



Relationships Between 6 × 8 m Repeated Sprint Performance with Change-of-Direction Demands, Anthropometric Characteristics, and Physical Performance in Under-12 Male Tennis Players

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ABSTRACT

This study aimed to examine the relationships between 6 × 8 m repeated sprint performance with change-of-direction demands (RSP-COD) and anthropometric characteristics and selected physical performance parameters in U12 male tennis players. A total of 16 male tennis players (11.25±0.77 years) voluntarily participated in the study. Height, body mass index (BMI), and body weight were assessed as anthropometric parameters. Physical performance tests included the Squat Jump (SJ), Countermovement Jump (CMJ), Horizontal Jump (HJ), and 5 m and 10 m linear sprint tests as primary measures, with the sit-and-reach test (flexibility) and 20 m backward sprint time as exploratory measures. The 6 × 8 m repeated sprint test was used as the primary outcome measure of RSP-COD. The normality of the data was tested using skewness and kurtosis coefficients and the Shapiro-Wilk test. Although the Shapiro-Wilk test revealed significant deviations for some variables, parametric tests were conducted because the skewness and kurtosis scores fell within the acceptable range of ±2. We examined relationships between variables using Pearson product-moment correlation coefficients, with statistical significance set at $p < 0.05$. Height ($r = -0.841$, $p < 0.001$), body weight ($r = -0.745$, $p < 0.001$), SJ ($r = -0.729$, $p = 0.001$), CMJ ($r = -0.824$, $p < 0.001$), and HJ ($r = -0.848$, $p < 0.001$) were significantly negatively correlated with the 6 × 8 m RSP-COD, supporting the directional hypotheses. Furthermore, moderate positive correlations between 5 m ($r = 0.677$, $p = 0.004$) and 10 m sprint times ($r = 0.535$, $p = 0.033$) and 6 × 8 m RSP-COD were observed. Among the exploratory variables, 20 m backward sprint time showed a very strong negative correlation ($r = -0.923$, $p < 0.001$). BMI ($r = -0.434$, $p = 0.093$) and sit-and-reach performance ($r = -0.029$, $p = 0.915$) were not significantly related. In this sample, the 6 × 8 m RSP-COD was associated with jumping ability, short-distance linear sprint performance, and anthropometric size characteristics, whereas BMI and static flexibility were not significantly associated. These findings should be interpreted cautiously, given the small sample size and cross-sectional correlational design.

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Introduction

Tennis is a high-intensity intermittent sport that requires a complex interplay of physical, technical, tactical, and psychological capacities ([Guo et al., 2024](#); [Xiao et al., 2022](#)). Tennis matches typically consist of 4-10 s point sequences followed by 10-20 s rest periods ([Villanueva-Guerrero et al., 2024](#)). To score points, players must constantly accelerate, decelerate, change direction, and maintain the correct position for each shot during these short sequences ([Luna-Villouta et al., 2024](#)). Therefore, acceleration, speed, and ability to change direction are considered important components of tennis performance, enabling timely and effective shots ([Diker et al., 2017](#)).

In modern tennis, success is directly related to physical components such as cardiovascular fitness, explosive power, agility, muscle strength, and increased stroke speed (serves, forehands, and backhands) ([Deng et al., 2022](#); [Parpa et al., 2023](#)). Short-distance sprint performance (under 10 m) is considered a critical indicator of performance, as it enables players to reach the ball quickly and prepare effective shots during rallies ([Kramer et al., 2021](#)). Studies have shown that even a difference of just 0.05 seconds in 5 m sprint performance can increase a player's chances of a successful return by allowing them to cover more distance on the court during the serve return, and that short-distance sprint performance is important not only during the serve return, but also throughout the rallies ([Kramer et al., 2016](#)).

Repeated sprint performance with change-of-direction demands (RSP-COD) is an important physical demand in tennis and is relevant for sustaining high-intensity efforts, including repeated accelerations, decelerations, changes of direction, and other short-duration high-intensity movements throughout a match ([Diker et al., 2017](#); [Hoppe et al., 2019](#)). This aspect of tennis performance relies on both maximal anaerobic sprint speed and aerobic capacity, as the aerobic system contributes substantially to the replenishment of energy stores during the recovery period between sprints ([Olsen et al., 2023](#)). In this context, lower-extremity neuromuscular strength, as reflected in jumping performance, and short-distance sprinting ability may contribute to fast movements that are specific to tennis matches ([Girard & Millet, 2009](#); [Vuong et al., 2022](#)).

The 11-12 age range (U12) is the transition period from childhood to adolescence and represents an important stage for the physical development of tennis players ([Guo et al., 2024](#)). Increases in height, muscle mass, and body weight during this period may be relevant to physical performance ([Guo et al., 2024](#); [Kramer et al., 2021](#)). The increase in muscle strength that occurs during biological maturation is associated with shorter sprint times and increased jump distances ([Xiao et al., 2022](#)). However, rapid growth may also be accompanied by neuromuscular imbalances and bilateral asymmetries, which may affect the injury risk in athletes ([Arede et al., 2022](#); [Lopez-Valenciano et al., 2023](#)). Therefore, monitoring the physical performance and anthropometric profiles of U12 athletes is crucial for individualizing training programs ([Girard & Millet, 2009](#)). Other important components of physical fitness studied in previous research on male junior tennis players include sprinting, jumping, and RSP-COD ([Moya-Ramon et al., 2020](#)).

The 6 × 8 m repeated sprint test was chosen for this study because the short sprint distance and repeated changes of direction reflect the important movement characteristics of tennis. The 8 m distance is comparable to the width of a standard tennis court, and the 6 × 8 m shuttle test has been used as part of the physical assessment of tennis players to measure 6 × 8 m RSP-COD. Recent research has reported excellent reliability for the 6 × 8 m shuttle test, with an intraclass correlation coefficient (ICC) of 0.95 (95% CI: 0.87-0.98), supporting its use as a practical measure of this performance characteristic in tennis players ([Trecroci et al., 2026](#)). In the present study, the term 6 × 8 m RSP-COD specifically refers to the completion time in this shuttle test. Exploring variables associated with the 6 × 8 m RSP-COD may provide useful information for monitoring physical performance and planning training programs in U12 tennis players.

Previous studies have extensively examined isolated sprint and jump performances in young tennis players (e.g., [Diker et al., 2017](#); [Kramer et al., 2016](#)). However, several important gaps remain in the literature on this topic. First, although the motor and biomotor determinants of older adolescent tennis players have been examined in previous studies (e.g., [Girard & Millet, 2009](#); [Parpa et al., 2023](#)), the physical performance and anthropometric

profiles of U12 tennis players have not been sufficiently studied during this crucial phase of biological growth and maturation. Second, although the 6×8 m shuttle run test has been used to assess physical fitness adaptations (e.g., [Trecroci et al., 2026](#)), and similar training protocols have been used to assess linear sprint and change-of-direction adaptations (e.g., [Fernandez-Fernandez et al., 2025](#)), the association between this multidirectional repeated test and foundational motor performance (jumps, linear sprints) and physical size parameters in U12 tennis players remains largely unexplored. Third, there is limited theoretical and empirical support for variables such as static flexibility (sit-and-reach) and backward sprinting performance. Backward running (20 m) and static lumbar flexibility (sit-and-reach) are commonly measured, but their biomechanical and physical relationships with multidirectional repeated shuttle runs are theoretically weak or unexplored and were therefore modeled as exploratory parameters in this study. Therefore, the aim of the present study was to investigate the relationships between RSP-COD (6×8 m) and anthropometric characteristics (height, body weight, and BMI) and selected physical performance variables (SJ, CMJ, HJ, static flexibility, 5 m and 10 m linear sprints, and 20 m backward sprint) in U12 male tennis players.

Using existing neuromuscular, motor development, and biomechanical frameworks, we derived three directional hypotheses and identified specific variables for exploratory analysis:

- H1 (Jumping Performance): SJ, CMJ, and HJ reflect the lower-extremity neuromuscular force-production capacity. Better performance is reflected in higher jumps and shorter 6×8 m times (indicating better repeated shuttle performance). We hypothesized a significant negative correlation between these jump measures and 6×8 m completion times.
- H2 (Linear Sprint Acceleration): Linear 5 m and 10 m sprint times were representative of short-distance linear acceleration. As both the linear sprints and the 6×8 m shuttle test are both timed (where lower times indicate better performance), we hypothesized a significant positive correlation between the 5 m / 10 m sprint times and the 6×8 m completion times.
- H3 (Anthropometric Characteristics): An increase in height and body weight during the prepubertal growth spurt is a common indicator of physical growth and may be associated with changes in physical performance in U12 athletes. We hypothesized that height and body weight would be significantly negatively correlated with 6×8 m completion times (i.e., taller and heavier athletes would complete the test faster). This hypothesis should be interpreted cautiously because body composition and biological maturation were not directly measured.
- Exploratory Analysis: Due to the lack of clear theoretical pathways or strong empirical relationships with multidirectional, high-intensity repeated shuttle runs, Body Mass Index (BMI), static flexibility (sit-and-reach test), and 20 m backward sprint performance were analyzed as exploratory variables without any a priori directional hypotheses.

Methods

Participants

This research was designed as a cross-sectional correlational study and conducted in Adana Province in October 2025. The sample size was determined pragmatically based on the number of eligible athletes available during the data collection period and the sample sizes reported in comparable previous studies involving tennis players and similar physical-performance tests ([Girard & Millet, 2009](#)). No a priori power analyses were performed. Therefore, all eligible athletes who met the predefined inclusion criteria and were available during the data collection period were included in this study. The inclusion criteria were as follows: having played tennis for at least 3 years, participating in tennis training at least 4 days per week and conditioning training 3 days per week, and having participated in national or international tennis tournaments. The exclusion criteria were as follows: sustained a sports injury within the previous 3 months, participated in tennis training less than 4 days per week, or did not participate in tournaments. Sixteen male tennis players were included in the study. Given the pragmatic sample

selection and small sample size, this study was considered exploratory, and the findings were interpreted with caution. The study was conducted in a single group format, and all measurements were taken during a single session. Prior to data collection, an orientation session was conducted to familiarize participants with the test procedures. Before all test sessions, the participants and their parents/guardians were instructed to maintain their usual dietary and daily routines and to refrain from strenuous exercise for 72 hours. The participants and their parents/legal guardians were informed of the testing procedures and pre-test instructions.

Study Design

Prior to the study, the participants were provided information about the tests. On the day of the study, all participants ran for 5 min (at a heart rate of 120 beats/min), with the heart rate monitored using a Polar H9 heart rate sensor (Polar Electro, Kempele, Finland), followed by 2 min of active rest before the tests. The participants then performed dynamic warm-up exercises that were specific to tennis. The participants were given 3 min of passive rest before the tests ([Abdioğlu et al., 2025](#)). Subsequently, physical performance tests were performed on the participants. All tests were conducted on an indoor hard court surface. Measurements were taken before lunch (between 09:00 and 12:00). All participants completed all tests while wearing tennis attire and shoes. The research protocol is shown in Figure 1.

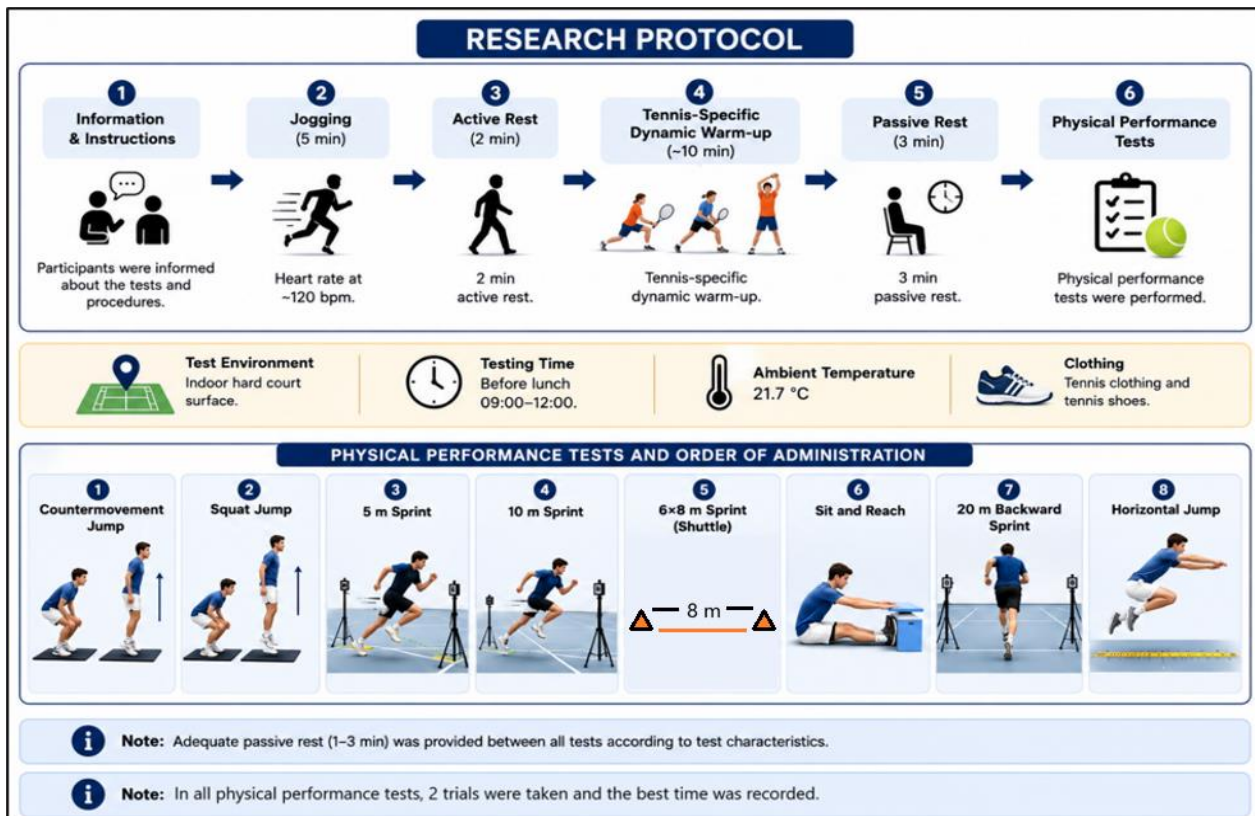


Figure 1. Research protocol illustrating the testing sequence, testing conditions, and order of physical performance assessment. The figure was created using ChatGPT (OpenAI, July 2026).

Data Collection Methodology and Performance Tests

Anthropometric Measurements: Participants were asked to stand barefoot to determine their height. During the measurement, the participants were instructed to stand with their feet together, look straight ahead, and take a deep breath. The research team measured the highest point above the participants' heads with 1 mm accuracy. Measurements were recorded in centimeters using a Harpenden Stadiometer (Holtain, Pembrokeshire, England). Body weight was measured while standing using a Tanita analyzer (MC 780; Tanita, Tokyo, Japan). All participants were asked to remove any metal objects during the measurement ([Mor et al., 2025](#)).

Countermovement Jump Test: Participants performed the jump test with their feet shoulder-width apart, hands on their hips, and knees bent. Before the jump, the participants were asked to squat until their knee joints were at approximately 90° of flexion. A 1-min passive rest period was provided between the repetitions. After two repetitions of the test, the best score was recorded. The obtained values were recorded in centimeters (cm). A jump mat (SmartJump, Jumpmetre, Japan) was used to measure vertical jump performance ([Markovic et al., 2004](#)).

Squat Jump Test: Athletes were asked to be ready before the test with their legs shoulder-width apart and their hands at their waists. During the test, the athletes were asked to squat until their knees were at approximately 90° of flexion, without removing their hands from their waists, and after holding this position for approximately 3 s, they performed a vertical jump. A 1-min passive rest period was provided between repetitions. The test was performed twice for each athlete, and the best score was noted. The obtained values were recorded in centimeters (cm). A jump mat (SmartJump, Jumpmetre, Japan) was used to measure vertical jump performance ([Markovic et al., 2004](#)).

Horizontal Jump Test: Participants were asked to jump forward with maximal effort when ready, from behind a line marked on the ground. After the jump, the research team determined the distance between the tip of the participant's toe before the jump and the furthest point of the heel after the jump. The participants were given 1 min of passive rest between each repetition. The participants performed the test twice, and the best score was recorded ([Yıldız et al., 2017](#)).

5 m and 10 m Sprint Test: Before the test, athletes stood 0.5 m behind a photocell gate (Fusion Sport, Brisbane, Australia). When they were ready, the test was started. Three photocell gates were used to mark the start and the finish. One minute of passive rest was provided between repetitions. The test was administered twice to each athlete, and the best score was recorded ([Aktaş et al., 2011](#)).

6 × 8 m Repeated Sprint Test with Change-of-Direction Demands: Photocell gates (Fusion Sport, Australia) were positioned at the start and finish of an 8 m shuttle run. The test distance was marked with two cones placed 8 m apart. The participants were positioned 0.5 m behind the starting photocell gate. On the start signal, each participant performed six maximal 8-m shuttle sprints, running between the two cones and turning 180° at the end of each 8-m interval. The participants were instructed to complete each sprint as quickly as possible. RSP-COD was assessed by recording the time required to complete six 8-m shuttle sprints. Each athlete performed two trials, and the best performance time (i.e., the lower time) was recorded. A passive recovery period of 3 min was allowed between the two trials. The 6 × 8 m shuttle test was based on the protocol described by [Trecroci et al. \(2026\)](#).

Sit-and-Reach Test (Static Flexibility): During the test, participants were asked to remove their shoes. They were then asked to sit on the floor, place the soles of their feet on the reach equipment, and reach forward with both hands without bending their knees. The longest point reached by the middle finger was recorded in centimeters (cm). Passive rest periods (1 min) were provided, and the athletes were given at least two attempts. The best score was evaluated ([Tural et al., 2021](#)).

20 m Backward Sprint Test: Before the test, the athletes positioned themselves 0.5 m behind the photocell gate (Fusion Sport, Brisbane, Australia), with their backs to the gate. The test was initiated when the participants were ready. The athletes ran backward as quickly as possible while maintaining their balance and were timed. Two photocell gates were used to mark the start and finish of the race. Passive rest periods of 1 min were given between repetitions. The test was administered twice for each athlete, and the best score was recorded ([Uthoff et al., 2020](#)).

Analysis of Data

Statistical analyses of the obtained data were performed using JASP statistical software (version 0.17.2.1; JASP Team, Amsterdam, Netherlands). Descriptive statistics of the demographic characteristics and physical performance variables of the participants are presented as means, standard deviations (SD), and maximum and minimum values. The normality of the data distribution was assessed using the Shapiro-Wilk normality test. Significant deviations from normality were observed for SJ ($p=0.002$), CMJ ($p=0.007$), sit-and-reach test

($p=0.003$), 20 m backward sprint ($p=0.049$), and BMI ($p=0.016$). However, the skewness values of these variables were 0.361, 0.276, -1.334, 0.553, and 0.832, respectively, whereas the kurtosis values were -1.823, -1.810, 1.533, -0.397, and -0.746, respectively. These values were within the acceptable range of ± 2 (George & Mallery, 2024). Other variables (HJ, 5 and 10 m sprints) were normally distributed ($p>0.05$). Therefore, parametric tests were used for statistical analysis. Scatter plots were visually inspected to assess linearity and homoscedasticity. Influential observations and potential outliers were evaluated using Cook's distance and standardized residuals. No observation had an absolute standardized residual greater than 3, and Cook's distance values did not suggest influential observations. In accordance with the main aim of the study, linear correlations between 6×8 m RSP-COD and the main hypothesized variables (height, body weight, SJ, CMJ, HJ, 5 m sprint, and 10 m sprint) were examined using Pearson's product-moment correlation coefficients to test the directional hypotheses. Exploratory correlation analyses were also performed for BMI, static flexibility (sit-and-reach), and 20 m backward sprint performance to evaluate potential associations for which there were no established directional hypotheses. Pearson product-moment correlation coefficients were used because the study employed an exploratory cross-sectional correlational design, and the assumptions for linear correlation were considered acceptable based on the diagnostic assessments, although the sample size was small ($n=16$). Therefore, the results should be interpreted with caution. The absolute r values were interpreted when interpreting the correlation coefficients based on the classification suggested by Dancy and Reidy (2007) summarized by Akoglu (2018) as 0.10-0.39 weak / 0.40-0.69 moderate / 0.70-0.89 strong / 0.90-1.00 very strong relationship. For all correlations, 95% confidence intervals were calculated using Fisher's r -to- z transformation. The level of statistical significance was set at $p<0.05$ for all analyses.

Results

Descriptive statistics regarding the demographic and athletic performance characteristics of the participants are shown in Table 1.

Table 1. Descriptive Statistics Regarding Demographic and Performance Characteristics of Participants.

Variables	n	min.	max.	$\bar{X} \pm SD$
Age (years)	16	11.0	12.0	11.3 $\pm$ 0.8
Training Age (years)		4.0	6.0	5.3 $\pm$ 0.8
Height (cm)		136.0	172.0	150.0 $\pm$ 10.0
Body Weight (kg)		30.0	65.8	41.7 $\pm$ 9.5
BMI (kg/m ²)		15.8	22.2	18.3 $\pm$ 2.3
SJ (cm)		22.4	35.8	28.1 $\pm$ 5.9
CMJ (cm)		21.8	37.0	29.3 $\pm$ 5.6
HJ (cm)		110.0	265.0	178.7 $\pm$ 50.9
Flexibility (cm)		11.5	26.5	20.5 $\pm$ 4.0
5 m Sprint (s)		1.0	1.4	1.2 $\pm$ 0.1
10 m Sprint (s)		1.8	2.3	2.1 $\pm$ 0.1
20 m Backward Sprint (s)		5.3	9.0	6.6 $\pm$ 1.1
6×8 m Repeated Sprint with Change-of-Direction Demands (s)		12.4	14.5	13.7 $\pm$ 0.7

Note: CMJ: Countermovement Jump, BMI: Body Mass Index, HJ: Horizontal Jump, SJ: Squat Jump

Table 1 presents the anthropometric characteristics and physical performance of the participants. Sixteen male tennis players participated in this study. The mean age was 11.3 ± 0.8 years, and the mean training age was 5.3 ± 0.8 years. There was a relatively considerable inter-individual variation in height and body weight. Among the physical performance variables, 5 m sprint performance showed relatively low variability, whereas horizontal jump performance showed high variability. The descriptive statistics for SJ, CMJ, HJ, flexibility, sprint performance, and 6×8 m RSP-COD are presented in Table 1.

Table 2. Correlations between 6×8 m repeated sprint performance with change-of-direction demands and anthropometric and physical performance variables.

Variable	Pearson's r	95% CI	p	Interpretation
Height (cm)	-0.841	-0.943 to -0.592	<0.001	Strong
Body Weight (kg)	-0.745	-0.906 to -0.396	<0.001	Strong
BMI (kg/m ²)	-0.434	-0.765 to 0.079	0.093	No significant
SJ (cm)	-0.729	-0.899 to -0.365	0.001	Strong
CMJ (cm)	-0.824	-0.937 to -0.556	<0.001	Strong
HJ (cm)	-0.848	-0.946 to -0.609	<0.001	Strong
Sit-and-Reach Test (cm)	-0.029	-0.517 to 0.473	0.915	No significant
5 m Sprint (s)	0.677	0.272 to 0.878	0.004	Moderate
10 m Sprint (s)	0.535	0.053 to 0.815	0.033	Moderate
20 m Backward Sprint (s)	-0.923	-0.973 to -0.787	<0.001	Very strong

Note: CMJ: Countermovement Jump, CI: Confidence Interval, BMI: Body Mass Index, HJ: Horizontal Jump, SJ: Squat Jump

The results of the Pearson correlation analysis between 6×8 m RSP-COD and anthropometric characteristics and physical performance variables are presented in Table 2.

For our directional hypothesis concerning anthropometric characteristics, height was strongly negatively correlated with 6×8 m completion time ($r=-0.841$, 95% CI=-0.943 to -0.592; $p<0.001$), and body weight was strongly negatively correlated with repeated sprint completion time ($r=-0.745$, 95% CI=-0.906 to -0.396; $p<0.001$). These relationships indicate that participants with greater height and body weight tended to complete the test in a shorter time. However, these correlations should be interpreted with caution because biological maturation was not assessed in the present study. For BMI, considered as an exploratory variable, no significant association was found ($r=-0.434$, 95% CI=-0.765 to 0.079; $p=0.093$).

For lower-extremity explosive power, vertical and horizontal jump performance variables were strongly and statistically significantly negatively correlated with 6×8 m completion times: SJ ($r=-0.729$, 95% CI=-0.899 to -0.365; $p=0.001$), CMJ ($r=-0.824$, 95% CI=-0.937 to -0.556; $p<0.001$), and HJ ($r=-0.848$, 95% CI=-0.946 to -0.609; $p<0.001$). Negative correlations indicated that greater vertical jump heights and horizontal jump distances were associated with shorter (better) 6×8 m completion times. These associations should be interpreted with caution, given the small sample size ($n=16$). There was no significant relationship between the exploratory sit-and-reach test (flexibility) and the other variables ($r=-0.029$, 95% CI=-0.517 to 0.473; $p=0.915$).

Linear sprint performance was moderately positively correlated with 6×8 m completion times for 5 m ($r=0.677$, 95% CI=0.272 to 0.878; $p=0.004$) and 10 m ($r=0.535$, 95% CI=0.053 to 0.815; $p=0.033$) sprint times. The positive

relationship between completion times suggests that athletes who are faster during short linear acceleration tests also tend to have shorter times in the multidirectional repeated sprint test. In contrast, a very strong negative correlation was found between 20 m backward sprint time and 6 × 8 m completion time ($r = -0.923$, 95% CI = -0.973 to -0.787; $p < 0.001$) among the exploratory variables. Thus, participants with longer 20 m backward sprint times tended to have shorter 6 × 8 m completion times.

Discussion

This study investigated the relationships between 6 × 8 m RSP-COD and anthropometric characteristics and physical performance variables in U12 male tennis players. The main findings were that the 6 × 8 m RSP-COD was significantly associated with body weight, height, lower-extremity explosive power (SJ, CMJ, and HJ), and selected sprint performance measures (5 m, 10 m, and 20 m backward sprints). In contrast, BMI and sit-and-reach performance were not significantly associated with the 6 × 8 m RSP-COD. These findings indicate associations between anthropometric characteristics, lower-extremity explosive performance, sprint performance, and RSP-COD in our sample. Given the cross-sectional correlational design, these associations should not be interpreted as being causal relationships.

Anthropometric Characteristics and Repeated Sprint Performance with Change-of-Direction Demands

In the present study, strong negative correlations were observed between height, body weight, and 6 × 8 m completion time, supporting the third directional hypothesis (H3). Because sprint performance was expressed as completion time, these negative correlations indicate that participants with greater height and body weight tended to complete the repeated sprint test in shorter times, indicating better performance. This finding is consistent with the possibility that physical growth and somatic development are associated with physical performance in the U12 category. However, these findings must be interpreted cautiously because biological maturation was not assessed in this study. Chronological age alone may not fully reflect individual differences in biological maturation in this age group, and differences in maturation status may have influenced the observed associations between the variables. Therefore, the contribution of biological maturation to these associations cannot be determined from the present study. In contrast, no significant relationship was found with BMI, which was evaluated as an exploratory variable. This is consistent with previous research; for example, [Spehnjak et al. \(2021\)](#) reported that height, body weight, and especially lean body weight, increase with age in elite football players, and that these variables are important indicators for monitoring athlete development. However, researchers have argued that elite-level athlete performance cannot be explained solely by anthropometric parameters; technical, tactical, and other physical characteristics also play a decisive role in athletic performance. In this regard, the lack of a significant relationship between BMI and repeated sprint performance in our study supports the view that sprint performance cannot be explained solely by general anthropometric measurements.

Similarly, [Martínez et al. \(2025\)](#), in their study of young amateur football players, reported that athletes with higher lean body weight performed better in sprinting, whereas a high body fat percentage was associated with poorer sprint performance. A meta-analysis by [Deng et al. \(2022\)](#) reported that plyometric training is associated with improvements in lower-extremity muscle strength and sprint performance. These findings provide a possible context for the negative association observed between body weight and RSP-COD in this study. However, body composition and lean body mass were not assessed in the present study. Therefore, it cannot be determined whether the observed association between body weight and RSP-COD is related to greater lean mass, body fat, or other characteristics associated with body size. Therefore, any interpretation involving lean muscle mass and force-production capacity should be considered speculative and cannot be confirmed using the present data.

The effects of growth and development on sprint performance also support the findings of the current study. [Kramer et al. \(2016\)](#) reported that increases in body size and lower-extremity strength during the growth process improved sprint physical performance variables in young male tennis players. Similarly, [Kramer et al. \(2021\)](#) reported that sprint performance with change-of-direction demands in young female tennis players could be

predicted based on their height and lower-extremity strength. Considering that maximum sprint speed develops in parallel with the growth and maturation process, the strong correlations found between both height and body weight and repeated sprint performance in U12 male tennis players support the potential relevance of physical development to sprint performance in this age group.

The strong correlation observed between height and RSP-COD is also consistent with findings obtained in other sports. For example, [Parpa et al. \(2023\)](#) reported that height is significantly related to serve and other stroke speeds in young tennis players and that taller athletes can increase force transfer by creating a more effective kinetic chain. In a similar study, athlete mass was reported to be an important variable affecting sprint performance, especially during the acceleration phase of the first 10 m of the sprint ([Kleeberger et al., 2024](#)). These findings provide a possible context for the strong correlations between height, body weight, and 6 × 8 m RSP-COD observed in the present study, although the specific mechanisms underlying these associations were not directly assessed in this study.

Lower-Limb Explosive Power and Repeated Sprint Performance with Change-of-Direction Demands

In the present study, significant correlations were found between all jump tests evaluating lower-extremity explosive power and the 6 × 8 m RSP-COD, supporting the first directional hypothesis (H1). Accordingly, strong negative correlations were found between SJ, CMJ, and HJ and completion times. Because sprint performance was evaluated in terms of completion time, these negative correlations indicate that greater jump performance was associated with shorter 6 × 8 m completion time. These findings indicate an association between lower-extremity explosive performance and RSP-COD in our sample.

Numerous studies have reported a strong relationship between lower-extremity explosive power and sprint performance. For example, [França et al. \(2024\)](#) reported that SJ, and especially CMJ performance, were significantly related to sprint and agility performance, and that CMJ remained significantly associated with sprint performance even after controlling for age and body composition. Similarly, a meta-analysis by [Thurlow et al. \(2024\)](#) revealed that repeated sprint training improved not only repeated sprint performance but also CMJ performance. Another study reported that eight weeks of sprint and change-of-direction training improved sprint and CMJ performance in young male tennis players ([Fernandez-Fernandez et al., 2025](#)).

When these studies are evaluated together, the relationships between sprint and jump performance may partly reflect some common neuromuscular characteristics, such as the ability to generate high force over a short period, rapid acceleration, and effective utilization of the stretch-shortening cycle. However, these characteristics were not directly assessed in this study. This interpretation is consistent with the findings regarding body composition and muscle strength in young athletes. For example, [Martínez et al. \(2025\)](#) reported that young soccer players with higher lean body weights performed better in the SJ. [Xiao et al. \(2022\)](#), in their systematic review of young tennis players, reported that power performance was most commonly assessed using the CMJ test and that different exercise programs were associated with improvements in CMJ performance in young tennis players. Although findings regarding power development are not entirely consistent across studies, the significant relationships observed between SJ and CMJ performance and the 6 × 8 m RSP-COD in the present study indicate that lower-extremity explosive performance is associated with the 6 × 8 m RSP-COD in this sample.

The strong relationship between HJ performance and 6 × 8 m RSP-COD is also consistent with the literature. [Johansen et al. \(2025\)](#) reported strong relationships between sprint performance and HJ performance and that HJ tests are effective complementary tools for evaluating sprint capacity. Similarly, [Kleeberger et al. \(2024\)](#) reported that HJ performance is strongly correlated with maximum sprint speed. This relationship has been attributed to common biomechanical characteristics, such as horizontal force generation, short ground contact time, and efficient use of the stretch-shortening cycle. Coaches may wish to periodically assess RSP-COD alongside short-distance sprint and jump performance during practice. The 5-10 m sprint tests provide an indication of short-distance acceleration performance, while SJ, CMJ, and HJ provide information on lower-extremity explosive performance.

Studies specific to tennis also support the current findings. For example, [Parpa et al. \(2023\)](#) reported that CMJ performance in young tennis players is significantly related to serve speed and that lower-extremity explosive power plays an important role in tennis. [Lopez-Valenciano et al. \(2023\)](#) reported that CMJ performance increased with biological maturity in elite young tennis players, especially in male athletes. Furthermore, [Guo et al. \(2024\)](#) reported in their systematic review that plyometric and neuromuscular training applied to young tennis players resulted in significant improvements in agility, speed, and strength performance values.

The relevance of lower-extremity strength to athletic performance has been discussed within the theoretical framework presented by [Suchomel et al. \(2016\)](#). Their study reported that maximal muscle strength is closely related to jump, sprint, and change-of-direction performance, and that strength level is related to force-time characteristics of explosive performance. In the context of the present study, the significant correlations observed between SJ, CMJ, HJ, and 6 × 8 m RSP-COD are consistent with the view that lower-extremity explosive performance is an important performance-related characteristic in tennis. However, given the cross-sectional correlational design, these findings indicate an association rather than a deterministic relationship, and lower-extremity explosive power cannot be considered a determinant of tennis performance based on the present data.

However, some studies have shown that this relationship is not linear. For example, [Oleksy et al. \(2024\)](#) showed that higher CMJ performance in professional athletes does not always correspond to better sprint performance. Therefore, jump height alone may not be sufficient to explain sprint performance. In the present study, the strong relationship between CMJ and RSP-COD indicates an association between these measures in this sample, but it does not establish that explosive power determines repeated sprint performance.

Longitudinal studies conducted on young tennis players also support the current findings. [Kramer et al. \(2016\)](#), in their study of young male tennis players, stated that an increase in lower-extremity explosive power significantly improved 5 m sprint performance, and that this effect was more pronounced in elite athletes than in non-elite athletes. Similarly, [Kramer et al. \(2021\)](#) reported that lower-extremity strength performance is an important determinant of sprint performance in young female tennis players and that growth and physical development are closely related to sprint capacity. Furthermore, the study indicated that players in tennis matches have to generate high acceleration in a very short time after a serve; therefore, lower-extremity explosive performance may be relevant to short-distance movement demands in tennis.

Linear Sprint Performance and Repeated Sprint Performance with Change-of-Direction Demands

In the present study, a moderate positive correlation was found between RSP-COD and 5 m and 10 m linear sprint times, supporting the second directional hypothesis (H2). Both the linear sprints and the repeated sprint test are expressed in terms of completion time; thus, these positive correlations indicate that participants with faster short-distance linear sprint times also tended to have shorter completion times in the repeated shuttle sprint test. This finding indicates an association between short-distance acceleration and multidirectional shuttle performance in these youth tennis players.

The very strong negative correlation between the exploratory 20 m backward sprint time and 6 × 8 m completion time was unexpected and should not be used as evidence of a common biomechanical or neuromuscular mechanism. This negative relationship indicates that participants with longer 20 m backward sprint times tended to complete the repeated sprint test in shorter times. This direction is counterintuitive, and no plausible motor development or biomechanical explanation can be established from the present data. Therefore, this finding should be regarded as exploratory and interpreted with extreme caution. Given the small sample size (n=16) and cross-sectional design, the finding may reflect sample-specific characteristics or measurement-related factors and warrants further investigation in larger samples with an appropriate a priori power analysis.

Previous research has also reported associations between short-distance sprint and repeated sprint performance. [Fernandez-Fernandez et al. \(2025\)](#) reported significant improvements in 10 m and 5 m linear sprint performance in young male tennis players following eight weeks of sprint and change-of-direction training, accompanied by

improvements in agility and jumping performance. [Thurlow et al. \(2024\)](#) similarly showed in their meta-analysis that repeated sprint training improved 10 m and 20 m sprint performance, as well as RSP-COD performance. Speed is one of the most frequently assessed performance components in young tennis players ([Xiao et al., 2022](#)), and previous research has reported that different exercise programs are associated with improvements in sprint performance. The researchers also emphasized that players in tennis competitions mostly perform high-intensity movements over distances of 8-12 m. In line with these findings, the observed relationships between short-distance sprint tests and RSP-COD in the present study are consistent with the movement demands of tennis.

The biomechanical and neuromuscular characteristics of sprinting also provide context for the findings for the 5 m and 10 m sprint tests. For example, [Kleeberger et al. \(2024\)](#) reported that sprint performance consists of acceleration and maximum-speed phases; athlete mass and acceleration capacity are more relevant during the first 10 m, whereas horizontal force generation is more relevant during later phases. [Johansen et al. \(2025\)](#) reported that sprint performance is closely related to high horizontal force generation and ground-contact characteristics, especially during the 10-20 m acceleration phase. Similarly, [Oleksy et al. \(2024\)](#) argued that performance during the first meters of a sprint is predominantly related to concentric force generation, whereas in later sprint phases, both concentric and eccentric force characteristics contribute during later sprint phases. These findings provide a possible context for the observed associations between 5 m, 10 m, and 6×8 m RSP-COD, although the underlying acceleration and neuromuscular characteristics were not directly assessed in the present study.

In contrast, the very strong negative correlation observed between 20 m backward sprint time and 6×8 m repeated sprint time was unexpected and should not be interpreted as evidence of a shared biomechanical or neuromuscular mechanism. As noted above, participants with longer 20 m backward sprint times tended to have shorter 6×8 m repeated sprint times. Given the small sample size and the correlational design, this finding may reflect sample-specific characteristics or measurement-related factors and requires further investigation in larger samples.

Force-production capacity and the rate of force-production are relevant to sprint performance. [Suchomel et al. \(2016\)](#) reported that maximal muscle strength is closely related to sprint and change-of-direction performance, and that strength level is related to force-time characteristics. In a meta-analysis, [Deng et al. \(2022\)](#) found that plyometric training significantly improved sprint speed in tennis players. One study suggested that plyometric, neuromuscular, and functional training improved speed, power, and agility in young tennis players. Moreover, it has been reported that combining high-intensity interval training with strength training can significantly contribute to short-distance sprint performance, RSP-COD, and power development ([Guo et al., 2024](#)). In light of these findings, the associations identified between 5 m, 10 m, and repeated sprint performance may be consistent with the relevance of common performance characteristics, such as rapid acceleration and force production, to these tasks. However, these characteristics were not directly assessed in the present study.

The effect of body composition on sprint performance in young athletes also provides context for the current findings. For example, [Martínez et al. \(2025\)](#) reported that young soccer players with higher lean body weight performed better in 10 m and 20 m sprints, whereas a high body fat percentage negatively affected sprint performance. This finding provides a possible context for the associations observed between short-distance sprint performance and RSP-COD in the present study. However, the specific contribution of force-generation capacity cannot be determined from the present data.

Longitudinal studies conducted on young tennis players also support the current results. For example, [Kramer et al. \(2016\)](#) reported that age, body weight, and increases in lower-extremity strength significantly improved 5 m sprint performance in young male tennis players, and that even very small changes in sprint duration could increase the player's movement advantage on the court. Similarly, [Kramer et al. \(2021\)](#) showed that sprint performance in young female tennis players is closely related to growth, physical development, and lower-extremity strength, and that small gains in sprint performance can contribute to game performance by increasing the players' preparation time for the stroke.

The present study showed moderate positive correlations between the 6 × 8 m completion time and the 10 m and 5 m sprint times, indicating that short-distance sprint performance was associated with RSP-COD in this sample. In contrast, a very strong negative correlation was found between 6 × 8 m completion time and 20 m backward sprint time. As both sprint variables were expressed as completion times, this inverse association indicates that participants with longer times to complete the 20 m backward sprint tended to have shorter times to complete the 6 × 8 m completion times. This unexpected direction should be interpreted with caution and should not be taken as evidence that better backward sprint performance is associated with better RSP-COD. The finding may reflect characteristics of the present sample rather than a general performance relationship, given the small sample size and correlational design.

Finally, another study indicated a significant difference between sexes in 10 m sprint performance, but no such difference in 5 m sprint performance. It was also emphasized that regular training can reduce performance differences in this age group ([Diker et al., 2017](#)). These findings, particularly the moderate correlation observed in our study between the 10 m sprint performance and RSP-COD, are consistent with the view that short-distance sprint performance is an important performance indicator in tennis.

Flexibility and Repeated Sprint Performance with Change-of-Direction Demands

In the current study, no statistically significant relationship was found between flexibility performance, assessed using the sit-and-reach test, and the 6 × 8 m RSP-COD. This finding is consistent with our exploratory assumption that static hamstring and lumbar flexibility in U12 male tennis players is not significantly associated with dynamic repeated shuttle sprint performance. Although tennis requires high acceleration, sudden deceleration, and changes in direction, these movements involve multiple physical characteristics, including muscle strength, explosive power, and neuromuscular coordination. The present findings do not allow the specific contribution of static flexibility to repeated sprint performance to be determined.

The literature on the relationship between flexibility and sprint performance is limited. For example, a review study reported that the number of studies examining the effect of flexibility on athletic performance is insufficient, and the available evidence is insufficient to reach a definitive conclusion ([Xiao et al., 2022](#)). [Diker et al. \(2017\)](#) reported that flexibility is particularly important in terms of range of motion and striking technique, but no significant difference was found between the sexes. Another study reported that functional training is particularly effective in improving flexibility and balance, whereas neuromuscular training is effective in improving speed, flexibility, and strength ([Guo et al., 2024](#)).

The present study employed a cross-sectional correlational design; therefore, these findings represent associations rather than causal relationships. The observed correlations should not be interpreted as evidence that changes in anthropometric characteristics or lower-extremity explosive power cause changes in RSP-COD. Overall, RSP-COD in this sample was associated with several physical performance characteristics, including explosive power and sprint performance, but not with passive static flexibility.

Limitations

This study had several limitations. First, our sample size was not determined using an "a priori power analysis". The sample size was based on sample sizes from studies with similar experimental designs published in the sports science field. Therefore, the current sample size may limit the statistical power, and the generalizability of the findings should be interpreted with caution. Second, the cross-sectional and correlational design does not allow causal relationships to be established. Another important limitation of our study is the relatively small number of participants (n=16), which may limit the stability of the correlation coefficients and the generalizability of the findings to different age groups or performance levels. Future studies should determine the sample size beforehand using an appropriate power analysis (G*Power, etc.) and include larger samples. Another limitation is the fact that biological maturation was not evaluated in the present study. Although participants were in the U12 age category, chronological age may not be an adequate sole indicator of individual differences in biological maturation.

Variables such as Tanner stage or peak height velocity (PHV) were not measured, and the possible effect of maturation on anthropometric characteristics, sprint performance, jumping ability, and repeated sprint performance could not be accounted for. Future studies should include appropriate measures of biological maturation to better separate the effects of growth and maturation from those of physical performance variables. Finally, multiple correlation analyses were conducted, which may increase the possibility of Type I error. Therefore, the results should be considered exploratory and treated with caution. Larger samples, longitudinal designs, and direct assessment of biological maturation are necessary to further evaluate these associations.

Future research should further examine these associations in larger samples and across different age groups and competitive levels, using longitudinal designs and direct assessment of biological maturation to better clarify the relationships between physical performance characteristics and RSP-COD.

Conclusion

In conclusion, the present study found significant associations between 6×8 m RSP-COD and height, body weight, lower-extremity explosive performance (SJ, CMJ, and HJ), and short-distance linear sprint performance (5 m and 10 m) in U12 male tennis players, supporting the directional hypotheses. Conversely, static flexibility (sit-and-reach) and BMI were not significantly associated with 6×8 m RSP-COD and were considered exploratory. The very strong negative correlation between exploratory 20 m backward sprint time and 6×8 m completion time was unexpected and should be interpreted with extreme caution, as it may reflect sample-specific characteristics rather than a general performance relationship. Overall, the findings indicate that vertical and horizontal jumping performance and short-distance linear sprint acceleration were associated with tennis-specific repeated change-of-direction sprint performance in this age group. These measures may be useful for monitoring performance development and informing individualized training programs, although this interpretation should be confirmed in larger and longitudinal studies.

Declarations

Author Contributions: MÖ and MA contributed to the study design. MÖ conducted the literature review. MÖ and MA performed data collection. MÖ performed data analysis and data computerization. MÖ and MA drafted the manuscript. All authors contributed to manuscript revision and approved the final version.

Ethics Approval and Consent to Participate: The study was approved by the Non-Interventional Clinical Research Ethics Committee of Mardin Artuklu University (approval date and number: 07.10.2025; 2025/10-23). Written informed consent was obtained from all participants' parents or legal guardians and written assent was obtained from the participating children before data collection.

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