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Article

Talent Identification In Football: Different Effects of Maturation on Sprinting, Change of Direction and Jumping in 13-Year-Old Players

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Featured Application: Authors are encouraged to provide a concise description of the specific application or a potential application of the work. This section is not mandatory.

Abstract: The aim of this cross-sectional study was to assess the influence of the maturity status on speed, explosive power and change of direction (COD) in 13-year-old football players. Ninety-eight male players (age: 13.1 ± 1.0 y) were divided into late, average, and early maturation groups. Physical fitness testing included the following variables: 10 and 30-meter sprint time and maximum speed in the 20-30 m segment of the 30-meter sprint test, the T-test time, countermovement jump height and horizontal distance in the triple jump. The data showed a significant effect of maturity status on performance in three parameters: in maximum speed in the 20-30 m section ($p = 0.024$), however, the only significant differences were found between the early-maturation group and average-maturation group ($p = 0.033$); in the COD ($p = 0.024$), where significant differences were confirmed between the late-maturation group and the average-maturation group ($p = 0.033$); in the unilateral triple jump distance of the dominant and non-dominant ($p = 0.007$ and $p = 0.001$, respectively) lower limb. For both limbs, significant differences between the late-maturation group and average maturation group ($p = 0.005$ and $p = 0.013$, respectively) as well as the late-maturation group and early-maturation group ($p = 0.007$ and $p = 0.045$, respectively) were proved. These results indicate that maximal speed, COD speed and unilateral lower limb reactive strength are moderated by biological age in football players aged 13 years.

Keywords: adolescence; growth; acceleration speed; maximal speed; explosive power; reactive strength

1. Introduction

Long term athlete development (LTAD) stands for models that aim to establish the best concepts for coaches, PE teachers and parents [1,2]. During LTAD phases, the accurate identification of talents is a crucial tool for sports clubs to assess the potential of young athletes [3]. One of the fundamental general issues in talent identification is the problem of comparing current performance to potential. The main reason is that maturity status has been confirmed as a significant contributor to performance in most physical fitness components [4]. Therefore, current LTAD models primarily concentrate on determining maturation changes and incorporating them into the interpretation of current physical performance, thereby estimating the potential of a young athlete [5,6]. The consideration of biological maturation is crucial in adolescence, given the highly individual timing and duration of maturation changes [7]. This applies especially around the period of peak height velocity (PHV), which occurs between 11-16 years for boys [4].

The process of talent identification is, to some extent, sport-specific [5]. In football, talent identification is primarily focused on physiological, psychological, technical and tactical skills of a

player [8]. The strongest fitness predictors of elite performance in football appear to be speed, agility, maximal power and the high rate of power development considering the short period spent on the ground to produce power [8–10]. In the case of speed, acceleration speed is crucial as it reflects the specific demands of movement on the field (11). However, during talent identification, speed over distances longer than 20 meters proves to be more important because the advantage of faster players becomes more apparent in longer distances and therefore, speed tests in football include both distances up to 20 m and distances over 20 m [10,12,13]. Regarding agility, an important indicator is the speed of change of direction [10]. This assessment is based on different variations of shuttle runs or the T-test [14,15]. In the case of explosive power, the measurements focus primarily on the maximal explosive power of the lower limbs during various forms of vertical and horizontal jumps [16]. Moreover, multiple jumps and/or drop jump exercise are used to measure reactive strength [17].

Recent literature on testing in youth soccer is increasingly focusing on the maximum sprint speed in adolescents [18,19]. Current findings indicate that during the PHV period, there is a significant increase in maximal speed, highlighting the considerable impact of maturation on speed assessment [19,20]. The influence of biological maturation on acceleration speed remains unclear. A recent study by Itoh and Hirose [21], which directly examined the influence of biological age on acceleration speed in U13 football players, did not find significant differences between players of different maturation statuses. On the other hand, Radnor et al. [22] found that maturation significantly affects football players' maximal speed development during PHV, while explosive power tends to develop most after PHV. Another study [23] reported a performance spurt in explosive power starting around 1.5 years before PHV and peaking during and up to 1 year after PHV. These findings suggest uneven physical fitness development during PHV, highlighting the importance of considering growth in testing. Current data regarding the influence of maturation on agility in football are inconclusive. A recent study by Itoh and Hirose [21] with young football players did not find any significant differences in agility across different groups divided by maturation. Similarly, Mathisen and Pettersen [18] did not observe any differences in agility between groups before and after PHV. On the contrary, a recent study by Yang and Chen [24] on 13-15-year-old football players found significantly better performance in agility in early matured players compared to late matured players. These conflicting findings indicate that more research is needed to better understand the relationship between maturation and agility in football players.

Collectively, the results of talent identification may substantially influence football players' careers. Current literature emphasizes the consideration of growth and maturation when evaluating the physical fitness level and performance potential in youth. However, conflicting findings indicate the need for further research to better understand how maturity status influences performance in fundamental fitness predictors of talent in football across different stages of development. Therefore, the aim of this study is to assess the influence of maturity status on linear and change of direction speed, explosive power and reactive strength in 13-year-old football players. The hypotheses of the study are as follows: 1. Maturity status does not influence the acceleration speed in 13-year-old football players; 2. Maturity status influences explosive power, reactive strength, and agility in 13-year-old football players.

2. Materials and Methods

2.1. Participants

This observational cross-sectional study included ninety-eight male football players (age: 13.1 ± 1.0 y; stature: 159.3 ± 10.2 cm; body mass: 46.6 ± 9.4 kg; fat free mass: 41.3 ± 8.5 kg; fat mass: 11.4 ± 4.3 %). For the purposes of the analysis, players were further divided into three maturational groups (Table 1). All players were from the regional football academy of the Czech Republic, they trained on average five times per week and normally played one competitive match per week during the season. Moreover, they participated in five PE classes focused on general fitness preparation. All participants were healthy and asymptomatic of illness and injuries and were fully informed about the content and purpose of testing and at the same time with the possibility of voluntarily withdrawing at any time

during its course without providing a reason. They were also informed about further procedures of data processing, their possible publication and guaranteed anonymity. Each player participated in the survey voluntarily, with expressed consent from their legal representative for the processing of obtained data and their potential publication. The ethical design of the investigation adhered to the Helsinki Declaration of 1964, including subsequent changes and modifications. The methods and procedures applied were carried out in accordance with the stated declaration. The design of the study followed valid principles, regulations and international guidelines for research involving human participants and was approved by the Ethics Committee of the Faculty of Physical Culture, Palacký University Olomouc (reference number: 76/2016).

2.2. Procedures

Data were collected over a total of three seasons from 2020 to 2022, with testing conducted during pre-season. Physical fitness testing was conducted indoors on a wooden floor, with no high-intensity competitions or training for 48 h prior to testing. Players wore appropriate clothing and footwear suitable for the given surface. Each player participated in a 15-minute habitual warm-up supervised by a coach before the testing. Players were familiarized with the testing procedure at the beginning of the testing session and at after the warm-up. The testing itself proceeded in a randomized order: CMJ, triple hop, 30 m sprint and T-test. Anthropometric measurements were taken before the physical fitness testing.

Table 1. Basic characteristics of groups according to maturation status.

	Early maturation	Average maturation	Late maturation
	n = 17	n = 46	n = 35
	M ± SD	M ± SD	M ± SD
Age (years)	12.95 ± 0.26	13.21 ± 1.37	12.93 ± 0.50
Stature (cm)	168.58 ± 6.38 *#	161.36 ± 10.18 †	151.99 ± 6.11
Body mass (kg)	54.92 ± 5.96 *#	49.16 ± 9.38 †	39.30 ± 4.23
Fat mass (%)	11.47 ± 4.43	11.64 ± 4.11	11.15 ± 4.63
FFM (kg)	48.59± 5.67 *#	43.45 ± 8.80 †	34.86 ± 3.77
SMM (kg)	26.92 ± 3.41 *#	23.90 ± 5.37 †	18.73 ± 2.25

FFM – fat free mass; SSM – skeletal muscle mass; M – mean; SD – standard deviation; #significant difference between the early and late maturation groups (p < 0.05); *significant difference between the average and late maturation groups (p < 0.05); †significant difference between the early and average maturation groups (p < 0.05).

2.2.1. Maturity Status

Beyond the consideration of chronological age, we evaluated the stage of biological development of the organism of the monitored subjects. Biological age was assessed specifically using the biological age proportional method [25]. An anthropometric measurement was performed on each participant, based on which the body structure development index (KEI) was calculated. The anthropometric measurement was carried out in accordance with ISAK (International Society for the Advancement of Kinanthropometry) international standards [26]. Stature (cm) was measured using the Tanita HR-001 anthropometer (Tanita, Tokyo, Japan) with a measurement error of 5 mm. Body weight (kg) was measured using the InBody 770 device (Biospace, Seoul, South Korea). The accuracy of measurement when determining body weight was 100 g. To determine the representation of monitored body composition fractions (kg; %), a non-invasive method of multi-frequency tetrapolar bioelectrical impedance (BIA) was employed using the InBody 770 device. BIA devices of this type show the highest degree of validity and reliability of measurement [27]. During the BIA examination, emphasis was on compliance with the conditions and measurement procedure recommendations [28]. The medical tape measure (Holtain, Great Britain) was used to determine the circumferential characteristics. The circumference of the arm (right) in flexion (cm) and the maximum circumference

of the calf (right, cm) were evaluated. The width and bone diameters were determined with a touch gauge with extendable arms – Pelvimeter P-216 (Trystom, Olomouc, Czech Republic). The biepicondylar width of the lower epiphysis of the humerus (cm) and the biepicondylar width of the lower epiphysis of the femur (cm) were evaluated. The Best II K-501 calliper (Trystom, Olomouc, Czech Republic) with a contact surface of 3 mm and a pressure force of 2 N was applied to assess the values of subcutaneous body fat (skin folds). Skin folds (mm) on the right half of the body were assessed above the crest of the hip bone (suprailiac), the skin fold on the arm (above the triceps brachii muscle halfway between the acromiale and radiale points), the skin fold on the back (below the lower angle of the scapula) and the calf II skin fold (in the medial part at the point of highest development of m. triceps surae). Body constitution expressed by somatotype was assessed using the Heath-Carter methodology [29].

The research data were processed using appropriate procedures in the Antropo program version 2000.1. (30). Further data processing took place in the specialized Testbal program (31). Data backup for all conducted research investigations was carried out anonymously and in accordance with the applicable GDPR provisions. The backup was stored in a data cloud managed within the scientific and technical park of the institution (32). Subsequently, player groups of different biological ages were created. If values differed by more than ± 12 months from the norms for the given chronological age, players were categorized as delayed or accelerated.

2.2.2. Change of Direction Testing

The T-test was selected as the tool for measuring COD, with the total test time (in seconds) recorded. The cones were arranged in a T shape. Participants started between two cones upon the commands “get ready” and “start”. First, they ran forwards to the cone positioned 10 meters away, followed by shuffling 5 meters to the right cone, another shuffle 10 meters to the left cone, then a 5-metre shuffle back to the center cone. Finally, they ran backwards to the starting point. Timing commenced at the “start” command and concluded when the participant crossed the finish line. Cone touching was not required as this method is not standardized in the literature [33]. Each participant had only one measured attempt. An attempt was considered unsuccessful if the participant failed to reach the finish line, chose the wrong direction, or crossed their legs during the shuffle. In such cases, the movement content of the test was explained again, and the athlete completed a second attempt following a 10-minute recovery. The T-test was chosen as the COD test due to its validity in assessing the general agility factor and the ability to change direction by 180° . The T-test demonstrated high interrater reliability of ICC=0.98 and test-retest reliability of IIC=0.83 [34]. Infrared timing gates Brower Timing System (Draper, UT, USA) were used for time recording.

2.2.3 30-Meter Sprint Testing

In the 30-meter sprint, acceleration speed and maximal speed were tested. The following parameters were measured during the 30-meter sprint: time 0-10 m (s), time 0-30 m (s) and maximal speed in 20-30 m (km/h). Participants were instructed to perform the fastest possible sprint over 30 meters. The initial stance was a standing position. The start was given with the commands “get ready” and “start”. Timing commenced when subjects passed through the timing gates (Brower Timing System, Draper, UT, USA) positioned at 0 m, 10 m and 30 m. Timing was stopped when participants crossed the finish line. The track was straight, with marked start and finish sections. Each player performed two trials with a 3-minute rest between and only the better time was considered for subsequent analysis. The intra-test reliability for the 30-meter sprint, evaluated through spatiotemporal sprint characteristics in boys during puberty demonstrated good consistency (ICC: 0.66-0.86) [19]. Maximal speed was measured using Sewio sensors with a frequency of 10 Hz (Sewio, Brno, Czech Republic).

2.2.4. Reactive Strength Testing

Participants’ reactive strength was evaluated by means of the triple jump test (total distance in cm). Participants were asked to hop as far as possible. They began by standing on the test leg with their toe on the marked start line. Then using a countermovement from knee flexion and hip flexion, they performed a triple jump with their dominant leg followed by their non-dominant leg. Participants were instructed to possibly use an arm swing, landing on the same leg. They performed two attempts on each leg with 3-minute rest between. Only the better attempt was considered for analysis. The distance was measured using a standard tape measure, perpendicular from the front of the start line to the posterior aspect of the heel at landing. An attempt was considered unsuccessful if the participant used the other leg. Triple jump showed an excellent test-retest reliability of ICC=0.94-0.95 [35].

2.2.5. Explosive Power Testing

Explosive power was measured by the CMJ test (cm). Participants were instructed to jump as high as possible. They stood on a force platform in an upright position and kept their hands on the hips. Then they lowered to a self-selected squat depth, performing eccentric and concentric jump phases to maximize jump height. Participants executed three attempts with a 1-minute rest interval between. The best attempt was recorded for evaluation. Jump height was assessed using a force platform (FP4, HUR Labs, Tampere, Finland) with a frequency of 1,000 Hz. CMJ demonstrated an excellent test-retest reliability (ICC=0.9) [36].

2.3. Statistical Analysis

The results of all tests were processed and subsequently converted into a table using Microsoft Excel (Microsoft Corp., Redmond, Washington, USA). The statistical analysis of the data was conducted using the data analysis software Statistica (Version 14.0, StatSoft, Tulsa, OK, USA). Descriptive statistics, including mean, standard deviation, median and interquartile range were calculated. The Shapiro-Wilk test was applied to assess the normality of data for all observed variables, revealing that normality was not confirmed across variables. To compare differences among groups classified by maturity status (early, average, late) for each variable, we employed the non-parametric Kruskal-Wallis ANOVA test. Subsequently, to assess differences between maturity status groups, multiple comparisons of mean ranks were used. Statistical significance was established at $p < 0.05$.

3. Results

The influence of maturity status on the parameters of the 30-meter sprint test is presented in Table 2. A significant effect of biological age was not confirmed for time in the 0-10 m segment. However, a significant effect of biological age was confirmed for the maximal speed in the 20-30 m segment ($p = 0.024$). A subsequent post-hoc analysis demonstrated significant differences between the early-maturation group and average-maturation group ($p = 0.033$). A significant effect of biological age was not confirmed for the 30-meter sprint test. Nevertheless, multiple comparisons of mean ranks revealed significant differences between the late-maturation group and early-maturation group ($p = 0.047$).

Table 2. Differences between maturity groups for acceleration speed, maximal speed, and 30 m sprint test performance.

Group	n	Sprint 30 m		Acceleration speed in 0-10 m (km/h)		Max speed 30 m (km/h)	
		Median	IQR	Median	IQR	Median	IQR
Late	35	5.14 #	0.29	2.18	21.3	25.60*	2.40
Average	46	5.06	0.42	2.19	21.1	26.70	1.90
Early	17	4.93	0.22	2.13	21.6	26.70	1.10

IQR – Interquartile range; *significant difference between the early and late maturation groups ($p < 0.05$);
*significant difference between the average and late maturation groups ($p < 0.05$).

The results of the CMJ and T-test for all groups of players are presented in Table 3. A significant effect of biological age was not confirmed for the jump height in the CMJ test or in the CMJA. Conversely, in the T-test, significant differences were demonstrated ($p = 0.024$) among the player groups. Subsequent multiple comparisons of mean ranks revealed a significant difference between the late-maturation group and average-maturation group ($p = 0.033$).

Table 3. Differences between maturity groups for T-test and CMJ.

Group	n	T-Test (s)		CMJ (cm)	
		Median	IQR	Median	IQR
Late	35	12.12 *	1.39	24.42	5.19
Average	46	11.72	0.60	25.21	5.56
Early	17	11.86	0.74	24.54	7.02

CMJ – countermovement jump; IQR – interquartile range; *significant difference between the average and late maturation groups ($p < 0.05$).

The results of the unilateral triple jump test for the dominant and non-dominant lower limbs of players from all groups are presented in Table 4. A significant effect of biological age was confirmed for both the length of the triple jump for the dominant limb ($p = 0.001$) and the length of the triple jump for the non-dominant limb ($p = 0.007$). For the length of the triple jump for the dominant limb, multiple comparisons of mean ranks revealed significant differences between the late-maturation group and average-maturation group ($p = 0.005$) and between the late-maturation group and early-maturation group ($p = 0.007$). Similarly, for the length of the triple jump for the non-dominant limb, multiple comparisons of mean ranks showed significant differences between the late-maturation group and average-maturation group ($p = 0.013$) and between the late-maturation group and early-maturation group ($p = 0.045$).

Table 4. Differences between maturity groups for unilateral triple jump.

Group	n	Triple jump DL (cm)		Triple jump ND (cm)	
		Median	IQR	Median	IQR
Late	35	511 *#	82	516*#	90
Average	46	554	77	560	64
Early	17	570	55	569	63

DL – dominant limb; NL – non-dominant limb; IQR – interquartile range; *significant difference between the early and late maturation groups ($p < 0.05$); *significant difference between the average and late maturation groups ($p < 0.05$).

4. Discussion

The data show that among the measured fitness components, biological age influences maximal speed, COD, and reactive strength of the lower limbs in players aged 13 years. Conversely, the impact of biological age on acceleration speed and explosive power was not confirmed. Given the movement content of the tests, this finding suggests that maturation influence specific fitness qualities differently for talent identification. It seems that test outcomes with higher demands on the quality of neuromuscular mechanisms, or tests where the result is more determined by the quality of

neuromuscular control/mechanisms, are influenced by maturation status in male football players at the age of 13 years.

4.1. Changes in Post-Game Landing Biomechanics

The results of this study on 13-year-old football players did not confirm the influence of biological age on acceleration speed measured in the 0-10 m segment of a 30 m sprint. This finding may have several explanations. Primarily, step frequency is likely to play a crucial role in the acceleration phase of players; however, the influence of maturation on step frequency in adolescent boys was not substantiated. It appears that, with growth and maturation, changes in step length become more prominent during sprinting [19]. The absence of an increase in acceleration, as demonstrated in the current study, aligns with the findings of Itoh and Hirose [21]. Their study also did not observe a positive influence of biological age on acceleration speed in a 10 m sprint in U13 competitive football players. However, Mathisen and Pettersen [18] reported a significant impact of body height on performance in a 10 m sprint in adolescent football players during the PHV period, suggesting an influence of biological age on acceleration speed in a 10 m sprint. While the authors point out that there is not substantial evidence to claim that the acceleration speed of young football players is influenced by body height, the relationship between body height and performance in a 10 m sprint was also found in a study by Wong, Chamari, Dellali, and Wisløff's [37]. In this context, the data of our study (Table 1) revealed significant differences in body height among participants of three maturation groups. However, significant differences in acceleration speed were not observed.

4.2. Maximal Running Speed

In the current study, maximal speed was measured in the 20-30 m segment, as previous findings demonstrated that players up to the age of 15 reach their maximal speed in the 20-30 m distance [38]. The data showed that the late-maturation group achieved lower maximal speed than the average-maturation group and early-maturation group. These differences could have more reasons. Firstly, as it was demonstrated that the length of the running stride gradually increases during maturation and proportionally increases with running speed during the PHV period [20], we suppose that late-maturation players had a shorter step length. Another explanation could be the differences in foot contact time. At maximal speed, a rapid stretch-shortening cycle (<250 ms) is applied, which is associated with greater demands on neuromuscular mechanisms [39]. Thus, in 13-year-old players, the level of maturation of neuromuscular regulation may be decisive, especially in longer sprints [40]. The ability to shorten ground contact time while utilizing maximal force production is influenced by leg stiffness [41]. This phenomenon, reported previously by Rumpf, Cronin, Oliver, & Hughes [42] demonstrates an increase in both relative and absolute leg stiffness across the pre-, mid- and post-PHV periods. Moreover, most previous cross-sectional studies show an increase (although nonlinear) in stiffness with age in pre- and post-pubertal boys with no experience in competitive sport [43,44].

Our results coincide with the results of a previous study by Meyers et al. [19], in which players around PHV or post-PHV had significantly higher maximal speed than players before PHV. Similarly, in a recent longitudinal study by Radnor et al. [22], the greatest performance improvements in maximal speed over 18 months were observed in a group of athletes who transitioned from the pre-PHV group (maturity offset of < -1 year from PHV) to the post-PHV group (maturity offset of > 1 year from PHV). The authors also observed a correlation between increasing maximal speed during adolescence and directing force horizontally during sprinting. This could suggest that an improved sprinting technique may be a contributing factor to the increase in maximal speed in ontogenesis. It can be assumed that this aspect could also explain the lower maximal speed of the late-maturation group found in our study.

4.3 30-Meter Sprint

Surprisingly, in this study, the Kruskal-Wallis ANOVA did not confirm the influence of biological age on performance in the 30-meter sprint. However, a subsequent assessment of the differences between maturity groups revealed a significant difference between the late-maturation and early-maturation groups. This suggests that with a more balanced distribution of players across different biological age groups, the impact of biological age on performance in the 30-meter sprint

could be confirmed. As performance in the 30-meter sprint is determined by both acceleration and maximal speed [45], we can speculate that players' performance in the 30-meter sprint were more influenced by the acceleration phase, where significant differences between players of different maturation statuses were not evident.

Our results contradict the findings of a recent study by Yang and Chen [24] focused on U13-U15 football players. In this study, the authors found significant differences in the 30-meter sprint time across all three maturation groups (early, average, late) within the U13 category. The impact of biological age on the performance of football players in sprinting was also demonstrated in a study by Williams, Oliver and Faulkner [46], where significant changes in the 30-meter sprint were identified every 6 months in football players aged 12-14. Similarly, a study by Philippaerts et al. [23] observed the impact of maturation even in players before PHV. Nevertheless, the greatest differences in the 30-meter sprint were recorded during the PHV period, while a plateau in performance was found 12-18 months after PHV. However, we observed that 13-year-old players did not yet enter the post-PHV period, and therefore, the results of the abovementioned study do not support our findings.

4.4. Change of Direction

Our study revealed a significant effect of biological age on COD performance. COD is influenced by a range of physical attributes such as straight sprinting, acceleration, eccentric and concentric strength, power and reactive strength [47]. These attributes are dependent on neuromuscular mechanisms and influenced by the natural adaptive response, which increases within the context of growth and maturation [1]. Our data indicate that the early maturation group in our study achieved higher levels in most of these attributes, which might explain the differences in COD performance in groups of players with different maturation statuses. Other significant factors influencing performance in COD may be good balance and stability. A higher level of maturation could improve acute mechanisms that contribute to better dynamic balance performance in early maturity players [48]. Finally, performance in COD could have been influenced by a higher level of cognitive functions in the early maturation group [7]. This finding is in a line with the results of the previously mentioned study by Yang and Chen [24], who also identified significant differences among football players of various maturation groups in the T-test. However, a study by Itoh & Hirose [21] on young football players did not find significant differences in the 10x5 m test and the crank test across different groups categorized by biological age.

4.5. Explosive Power

The influence of biological age was not confirmed for explosive power of the lower limbs assessed by the CMJ test. These findings support the results of a recent study [49], which examined the impact of maturation on explosive power in various football categories and found no influence of maturity on CMJ performance in the U13 category. However, there are other recent studies focusing on young football players that do not support these findings. Deprez et al. [50] observed an increase in CMJ performance in U13 players based on their current maturity status. In a study by Radnor et al. [22], a significant increase in CMJ performance was found in adolescent boys before, during and after PHV. However, contrary to the authors' assumption that the greatest increase in CMJ performance occurs in boys who transitioned from pre-PHV to post-PHV within 18 months, the largest performance increase was observed in subjects who had already completed the entire PHV period. This finding aligns with the results of the mentioned study by Deprez et al. [50]. This could explain why significant differences between players of different biological ages were not confirmed in our players who appear not to be considered post-PHV. Therefore, due to the inconsistent results of the studies published so far, we suppose that when assessing the talent of 13-year-old football players, sports experts and coaches should consider that the extent to which differences in explosive power of the lower limbs using the CMJ test may be attributed to the degree of maturity is currently unclear.

4.6. Reactive Strength

Opposite to explosive power, the data obtained indicate that biological age has an impact on reactive strength of both dominant and non-dominant lower limbs in 13-year-old football players. As in the case of maximal speed, late-maturation group demonstrated poorer performance in the unilateral triple jump than average-maturation or early-maturation groups. This difference observed in the unilateral rebound-based test may be primarily attributed to neuromuscular development, which influences SSC performance and becomes apparent during growth and maturation [40,51,52]. We assume that biologically older players have better performance due to a higher rate of force production in a short time, primarily as a result of their ability to involve a greater percentage of motor units during contractions, especially type II units, better coordination of this recruitment and also more efficient muscle pre-activation [53–55]. The changes and differences in the application of these mechanisms, as well as other mechanisms associated with motor control (e.g. reflex control) and also structural changes (e.g. muscle and tendon cross-sectional area), could positively influence quick absorption upon landing during the eccentric phase of the SSC before transferring to the concentric phase of the jump, and also force production during the subsequent concentric phase of the SSC. In connection with the maturation of the central nervous system, the level of muscle pre-activation increases even before PHV, and especially during PHV, significantly influencing reactive strength [53].

It is difficult to compare the findings of the current study on reactive strength testing with the findings of other studies, as we did not identify any study that would examine the impact of biological age on the unilateral triple jump. However, in the already mentioned study by Itoh & Hirose [21] on U13 football players, early and average maturation groups outperformed the late maturation group significantly in the 5-step bounding test. Our finding is indirectly supported by the only mixed longitudinal study in male U14 and U16 (maturity offset 1.69 ± 0.71 y) football and basketball players [56], in which gradual improvement in reactive strength was observed.

4.7. Limitations

The findings of this study should be interpreted with caution due to at least three limitations. Firstly, the sample size was not pre-determined before the study. Secondly, there were variations in numbers of players within the analyzed subgroups of players with different maturation statuses. Thirdly, the evaluation was limited to players from a single regional football academy.

5. Conclusions

This study confirmed that maturation status moderates maximal speed measured in the 20-30 m section during the 30-meter sprint test, COD speed assessed by the T-test and reactive strength of the lower limbs evaluated by the unilateral triple jump/hop test in 13-year-old football players. Conversely, the influence of biological age was not observed in acceleration speed assessed in the 10 m section during the 30-meter sprint, in the overall time of the 30-meter sprint test and in the explosive power of the lower limbs measured by the CMJ test. We recommend considering these findings in sports practice when selecting tests and evaluating their results in 13-year-old football players for talent identification or other purposes. However, since the results of previous studies are conflicting for tests where the influence of the stage of maturation on test scores was not found, we recommend using these tests carefully for identifying talented players.

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References

1. Lloyd, R. S.; Oliver, J. L. The Physical Development Model: A New Approach to Long-Term Athletic Development. *Strength Cond. J.* **2012**, *34*, 61–72.
2. Pichardo, A. W.; Oliver, J. L.; Harrison, C. B.; Maulder, P. S.; Lloyd, R. S. Integrating Models of Long-Term Athletic Development to Maximize the Physical Development of Youth. *Int. J. Sports Sci. Coach.* **2018**, *13*, 1189–1199.
3. Williams, C. A.; Oliver, J. L.; Lloyd, R. S.; Granacher, U. Talent Development. In *Strength and Conditioning for Young Athletes*; Lloyd, R. S.; Oliver, J. L., Eds.; Routledge: 2019; pp. 33–46.
4. Lloyd, R. S.; Oliver, J. L.; Faigenbaum, A. D.; Myer, G. D.; de St. Croix, M. B. Chronological Age vs. Biological Maturation: Implications for Exercise Programming in Youth. *J. Strength Cond. Res.* **2014**, *28*, 1454–1464.
5. Rees, T.; Hardy, L.; Güllich, A.; Abernethy, B.; Côté, J.; Woodman, T.; Warr, C. The Great British Medalists Project: A Review of Current Knowledge on the Development of the World's Best Sporting Talent. *Sports Med.* **2016**, *46*, 1041–1058.
6. Till, K.; Emmonds, S.; Jones, B. Talent Identification. In *Strength and Conditioning for Young Athletes*; Lloyd, R. S.; Oliver, J. L., Eds.; Routledge: 2019; pp. 21–44.
7. Malina, R. M.; Bouchard, C.; Bar-Or, O. *Growth, Maturation, and Physical Activity*; Human Kinetics: 2004.
8. Sarmiento, H.; Anguera, M. T.; Pereira, A.; Araújo, D. Talent Identification and Development in Male Football: A Systematic Review. *Sports Med.* **2018**, *48*, 907–931.
9. Meylan, C. M.; Cronin, J. B.; Oliver, J. L.; Hughes, M. G.; Manson, S. An Evidence-Based Model of Power Development in Youth Soccer. *Int. J. Sports Sci. Coach.* **2014**, *9*, 1241–1264.
10. Murr, D.; Raabe, J.; Höner, O. The Prognostic Value of Physiological and Physical Characteristics in Youth Soccer: A Systematic Review. *Eur. J. Sport Sci.* **2018**, *18*, 62–74.
11. Jovanovic, M.; Sporis, G.; Omrcen, D.; Fiorentini, F. Effects of Speed, Agility, Quickness Training Method on Power Performance in Elite Soccer Players. *J. Strength Cond. Res.* **2011**, *25*, 1285–1292.
12. Emmonds, S.; Till, K.; Jones, B.; Mellis, M.; Pears, M. Anthropometric, Speed, and Endurance Characteristics of English Academy Soccer Players: Do They Influence Obtaining a Professional Contract at 18 Years of Age? *Int. J. Sports Sci. Coach.* **2016**, *11*, 212–218.
13. Meyers, R. W.; Oliver, J. L.; Hughes, M. G.; Lloyd, R. S.; Cronin, J. B. New Insights into the Development of Maximal Sprint Speed in Male Youth. *Strength Cond. J.* **2017**, *39*, 2–10.
14. Gil, S. M.; Zabala-Lili, J.; Bidaurreaga-Letona, I.; Aduna, B.; Lekue, J. A.; Santos-Concejero, J.; Granados, C. Talent Identification and Selection Process of Outfield Players and Goalkeepers in a Professional Soccer Club. *J. Sports Sci.* **2014**, *32*, 1931–1939.
15. Silva, M. C.; Figueiredo, A. J.; Simoes, F.; Seabra, A.; Natal, A.; Vaeyens, R.; Malina, R. M. Discrimination of U-14 Soccer Players by Level and Position. *Int. J. Sports Med.* **2010**, *31*, 790–796.
16. Le Gall, F.; Carling, C.; Williams, M.; Reilly, T. Anthropometric and Fitness Characteristics of International, Professional, and Amateur Male Graduate Soccer Players from an Elite Youth Academy. *J. Sci. Med. Sport* **2010**, *13*, 90–95.
17. Ramirez-Campillo, R.; Moran, J.; Oliver, J. L.; Pedley, J. S.; Lloyd, R. S.; Granacher, U. Programming Plyometric-Jump Training in Soccer: A Review. *Sports* **2022**, *10*, 94.
18. Mathisen, G.; Pettersen, S. A. Anthropometric Factors Related to Sprint and Agility Performance in Young Male Soccer Players. *Open Access J. Sports Med.* **2015**, 337–342.
19. Meyers, R. W.; Oliver, J. L.; Hughes, M. G.; Cronin, J. B.; Lloyd, R. S. Maximal Sprint Speed in Boys of Increasing Maturity. *Pediatr. Exerc. Sci.* **2015**, *27*, 85–94.
20. Meyers, R. W.; Oliver, J. L.; Hughes, M. G.; Lloyd, R. S.; Cronin, J. B. Influence of Age, Maturity, and Body Size on the Spatiotemporal Determinants of Maximal Sprint Speed in Boys. *J. Strength Cond. Res.* **2017**, *31*, 1009–1016.
21. Itoh, R.; Hirose, N. Relationship Among Biological Maturation, Physical Characteristics, and Motor Abilities in Youth Elite Soccer Players. *J. Strength Cond. Res.* **2020**, *34*, 382–388.
22. Radnor, J. M.; Oliver, J. L.; Waugh, C. M.; Myer, G. D.; Lloyd, R. S. Muscle Architecture and Maturation Influence Sprint and Jump Ability in Young Boys: A Multistudy Approach. *J. Strength Cond. Res.* **2022**, *36*, 2741–2751.

23. Philippaerts, R. M.; Vaeyens, R.; Janssens, M.; Van Renterghem, B.; Matthys, D.; Craen, R.; Malina, R. M. The Relationship Between Peak Height Velocity and Physical Performance in Youth Soccer Players. *J. Sports Sci.* **2006**, *24*, 221–230.
24. Yang, S.; Chen, H. Physical Characteristics of Elite Youth Male Football Players Aged 13–15 Are Based Upon Biological Maturity. *PeerJ* **2022**, *10*, e13282.
25. Brauer, B. M. Die Bestimmung des Biologischen Alters in der Sport und Jugendärztlichen Praxis mit Neuen Anthropometrischen Methoden. *Ärztl. Jugend.* **1982**, *73*, 94–100.
26. Marfell-Jones, M. J.; Olds, T.; Stewart, A. D.; Carter, L. *International Standards for Anthropometric Assessment*; Potchefstroom, South Africa: International Society for the Advancement of Kinanthropometry (ISAK), 2006.
27. Kutáč, P. Komparace Výsledků Zastoupení Tělesného Tuku a Validita Měření Bioimpedančními Analyzátorů s Rozdílnými Měřicími Frekvencemi u Mladých Atletů. *Česká Antropol.* **2016**, *66*, 15–19.
28. Heyward, V. H.; Wagner, D. R. *Applied Body Composition Assessment*, 2nd ed.; Human Kinetics, 2004.
29. Carter, J. E. L. *The Heath-Carter Anthropometric Somatotype – Instruction Manual*; San Diego: San Diego State University, 2002.
30. Bláha, P. *Antropo* [Computer software]. Praha: Antrobla, 2000.
31. Prycl, D.; Sigmund, M. *Testbal* [Computer software]. Olomouc: Aplikační Centrum BALUO, Fakulta Tělesné Kultury, Univerzita Palackého, 2021.
32. Prycl, D.; Sigmund, M.; Ondra, L.; Suchomel, P. *Komplexní Systém Sportovní Diagnostiky - TESTBAL*; Olomouc: Aplikační Centrum BALUO, Fakulta Tělesné Kultury, Univerzita Palackého, 2021.
33. Raya, M. A.; Gailey, R. S.; Gaunaurd, I. A.; Jayne, D. M.; Campbell, S. M.; Gagne, E.; Tucker, C. Comparison of Three Agility Tests with Male Servicemembers: Edgren Side Step Test, T-Test, and Illinois Agility Test. *J. Rehabil. Res. Dev.* **2013**, *50*.
34. Sporis, G.; Jukic, I.; Milanovic, L.; Vucetic, V. Reliability and Factorial Validity of Agility Tests for Soccer Players. *J. Strength Cond. Res.* **2010**, *24*, 679–686.
35. Davey, K.; Read, P.; Coyne, J.; Jarvis, P.; Turner, A.; Brazier, J.; Bishop, C. An Assessment of the Hopping Strategy and Inter-Limb Asymmetry During the Triple Hop Test: A Test-Retest Pilot Study. *Symmetry* **2021**, *13*, 1890.
36. Markovic, G.; Dizdar, D.; Jukic, I.; Cardinale, M. Reliability and Factorial Validity of Squat and Countermovement Jump Tests. *J. Strength Cond. Res.* **2004**, *18*, 551–555.
37. Wong, P. L.; Chamari, K.; Dellal, A.; Wisløff, U. Relationship Between Anthropometric and Physiological Characteristics in Youth Soccer Players. *J. Strength Cond. Res.* **2009**, *23*, 1204–1210.
38. Buchheit, M.; Simpson, B. M.; Peltola, E.; Mendez-Villanueva, A. Assessing Maximal Sprinting Speed in Highly Trained Young Soccer Players. *Int. J. Sports Physiol. Perform.* **2012**, *7*, 76–78.
39. Galay, V. S.; Poonia, R.; Singh, M. Understanding the Significance of Plyometric Training in Enhancement of Sports Performance: A Systematic Review. *Vidyabharati Int. Interdiscip. Res. J.* **2021**, *11*, 141–148.
40. Radnor, J. M.; Oliver, J. L.; Waugh, C. M.; Myer, G. D.; Moore, I. S.; Lloyd, R. S. The Influence of Growth and Maturation on Stretch-Shortening Cycle Function in Youth. *Sports Med.* **2018**, *48*, 57–71.
41. Moran, J.; Liew, B.; Ramirez-Campillo, R.; Granacher, U.; Negra, Y.; Chaabene, H. The Effects of Plyometric Jump Training on Lower-Limb Stiffness in Healthy Individuals: A Meta-Analytical Comparison. *J. Sport Health Sci.* **2023**, *12*, 236–245.
42. Rumpf, M. C.; Cronin, J. B.; Oliver, J. L.; Hughes, M. G. Vertical and Leg Stiffness and Stretch-Shortening Cycle Changes Across Maturation During Maximal Sprint Running. *Hum. Mov. Sci.* **2013**, *32*, 668–676.
43. Laffaye, G.; Choukou, M. A.; Benguigui, N.; Padulo, J. Age- and Gender-Related Development of Stretch-Shortening Cycle During a Sub-Maximal Hopping Task. *Biol. Sport* **2016**, *33*, 29–35.
44. Lloyd, R. S.; Radnor, J. M.; de St. Croix, M. B.; Cronin, J. B.; Oliver, J. L. Changes in Sprint and Jump Performances After Traditional Plyometric and Combined Resistance Training in Male Youth Pre- and Post-Peak Height Velocity. *J. Strength Cond. Res.* **2016**, *30*, 1239–1247.
45. Rumpf, M. C.; Cronin, J. B.; Oliver, J. L.; Hughes, M. Assessing Youth Sprint Ability – Methodological Issues, Reliability, and Performance Data. *Pediatr. Exerc. Sci.* **2011**, *23*, 442–467.
46. Williams, C. A.; Oliver, J. L.; Faulkner, J. Seasonal Monitoring of Sprint and Jump Performance in a Soccer Youth Academy. *Int. J. Sports Physiol. Perform.* **2011**, *6*, 264–275.
47. Fiorilli, G.; Mitrotasios, M.; Iuliano, E.; Pistone, E. M.; Aquino, G.; Calcagno, G. Agility and Change of Direction in Soccer: Differences According to the Player Ages. *J. Sports Med. Phys. Fit.* **2016**, *57*, 1597–1604.
48. Sariati, D.; Hammami, R.; Zouhal, H.; Clark, C. C.; Nebigh, A.; Chtara, M.; Ben Ounis, O. Improvement of Physical Performance Following a 6-Week Change-of-Direction Training Program in Elite Youth Soccer Players of Different Maturity Levels. *Front. Physiol.* **2021**, *12*, 668437.
49. Toselli, S.; Mauro, M.; Grigoletto, A.; Cataldi, S.; Benedetti, L.; Nanni, G.; Greco, G. Assessment of Body Composition and Physical Performance of Young Soccer Players: Differences According to the Competitive Level. *Biology* **2022**, *11*, 823.

50. Deprez, D.; Valente-Dos-Santos, J.; Coelho-e-Silva, M. J.; Lenoir, M.; Philippaerts, R.; Vaeyens, R. Longitudinal Development of Explosive Leg Power from Childhood to Adulthood in Soccer Players. *Int. J. Sports Med.* **2015**, *36*, 672–679.
51. Lambertz, D.; Mora, I.; Grosset, J. F.; Perot, C. Evaluation of Musculotendinous Stiffness in Prepubertal Children and Adults Taking Into Account Muscle Activity. *J. Appl. Physiol.* **2003**, *95*, 64–72.
52. Lloyd, R. S.; Oliver, J. L.; Hughes, M. G.; Williams, C. A. The Influence of Chronological Age on Periods of Accelerated Adaptation of Stretch-Shortening Cycle Performance in Pre- and Post-Pubescent Boys. *J. Strength Cond. Res.* **2011**, *25*, 1889–1897.
53. Tumkur Anil Kumar, N.; Oliver, J. L.; Lloyd, R. S.; Pedley, J. S.; Radnor, J. M. The Influence of Growth, Maturation, and Resistance Training on Muscle-Tendon and Neuromuscular Adaptations: A Narrative Review. *Sports* **2021**, *9*, 59.
54. Dotan, R.; Mitchell, C.; Cohen, R.; Gabriel, D.; Klentrou, P.; Falk, B. Child-Adult Differences in the Kinetics of Torque Development. *J. Sports Sci.* **2013**, *31*, 945–953.
55. Fox, E. J.; Moon, H.; Kwon, M.; Chen, Y. T.; Christou, E. A. Neuromuscular Control of Goal-Directed Ankle Movements Differs for Healthy Children and Adults. *Eur. J. Appl. Physiol.* **2014**, *114*, 1889–1899.
56. de St. Croix, M.; Lehnert, M.; Maixnerova, E.; Ayala, F.; Psotta, R. The Influence of Age and Maturation on Trajectories of Stretch-Shortening Cycle Capability in Male Youth Team Sports. *Pediatr. Exerc. Sci.* **2021**, *33*, 16–22.

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