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Original Article

Chronological age and performance differences: A comparative analysis of speed, change of direction and explosive power amongst U-15 and U-18 soccer players

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Abstract

Background: Chronological age is calculated from a single time point away from an individual's date of birth, and changes in physical fitness may vary amongst individuals. Understanding how these variations manifest across different age groups is crucial for optimizing athletic performance in youth sports.

Aim: This study aims to examine the disparities in speed, change of direction (COD), and explosive power performance between two competitive age groups of youth soccer players.

Methods: Thirty soccer players ($n = 30$) were recruited from a secondary school, comprising two age groups: under 15 ($n = 15$) and under 18 ($n = 15$) years. The participants underwent three physical tests assessing speed, COD, and explosive power performance.

Results: The findings revealed significant differences in explosive power performance between the two age groups ($P = 0.04$). Speed performance exhibited a trend towards significance ($P = 0.05$), while COD results did not reach statistical significance.

Conclusion: These outcomes underscore the potential influence of age on sport-related performance, particularly in explosive power. This suggests that training programs may need to be tailored differently for athletes in different age groups to maximize performance outcomes.

Key Words: Age and maturity impact, change of direction, explosive power, soccer, speed

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INTRODUCTION

Over the recent years, the landscape of modern soccer has undergone a profound transformation, evolving into a dynamic and high-paced intermittent sport (Michailidis et al., 2021; Yu et al., 2021; Andrašić et al., 2021). Soccer nowadays has been characterised by a blend of short-duration, high-intensity activities, including sprinting, running, jumping, duels, tackling, change of direction (COD) and various instances of walking and standing (Pavillon et al., 2021; Gualtieri et al., 2023). In a typical soccer game, players performed high-intensity movements every 60 s and maximal efforts every 4 min and during the whole match (Pavillon et al., 2021). It was reported that overall players perform more than 1200 unpredictable changes in activity, which comprises up to 11%–12% of sprinting from overall total distances

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covered, 1200–1400 changing direction and 30–40 tackling and jumping and between 90 and 140 interaction with the ball which includes passing, kicking and also dribbling (Yu et al., 2021; Negra et al., 2022; Hulton et al., 2022) which most of the actions involved in soccer are mostly highly explosive (Križaj, 2020).

By possessing great physiological abilities may benefits in optimising performance and may enhance tactical implication of the coaches (Zghal et al., 2019; Yu et al., 2021; Keiner et al., 2021). The significance of possessing good speed, COD and explosive power is emphasised in the context of individual players and their impact on the team not only in adult but also in youth soccer game (Zghal et al., 2019; Andrašić et al., 2021). This is because, during the game, attackers are tasked with applying pressure and executing tackles on opponents, while defenders aim to minimise the field space to restrict attacking movements and mitigate potential threats to the team (Andrašić et al., 2021). This trend underscores the increasingly athletic nature of contemporary soccer, where attributes such as strength, power and their derivatives, including sprinting, jumping and COD were correlated and play pivotal roles in determining success (Sonesson et al., 2020; Sariati et al., 2020; Keiner et al., 2021). This is supported by Križaj (2020) where in the study stated that there was moderate to strong relationship on how sprinting and changing direction required adequate amount of lower limb explosive power.

Speed is one of the performance indicators to success in soccer which it is defined as high-velocity running and ability to cover a distance from one point to another (Yildiz et al., 2018). In practical terms, it denotes the body's ability to move swiftly to cover distance as fast as possible (Krosta et al., 2020). The utilisation of speed is prevalent throughout both halves of a soccer game (Field et al., 2022). Within soccer game situation, average distance covered by sprinting or speed is up to 110–330 m respected to their playing position (Yildiz et al., 2018; Krosta et al., 2020). Saeidi and Khodamoradi (2017) highlight that professional athletes cover 5%–10% less distance in the second half, particularly at medium intensity (11.1–19.0 km/h) and high (18.0–30.0 km/h) intensity speed categories. However, a study by Reinhardt et al. (2019) indicated that average elite soccer players' distance cover for high-intensity running is up to 24%–36% and for linear sprinting is up to 36%–63% of overall distance cover throughout the whole game. In the aspect of youth soccer players, it was reported that the youth players approximately covered 6–8 km and performed average of 80 accelerations (>1 m/s^2) per match with a duration of 2 and 4 s each (Fernández-Galván et al., 2022). Sprint performance assessment has shown to be correlated to lower body muscle strength-power in youth soccer players and if the players possessed great sprinting capabilities may result in scoring advantages (Sonesson et al., 2020).

In the past few decades, COD and reactive agility were considered to be the same skill (Andrašić et al., 2021). However, after continuous research has been done, COD is described as a motion in which no immediately reaction to a stimulus is required, thus the path exchange is pre-deliberate or pre-planned (Andrašić et al., 2021). COD also known as a speed component that has a rapid whole-body movement with COD in response to a stimulus and used a lot in soccer which it involved acceleration phase and a deceleration phase, followed by the acceleration in a different direction (Falch et al., 2019). COD is an important element in invasion sport like soccer (Sariati et al., 2020; Michailidis et al., 2021) which it is a common skill required to success in invasive sport like soccer (Andrašić et al., 2021). Besides that, as according to Horníková and Zemková (2021), COD movements in invading sport as soccer are determined by stride modifications, physical factors such as directly sprinting pace and leg-muscle features, which consist of strength, power and reactive strength. In a single game, soccer players will change running direction approximately every 2–4 s and a total of 1200–1400 times (Keiner et al., 2021). Thus, this shows that COD is very important to effectively execute such movements that are required frequently in a single soccer match. The players that have high-COD ability could give an advantage towards him or her in the game (Keiner et al., 2021). This is supported by Trecroci et al. (2020). COD manoeuvres such as side steps, swerves, turns, crossover steps and bypass manoeuvres are crucial movements in soccer which they allow players to evade opponents effectively, create space for teammates and position themselves for scoring opportunities.

Explosive power is defined as the dynamic strength and speed of muscle contractions, characterised by rapid and forceful movements (Darni and Elkadiowanda, 2019). Explosive power is a crucial motor skill in many sports including soccer (Marko Joksimović et al., 2019). It hinges on both muscular strength and the velocity of bodily motion, as highlighted by experts who suggest it combines these two essential abilities (Darni and Elkadiowanda, 2019). Lower limb explosive power directly influences both sprinting speed and in COD movements which youth players who possessed high level of explosive power could enhanced their ballistic movements translating into improving their performance in jumps, turns and sprinting ability (França et al., 2021; Cossio-Bolaños et al., 2021). This is supported by Marko Joksimović et al. (2019) that indicated that explosive power curial in maximising high speed movement execution in activities such as jumping and sprinting. As in soccer game, power also important when involving explosive contractions of muscles with forces produced at higher velocities for any movements such as shooting, assisting in short or long passes, attempting to jump to the maximum height to score a head or quickly change direction situations happened during one on one duels (Behm, 2018). This is supported by Jusoh et al., (2019) and stated that power is one of the most important physical components to gain success in modern soccer and power (strength-speed), speed and all the related factors are the key contributors to the performance of soccer team.

The rationale for selecting these age groups stems from a scarcity of research that explores changes in physical performance amongst different ages and maturity (Giudicelli et al., 2021; Fernández-Galván et al., 2022) which this current study highlighting chronological age that cause the athletes' performance differences where typically chronological age served as the primary measure for assessing an individual's growth and maturity (Ke et al., 2021). Existing evidence suggests that physically mature boys generally demonstrate better performance than their less mature counterparts (Pichardo et al., 2019). However, limited studies exist to robustly support this observation (Zghal et al., 2019). This is supported by Sonesson et al. (2020) where the study stated that previous evidence shown that performance of the youth athlete became plateu after the age of 15 years old. To contribute more substantial evidence supporting disparities in performance between various ages, the current study seeks to investigate the differences in speed, COD and power performance amongst U-15 and U-18 soccer players.

METHODS

Experimental approach to the problem

The descriptive research design was used in this study which three physical testing and assessments were applied to the subjects which were 20m sprint test, arrowhead test and countermovement jump (CMJ) test to detect the differences of speed, COD and explosive power performance between the U-15 and U-18 soccer players. 48 h before testing, subjects were asked to refrained from any physical activities. During the testing, the subjects were informed about testing procedures as a group to be sure that they all get the same instructions. The testing started after anthropometric measurements (height and weight) and a standardised warm-up. After that, familiarisation of the tests was done to make sure the subjects understands and familiar on how to do the test. After finish, the assessment begun and started with sequences of 20m sprint test (three trials), arrowhead test (three trials to the right direction and three for the left direction) and CMJ test (three trials). There were 20 min rest intervals between the tests. A brief explanation about the testing protocols is described as follows.

Subject

Thirty under 15 (*n* = 15, mean ± SD; aged = 14.47 ± 0.81 years; height = 1.65 ± 0.06 m; body mass = 55.04 ± 12.64 kg) and under 18 (*n* = 15, mean ± SD; aged = 16.27 ± 0.44 years; height = 1.68 ± 0.05 m; body mass = 56.71 ± 7.59 kg) soccer players who actively played for amateur youth competition from the Sultan Idris Shah II Secondary School, Malaysia, enrolled in this study. A priori sample size calculation was performed using G*Power software (Version 3.1.9.7; Faul, Erdfelder, Lang, & Buchner, 2007), and it was determined that a minimum of 15 subjects per group was required for this study, with a desired power of 0.80 and an alpha of 0.20, to detect differences in speed, change of direction (COD), and explosive power performance between U-15 and U-18 soccer players. The selected subjects must be free from any injuries for over 6 months at the lower limb regions before testing. The subjects and their parents/legal guardians were fully informed of the procedures of this study and have gave their written informed consent. The current study experimental protocol was fully approved by the university ethics committee before the commencement of the assessment and the study was performed in accordance with the university ethics committee guidelines.

Protocol

Anthropometric measurements

The standing height was measured by stadiometer and subjects' weight was taken using the digital weight scale.

Warm up protocol

Standardised warm-up was done for about 10 min led by the researcher. The warm-up consisted of 5 min dynamic warm-up and movements. After that, the testing familiarisation was done which researcher demonstrated the correct movements and procedures of the test and then the subjects practiced each assessment to make sure they were familiar with the tests.

Speed assessment

20m sprint test was used to measure the speed. The test was a maximal sprint effort testing (Madarsa et al., 2021) and is oftenly used to measure acceleration and maximum speed qualities (Brini et al., 2021). During the test, timing gates (Brower Timing System, USA) were used to record sprint time to the nearest 0.001 s (Murtagh et al., 2018) and to avoid any potential biased. The timing gate was placed at point A (0m) at the starting line and at the finish line/point B (20 m) which it recorded photocells with 1 ms accuracy (Brini et al., 2021). Subjects were required to stand body leaned forwards and when they were ready, they need to perform three maximal sprint efforts for 20 m distance (Brini et al., 2021), as shown in Figure 1, separated by approximately 3 min of passive recovery. The best time between three efforts was recorded to the nearest two decimals.

Change of direction assessment

The arrowhead used to measure COD which this test can be used to evaluate a soccer player's capacity for longer distance sprints involving COD (Michailidis et al., 2021) and reliable in measuring COD in soccer (Rago et al., 2020). The subjects needed to complete six trials (three to the right and three to the right). The participants were placed at starting cone (A), 0.20m from the gate and then when they were ready, they need to sprint to the middle cone (B), turned to the left (E) or right (C) (depending on the trials) to sprint around the side marker, sprint around the top cone (D), before sprinting back to A through the brower timing system to finish the test (Rago et al., 2020). The tests were done

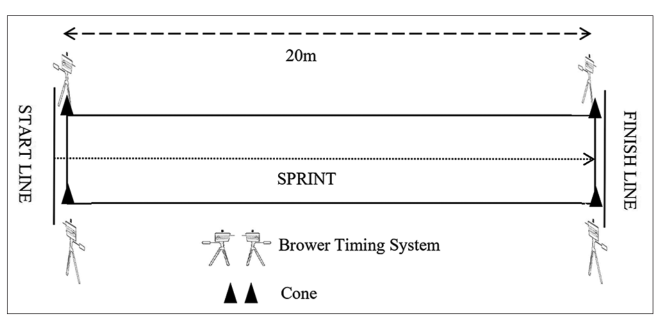

Figure 1: 20 m sprint test

on the right side first before left and they rotated alphabetically by surname for each trial, as shown in Figure 2. This provided approximately 3 min of rest which was enough recovery for the subjects to do the next trials. The best time between the trials was recorded to be analysed.

Explosive power assessment

Explosive power was analysed by CMJ test which as according to Barker et al. (2018), CMJ is a great assessment to analyse lower body power and is easier to perform rather than other jumping tests such as drop jumps or approach jumps. In the current study, instead of using traditional vertex, CMJ was observed through mobile application (My Jump 2) and recorded using a mobile smartphone (iPhone XR) (Haynes et al., 2019). The mobile application calculated the CMJ flight time by identifying the take-off and the landing of the video recorded and is a valid, reliable, useful and affordable tool for measuring jump performance for youth athlete (Bogataj et al., 2020). All the personal data of the subjects were pre-inserted. The subjects began in a standing position with their torso upright, knees fully extended, feet shoulder-width apart, and hands on their hips. Upon instruction, they performed a quick downward movement, bending their knees to approximately 90° of flexion, followed by a rapid upward movement to jump as high as possible (Bogataj et al., 2020) [Figure 3]. The subjects needed to perform three maximal jumps while maintaining their hands on their hips. My Jump 2 calculated the CMJ flight time by identifying the take-off and the landing of the video recorded [Figure 4] and then transforming it into a jump height using the equation $h = t\,2 \times 1.22625$. CMJ movements were recorded by the researcher from same position and 1.5 m apart from the subjects as according to the manufactory instructions. The highest jump amongst the three was taken into analysis.

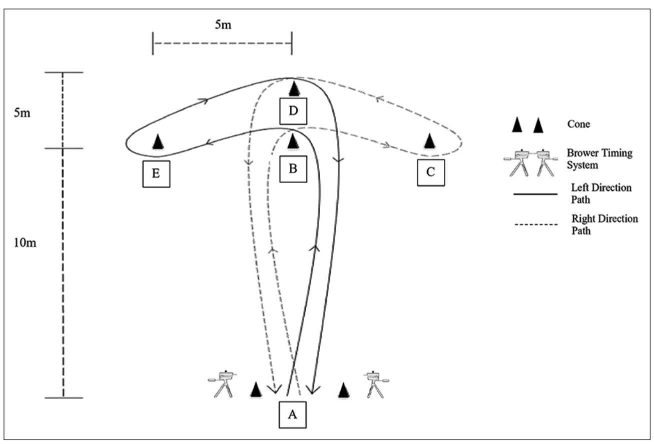

Figure 2: Running path for arrowhead test

Statistical analysis

In the statistical analysis, the mean and the respective standard deviations of each variable in the study and in all contexts of planned analysis were calculated and presented in text and tables. SPSS (Version 25, SPSS) was used for the statistical analyses and researcher used independent *t*-test to calculate the differences in speed, COD and explosive power performance in U-15 and U-18 soccer players.

RESULTS

The aim of this study is to investigate the differences in speed, COD and explosive power performance in U-15 and U-18 soccer players [Table 1]. Independent *t*-test result [Table 2] revealed a statistically significant difference ($P < 0.05$, $P = 0.043$) was found in explosive power between the U-15 and U-18 soccer players. In addition, a trend towards significant ($P = 0.05$) was also observed in speed performance between the two age groups. In the current study, there are no significant differences in COD between U-15 and U-18 soccer players which the results showed scored $P > 0.05$ ($P = 0.14$, $P = 0.35$).

DISCUSSION

Based on the significant and trend towards significant result that had been found by the current finding, this could attribute to the difference in chronological age which the U-18 soccer players are older and tend to have better performance in physical fitness than the younger counterpart; therefore, in this case, capable of

Figure 3: Counter-movement jump

producing greater muscular power during explosive power and speed testing. This is supported by Béres et al. (2021) and stated that early-maturing players in youth soccer exhibit higher physical fitness scores and may surpass their less mature counterparts at various stages of selection. Growth and maturity are typically assessed by both chronological age and biological age (Ke et al., 2021). In the current study, we focus on the influence of chronological age on testing performance. Chronological age is simply calculated based on the date of birth (Currie, 2018) and is commonly used as the age category in the physical fitness standards globally (Ke et al., 2021). Many past studies indicated that chronological age has a significant impact on physical fitness (Ke et al., 2021) and past studies also indicated that chronological age has significant roles with physical maturation which may influence on physical performances (Lesinski et al., 2020; Giudicelli et al., 2021; Ke et al., 2021). This is because older players tend to mature earlier and may possessed greater anthropometric qualities and better sport performances (Radnor et al., 2021).

Age, growth and physical maturation due to different age groups may give influence on performance and sport-specific manner for the athletes (Currie, 2018). This phenomenon can be attributed to several factors, including physiological development, muscular strength gains over time, enhanced neuromuscular coordination and more refined motor skills. Furthermore, experience and tactical understanding acquired through years of participation contribute significantly to their ability to optimise performance during the physical assessments. These insights underscore the complex interplay between age-related physiological advantages and the cumulative benefits of prolonged athletic experience in shaping superior physical testing outcomes amongst older athletes. This statement is supported by Peitz et al. (2018) indicated that as the individual transitions from childhood to adulthood, numerous physiological changes occur in the neuromuscular system, including muscle-tendon development, muscle activation, circulation of androgens and motor unit recruitment. Besides that, a study by Pichardo et al. (2019) stated that this transition will not only affect the athletes' growth development and physiological changes but also their strength and performance in motor skill tasks such as running, jumping and sprinting. This is supported by Kumar et al. (2021) indicated that these physiological changes may influence the capabilities of the youth players to perform well in fitness performances.

In addition, as players mature, they tend to display increased maximal force production and improved muscle capabilities, specifically regarding their muscle's stretch-shortening cycle (SSC) and the strength of the lower limb muscles crucial for executing jumps (Kurihara et al., 2021). This is supported by França et al. (2021) stated that chronological age is one of the longitudinal predictor of explosive leg power from childhood to young adulthood and it is believed that explosive leg power performance in boys increases linearly from ages 5 to 18 years. The results of this study are consistent with those of Guimarães et al. (2019), who examined the effects of different age and maturity statuses on physical performance and technical skill development in basketball players. They found that older and more mature players had larger body sizes, weighed more, and possessed greater levels of muscular strength, power, and speed, which contributed to better jumping performance and improved timing in sprinting tests. These individual characteristics will cause better explosive actions and gestures which contribute to better force production and speed (Mancha-Triguero et al., 2021). A study by Pichardo et al. (2019) indicated that more mature athletes tend to have greater muscle mass and stature during growth spurts, which can influence differences in test results. In the context of soccer, previous research has shown differences in power performance and a trend towards significance in sprinting ability between mature and younger players (Murtagh et al., 2020; Lesinski et al., 2020; Fernández-Galván et al., 2022). This is supported by Yapici et al., 2022 muscle strength increases with age, with the most significant growth in muscle mass occurring during adolescence. This could give possible insight that physiological changes associated with age, growth and maturation that gave better results in elderly players than the weaker counterparts.

Table 1: Demographic comparison between U-15 and U-18

Variables	U-15 (*n*=15)	U-18 (*n*=15)
Age (years)	14.47±0.81	16.27±0.44
Weight (kg)	55.04±12.64	56.71±7.59
Height (m)	1.65±0.06	1.68±0.05

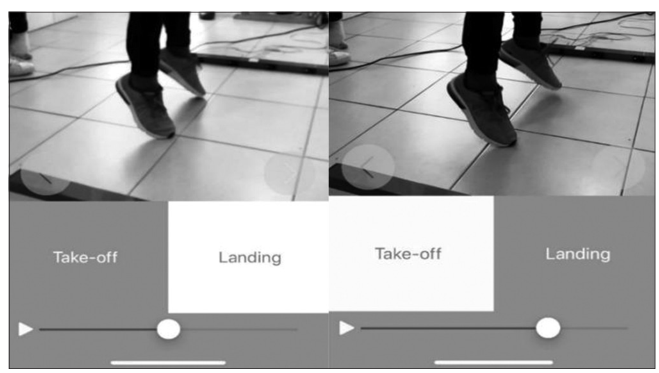

Figure 4: Landing frame and take-off frame

Table 2: Performance test comparison between U-15 and U-18

	U-15, mean±SD	U-18, mean±SD	df	*t*	*P*
Speed assessment (20m sprint test)	3.23±0.09	3.16±0.11	27.43	2.01	0.05
COD assessment arrowhead test (right)	8.45±0.30	8.28±0.29	27.98	1.51	0.14
COD assessment arrowhead test (left)	8.49±0.30	8.39±0.30	28.00	0.95	0.35
Explosive power assessment (CMJ test)	36.66±4.48	40.37±5.10	27.54	−2.12	0.04*

*Significant difference. COD: Change of direction, CMJ: Counter-movement jump, SD: Standard deviation

Thus, the significant result of this current study may act as one of the evidence that showed the differences in speed and explosive power performance between two different youth age groups.

In the current study, there are no significant differences found in COD and low-to-moderate differences in speed performance between U-15 and U-18 soccer players. As for COD performance is when they are challenged in situations in which the player could pre-plan, the movements in situations which player must quickly react to external (Pojskic et al., 2018). This current study has similar result as a study conducted by Fiorilli et al. (2017) which in the study two age groups (U-16 and U-18) were tested and the result showed that there was no difference in the COD left and COD right test between U-16 and U-18 players. This may happen because subjects could have specific COD skills independently despite their age was different (Fiorilli et al., 2017; Dugdale et al., 2020). Moreover, several factors may influence COD results during the testing such as technique, observation, perception, anticipation and decision-making during the movement execution (Sariati et al., 2020; Sinkovic et al., 2023). This is supported by Pojskic et al. (2018) who stated that individual technical skills and proper movement techniques could influence COD. In addition, Dugdale et al. (2020) indicated that the technical competency of the subjects during COD assessment may affect the result. Sánchez-López et al. (2023) indicated that COD performance was neither influenced by the players' acceleration nor their linear speed but more on isolated technical factors such as lower body braking force, contact time on the ground, correct pelvis alignment and penultimate foot contact on the ground during movement's execution. Therefore, even though the tests presented and evaluated have shown good validity and reliable to assess COD performance in soccer (Rago et al., 2020; Michailidis et al., 2021), additional studies are necessary to explore agility-related performances specific to dribbling in soccer to analyse the differences between two age groups (Pojskic et al., 2018).

This study has a limitation that needs to be acknowledged. The current study did not use the gold standard measurement to specifically assessing the influence of maturity on physical performances but instead referring to past studies that stated chronological age might influence maturity to analyse the differences in physical testing results. This is because, although chronological age is one of the indicators to measure maturation in young athletes (Lesinski et al., 2020; Giudicelli et al., 2021), different maturity status may influence the physical testing outcomes (Pichardo et al., 2019). The future study could highlight the possible influences of the onset of maturity that cause differences between the two age groups to have better results in COD and especially in speed which this current study's result is quite arguably. As for COD, as stated before, additional studies were required in exploring COD in soccer which soccer-specific COD movements such as dribbling while doing COD movements could help in assessing the differences between the youth players. Besides that, the current study did not implemented any sort of training programme towards the youth players which players' performance may varied if they had consistently sustained in months of training (Silva, 2022). Additional studies should be carried out to study the age-related differences that tested the subjects' performance after few weeks of underwent training regime. Finally, relatively small sample size is also one of the limitations for this study which bigger sample size could influence the results and might have different outcomes (Brysbaert, 2019). Despite all the limitations, the results reported by this current study will help to be one of evidence that shows differences between two chronological age groups in terms of speed, COD and explosive power. Finally, this current study could contribute to developing scientific knowledge in the area of soccer training which it may help in developing specific training programme to ensure that all the requirement and particular needs in different age groups could be fulfilled.

CONCLUSION

Even though only one significant result was found in our study (explosive power), the other two assessments only showed moderate to high effect (speed) and no significant result (COD) on how influence of age and maturity may influence performance between the two age groups, it is believed that our data have crucial practical implications, particularly for the ones involved in youth soccer. This study could give possible insight on the significant impact of chronological age on sport-related performance, influenced by the interplay of physical and physiological variables tied to age, growth and maturation. Typically, earlier-maturing boys are taller, heavier and more muscular. Notably, these differences can be influenced by targeted training interventions. In response, soccer coaches and trainers should design suitable programmes, considering the diverse physical and physiological characteristics amongst players. Individualising the training process is essential, accounting for age-related variations. Coaches can use these findings to tailor-specific training regimens, addressing the unique needs and muscle maturity of each player.

In summary, although growth and maturation variables were not included in our analysis, representing the primary limitation of this study, as stated before, we believe our data have significant practical implications, especially for those involved in youth soccer. This study provides valuable insights for coaches, highlighting the nuanced relationship between age and sport performance. By recognising and accommodating individual differences, coaches can optimise training programmes for enhanced effectiveness in the context of youth soccer.

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Conflicts of interest

There are no conflicts of interest.

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