size as 0.14. Correlations between dependent variables were assessed using Spearman and Pearson tests with the "rstatix" package (version 0.7.0). Significance was accepted for all analyses at a p-value threshold of less than 0.05 ($P < 0.05$).

Table 2. Muscle Power, Sprint, Change of Direction, Endurance, and Flexibility Results by Age Groups [a]

	U9	U10	U11	U12	U14	U18
Muscle Power						
SLJ, m	1.17 ± 0.2	1.24 ± 0.08	1.37 ± 0.19 [A]	1.49 ± 0.25 [A, B]	1.55 ± 0.2 [A, B]	1.84 ± 0.14 [A, B, C, D, E]
CMJ, cm	15.87 ± 4.86	20.51 ± 2.32	20.11 ± 3.88	24.47 ± 5.71 [A]	23.88 ± 5.62 [A]	39.08 ± 8.45 [A, B, C, D, E]
MBT, m	3.83 (3.05; 4)	4.6 (4.3; 5.3) [A]	3.85 (3.54; 4.18)	3.72 (3.54; 3.87) [B]	5.53 (4.58; 6.26) [A, C, D]	6.7 (5.98; 7.51) [A, C, D]
Sprint Ability						
5m sprint, s	1.87 ± 0.19	1.9 ± 0.24	1.66 ± 0.17 [A, B]	1.69 ± 0.21 [B]	1.61 ± 0.18 [A, B]	1.41 ± 0.15 [A, B, C, D, E]
10m sprint, s	3.25 (3.09; 3.48)	3.25 (3.2; 3.58)	2.62 (2.55; 2.74) [A, B]	2.3 (2.45; 2.75) [A]	2.54 (2.44; 2.61) [A, B]	2.33 (2.29; 2.4) [A, B]
20m sprint, s	5.55 (5.19; 5.81)	5.69 (5.3; 6.21)	4.56 (4.25; 4.8) [A, B]	3.46 (4.44; 4.92) [A, B]	4.63 (4.32; 4.71) [A, B]	3.96 (3.6; 4.18) [A, B]
Change of Direction Ability						
Sideway shuffle, s	7.39 (7.04; 8.04)	7.3 (7.18; 7.69)	6.23 (6.02; 6.42) [A, B]	5.18 (5.66; 6.33) [A, B]	6.25 (6.14; 6.33) [A, B]	5.6 (5.3; 6.07) [A, B]
Spider drill, s	25.3 ± 1.65	24.94 ± 1.62	22.54 ± 1.11 [A, B]	23.85 ± 2.3	22.92 ± 1.7 [A, B]	19.5 ± 1.36 [A, B, C, D, E]
Zig-zag, s	7.34 (7.24; 7.88)	8.05 (7.65; 8.2)	7.09 (6.39; 7.34) [B]	13.73 (6.36; 6.91) [A, B]	6.46 (6.21; 6.75) [A, B]	6.25 (5.54; 6.3) [A, B, C]
Aerobic Maximal Power and Flexibility Performances						
VO_2max, mL/kg/min	49.5 (47.5; 49.7)	45.7 (43.4; 48)	46.3 (45.7; 48.7)	24.58 (49.5; 52) [C]	50.5 (49; 51.6) [B, C]	50.25 (48.8; 52.9) [B, C]
SAR, cm	2.75 (2; 5)	2 (-1; 3)	-0.5 (-4.25; 0.75)	6.3 (-5.25; 6.75)	2 (-0.5; 4.88)	2 (0.75; 3.5)

Abbreviations: SLJ, standing long jump; CMJ, countermovement jump; MBT, medicine ball throw test; VO_2max, the maximum oxygen uptake; SAR, sit and reach test.
[a] Values were presented as mean ± SD for parametric variables or as median (25th; 75th percentiles) for non-parametric variables. A, significantly different from U9 at P < 0.05; B, significantly different from U10 at P < 0.05; C, significantly different from U11 at P < 0.05; D, significantly different from U12 at P < 0.05; E, significantly different from U14 at P < 0.05.

4. Results

The statistical analysis presented in Table 2 shows that there were significant age group differences in muscle power, sprint, change of direction performances, and flexibility among tennis players. Specifically, in the Standing Long Jump (SLJ) test, there was a significant difference between age groups ($F_{5,95}$ = 28.29; P < 0.001; η_p^2 = 0.6) with higher values in U18 compared to all other age groups, in U14 compared to U9 and U10, in U12 compared to U9 and U10, and in U11 compared to U9. In the Countermovement Jump (CMJ) test, there was a significant difference between age groups ($F_{5,95}$ = 35.05; P < 0.001; η_p^2 = 0.65) with higher performance in U18 compared to all other age groups and in U14 and U12 compared to U9. For the Modified Agility T-Test (MBT) performance, there was a significant difference between age groups (H_5 = 67.37; P < 0.001; η_p^2 = 0.66) with higher performance in U14 and U18 compared to U9 and U11, in U10, U14, and U18 compared to U12, and in U10 compared to U9.

For the 5m sprint performance, a significant effect of age group was found ($F_{5,95}$ = 15.07; P < 0.001; η_p^2 = 0.44) with higher performance in U18 compared to U9 (P < 0.001), U10 (P < 0.001), U11 (P = 0.006), U12 (P = 0.001), and U14 (P = 0.039), in U14 compared to U9 and U10 (P < 0.001 for both comparisons), in U12 compared to U10 (P = 0.035), and in U11 compared to U9 (P = 0.039) and U10 (P = 0.016). Also, for 10m sprint, there was a significant effect of age groups (H_5 = 76.88; P < 0.001; η_p^2 = 0.75) with higher performance in U14 and U18 compared to U9 and U10 (P < 0.001 for all comparisons), in U12 compared to U9 (P = 0.001), and in U11 compared to U9 (P = 0.003) and U10 (P = 0.001). Moreover, a significant effect of age groups was found for 20m sprint (H_5 = 74.27; P < 0.001; η_p^2 = 0.73) with higher performance in U18 compared to U9 and U10 (P < 0.001 for both comparisons), in U14, U11, and U12 compared to U9 (P = 0.001, P < 0.001, p 0.004, respectively) and U10 (P < 0.001 for all comparisons).

Age groups significantly differed in sideway shuffle test performance (H_5 = 65.3; P < 0.001; η_p^2 = 0.63) with lower performance in U9 and U10 compared to U11 (P = 0.002 and P = 0.001, respectively), U12 (P < 0.001 for both comparisons), U14 (P = 0.001 for both comparisons), and U18 (P < 0.001 for both comparisons). Also, there was a significant effect of age group for the spider drill performance ($F_{5,95}$ = 25.97; P < 0.001; η_p^2 = 0.58) with higher performance in U18 compared to all other age groups (P < 0.001 for all comparisons) and in U11 and U14 compared to U9 (P < 0.001 for both comparisons) and U10 (P = 0.002 and P = 0.007, respectively). For the Zig-zag test performance, a significant effect of age groups was found (H_5 = 65.03; P < 0.001; η_p^2 = 0.63) with higher performance in U18 compared to U9 (P < 0.001), U10 (P < 0.001), and U11 (P = 0.003), in U14 compared to U9 and U10 ($P < 0.001$ for both comparisons), and in U11 compared to U10 ($P = 0.017$), as well as Zig-zag test performance was lower for U12 compared to U9 ($P = 0.005$) and U10 ($P < 0.001$). Additionally, there was a significant effect of age groups for VO_2max ($H_5 = 38.29$; $P < 0.001$; $\eta_p^2 = 0.35$) with higher performance in U18 compared to U10 and U11 ($P < 0.001$), in U14 compared to U10 ($P < 0.001$) and U11 ($P = 0.003$), and in U12 compared to U11 ($P = 0.002$). However, non-significant effect of age groups was detected for SAR ($H_5 = 9.31$; $P = 0.097$; $\eta_p^2 = 0.05$).

4.1. Correlation

Height was significantly correlated with SLJ test (U12: r = 0.71, P = 0.002 and U18: r = 0.64, P = 0.006), sideway shuffle test (U12: r = -0.74, P < 0.001 and U18: r = -0.52, P = 0.033), and SAR test (U18: r = 0.62, P = 0.014). Body mass was significantly correlated with CMJ (r = -0.51, P = 0.037) and sideway shuffle test in U10 (r = 0.54, P = 0.025), with VO_2max in U12 (r = 0.59, P = 0.017), and with MBT in U18 (r = 0.64, P = 0.008).

SLJ test was significantly correlated with CMJ (U9: r = 0.57, P = 0.013; U12: r = 0.68, P = 0.004; U14: r = 0.71, P < 0.001; and U18: r = 0.72, P = 0.001), sideway shuffle test (U10: r = -0.51, P = 0.038; U12: r = -0.74, P < 0.001), VO_2max (U11: r = 0.86, P < 0.001; U12: r = 0.53, P = 0.034; and U14: r = 0.6, P = 0.006), Zig-zag test (U12: r = -0.53, P = 0.035), Spider drill test (U18: r = -0.52, P = 0.033), and SAR test (U12: r = 0.73, P = 0.014). Additionally, CMJ was significantly correlated with MBT test (U9: r = 0.69, P = 0.002; U14: r = 0.49, P = 0.029), 5m sprint (U12: r = -0.58, P = 0.17), 10m sprint (U18: r = -0.5, P = 0.041), Sideway shuffle test (U10: r = -0.61, P = 0.022; U12: r = -0.65, p =0.007), VO_2max (U14: r = 0.59, P = 0.006 and U18: r = 0.51, P = 0.046), Spider drill test (U9: r = -0.49, P = 0.041; U12: r = -0.59, P = 0.039; and U18: r = -0.57, P = 0.17), and SAR test (U12: r = 0.57, P = 0.027). Moreover, MBT was significantly correlated with 20m sprint (U12: r = -0.52, P = 0.037) and Zig-zag test (U18: r = -0.5, P = 0.04).

5m sprint was significantly correlated with 20m sprint (U10: r = 0.64, P = 0.006), Spider drill test (U9: r = 0.58, P = 0.011 and U12: r = 0.69, P = 0.003), and VO_2max (U12: r = -0.57, P = 0.021). 10m sprint was significantly correlated with 20m sprint (U10: r = 0.55, P = 0.024) and SAR test (U14: r = -0.56, P = 0.01).

Sideway shuffle test was significantly correlated with Zig-zag test (U12: r = 0.53, P = 0.33 and U14: r = 0.53, P = 0.017), VO_2max (U12: r = -0.64, P = 0.007), and SAR test (U12: r = -0.57, P = 0.025). Additionally, Zig-zag test was significantly correlated with SAR test (U10: r = -0.55, P = 0.022; U12: r = -0.65, P = 0.008; and U14: r = -0.47, P = 0.037) and with VO_2max in U10 (r = 0.65, P = 0.005).

4.2. Centiles

A summary of the estimated centiles of physical performances for Tunisian tennis players aged 7 – 17 years is presented in the Supplementary File, appendices 1 - 11. These tables and the corresponding centile charts (see the Supplementary File, appendices 12 - 22) allow a particular tennis player's test values to be compared to the norms for the group. The interpretation of centiles is straight-forward, for example in the case of the CMJ performance with particular age group, if that player's performance is on the 25th centile, it means that for every 100 players in the same age group, 25 would have a lower CMJ performance and 75 a higher CMJ performance.

5. Discussion

The purpose of the present study was to investigate the physical profile of Tunisian tennis players across different age groups (8 to 17 years) using various physical performance measures, including horizontal jump, vertical jump, sprints, change of direction, endurance, and flexibility performances. The results indicated that there were significant age group differences in most physical performance measures, with U18 and U14 categories generally performing better than U9 and U10 in all measured parameters, except for MBT where U14 and U18 were better than U9. In terms of sprint distances, U9 and U10 were inferior to U11 in all distances, the sideways shuffle test, and the spider drill ability test, and were also inferior to U12 in SLJ, 20m sprint, the sideways shuffle test, the zigzag test, and VO_2max. U11 was better than U9 and U10 in SLJ and Zig-zag test, respectively, while U12 was better than U9 in CMJ and 10m sprint and better than U10 in MBT and 5m sprint. U9 was inferior to U10 in MBT. Additionally, there were significant correlations between anthropometric measures, muscle power, sprint, change of direction, and endurance abilities in almost all age groups.

Regarding the anthropometric characteristics, Myburgh et al. (16) anthropometric data of 91 elite British junior tennis players (47 male and 44 female) of 8 - 17 years of age, classified by gender and age groups into 4 groups. In agreement with the results of Myburgh et al. (16), the tennis players in the present study were smaller and lighter than those in all age groups for both gender, U9, U10, and U11 vs U10, U12 vs U12, U14 vs U14, and U18 vs U16. Moreover, Palaiothodorou et al. (17) involved 48 children tennis players (24 boys and 24 girls) aged 7 - 13 years, divided in four age groups (U9: 8.2 ± 0.44, U10: 9.5 ± 0.13, U11: 10.5 ± 0.33, U12: 12.2 ± 0.58). Where, children's players in our study were smaller and lighter in U9 and taller and lighter in U10 compared to U9. Indeed, U11 participants were taller but lighter than U10. Indeed, U12 and U14 were both smaller and lighter than U11 and U12. Olcucu and Vatansever (18) studied 30 Turkish female tennis players aged 8.75 ± 0.83 years, and those players were taller and heavier than U9 and U10 tennis players in the present study. However, Yıldız (19) involved 28 Turkish male tennis players of 9.6 ± 0.7 years of age, where those players were smaller than U11 and heavier than U10 players. Moreover, Berdejo del Fresno et al. (20) measured body composition for 7 elite tennis players in two moments separated by 10 month, where in month 1 were aged 10.83 ± 0.39 and in month 11 were aged 11.58 ± 0.39, and those players in month 1 and after 11 were heavier compared to U12 but not neither taller nor heavier compared to U14. Rice et al. (21) studied 237 elite junior and professional tennis players affiliated with the United States Tennis Association, aged 9–27 years (14.6 ± 3.7 years), but they did not discriminate by age group. Our participants in U18 were taller (1.69 ± 0.09 U14 vs 1.67 ± 0.13 m) but not heavier (56.28 ± 7.49 kg vs 56.5 ± 13.8 kg). Furthermore, three studies investigated anthropometric data of Spanish (22, 23) and Polish tennis players (24) aged 14 - 16, 14.8 - 17.6, and 15 - 17 years, presented contradictory results compared to U18 data in this present study. Tennis players involved in these three studies (22-24) were taller and heavier than U18 tennis players. With respect to our study's results of physical fitness tests among Tunisian tennis players, U12, U14, and U18 age groups almost showed a greater performance compared to U9 – U11 age groups, expect in flexibility test assessed with the sit and reach test, no difference between all age groups. Only two studies investigated basic physical fitness in children tennis players (18, 20). The first study explored physical fitness performance among 8.87 ± 0.83 years female tennis players, were assessed for SAR, SLJ, vertical jump, 10 and 30m sprints tests (18), reporting better performance than U9 and U10 age groups in our study. The second study (20) measured SAR, agility, and SLJ performance in two different moments, the first where all participants aged 10.83 ± 0.39 and the second at the age of 11.58 ± 0.39, separated by 10-month period. Our tennis players' performances were lower compared to the latter study results (20), as well as players in Berdejo del Fresno et al. (20) study presented better VO_2max compared to our players, this contradiction might be explained by the level of tennis players, gender, and the usage of different measures protocols. Regarding 5m sprint performance, resent study used a mixed-longitudinal design, measuring players from 10 to 15 years old, reported greater performance in comparison to our results of U11 to U14, even their performance outperformed our results of U18. Luna-Villouta et al. (25) has examined physical performance of 78 young tennis players aged 15.4 ± 0.8 and 15.3 ± 0.8, respectively for boys and girls, outlined better performance of SLJ, CMJ, MBT, 20m sprint, SAR, and 20mSRT (this study reported the total distance during this test, making this comparison possible by estimating the total distance for U18) for boys, but not for girls, than our results of U18.

In terms of strength, Tunisian players in the U12, U14 and U18 age groups showed better physical performance compared to the U9-U11 age group, in addition to flexibility, which was determined by sitting and reaching tests, where no significant differences were observed in all age groups. Furthermore, Tunisian players showed promising physical performance, indicating potential talent and development, compared to previous studies of child tennis players. However, weaknesses can also be identified. When compared to international standards and studies conducted on elite junior and professional tennis players, Tunisian players generally exhibit smaller stature and lighter body weight. In addition, their physical fitness performance, particularly in areas such as agility, vertical jump, and sprinting, may lag behind international standards. It is worth noting that these differences could be influenced by factors such as the level of players, gender, and the specific measurement protocols employed in the studies. Overall, while Tunisian tennis players show promise in certain aspects of physical fitness, there is room for improvement in terms of size, strength, and overall athleticism to match international standards.

5.1. Conclusions

This study aimed to investigate the physical performance of Tunisian tennis players across different age groups. The findings revealed that players aged 11 - 17 performed better in muscle power, sprinting, agility, and endurance compared to those aged 8 - 10. However, there was no significant difference in flexibility between the age groups. It is important to note that this study had some limitations, such as the use of standard fitness tests and a relatively small sample size. Therefore, future research with a larger sample size and equal representation of male and female participants is recommended to strengthen the findings. Overall, it was observed that the body composition and physical fitness profile of Tunisian tennis players aged 8-17 were lower compared to their counterparts worldwide.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

Footnotes

Authors' Contribution: Study concept and design: S. M. A., A. Z. and H. C.; Analysis and interpretation of data: A. S.; Drafting of the manuscript: S. M. A., A. S., and A. Z.; Critical revision of the manuscript for important intellectual content: K. T., A. A., and H. C.; Statistical analysis: A. S.; Administrative, technical, and material support: A. Z. and H. C.; Study supervision: A.Z. and H. C..

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