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Biological maturation influences selection process in youth elite soccer players

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ABSTRACT: This study examined the influence of birth date, salivary testosterone [sT] concentration, sexual maturity status, and general strength on the selection process of an elite Brazilian soccer club during a 12-month period, which was a 2nd phase of a 24-month selection process. The stature, body mass, sT, sexual maturity status [Tanner scale], and hand grip strength were assessed for 143 players during 2 weeks. From these 143 players, 100 players were dismissed [DIS] and 43 players were selected to integrate the club's under-14 squad. Following 1-year training period, the under-14 team was assembled with 9 players designated as starters [STA], and then, comparisons were conducted taking into account a group of non-starters (selected; SEL = 34 players) and STA (n = 09). The DIS, SEL, STA players, and reference population, were compared for birth distribution. A greater proportion of players was born in the first trimester in the STA [75.0%], SEL [57.1%] and DIS [50.0%] groups compared to the reference population [25.8%]. One-way ANOVA showed a higher sT for STA group [516.0 ± 129.9 pmol·L^{-1}], compared to SEL [415.5 ± 117.9 pmol·L^{-1}] and DIS groups [390.9 ± 84.9 pmol·L^{-1}; p = 0.003), and Kruskall-Wallis test showed a higher gonadal development for STA compared to DIS [p = 0.001]. The current findings suggest a strong influence of birth date and biological maturation on young soccer players selection process. Soccer coaches should consider these influences when making decisions about player selection of elite youth players.

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INTRODUCTION

Youth soccer players commonly compete in competitions grouped by age. Because of this categorization, players who are born early in the selection year [e.g. first trimester] have consistently shown to have advantage in the selection process compared to their relatively younger counterparts who are born later in the selection year [e.g. born in fourth trimester of the selection year]. This chronological age-related advantage has been referred to as relative age effect [RAE]. [1, 2, 3, 4]

Advanced biological maturation status has also been associated with a greater chance of success in soccer selection process [5, 6]. Less mature boys are reported to have disadvantage compared to their more mature age-matched counterparts for both anthropometric measurements and physical performance tests. Studies have consistently demonstrated that more mature boys are heavier, more powerful, and perform better in tasks related to strength, speed, and endurance capabilities [5, 6, 7, 8, 9, 10, 11]. For instance, Hill et al. [6] reported that 54.8% of youth players participating in a selection process of an English professional soccer academy were born in the first quarter of the year across all age groups (from U-9 to U-16), and in addition, none of players in the U-15 and U-16 age group was categorized as late maturing. As a result, these early maturing players have a significant advantage in sports that require speed, power and regular physical contact, such as soccer, basketball, hockey, and rugby [10, 11, 12, 13, 14, 15]. In a recent study, Baxter-Jones et al. [13] investigated youth athletes who participated in team sports selection processes and reported that these athletes were more likely to be born in the first and second quartiles in the selection year, be taller, and in some sports early maturers.

Biological maturation is strongly related to the rate of sex hormone secretion during adolescence [16]. Therefore, it is reasonable to expect a higher testosterone concentration for earlier maturing boys compared to their later maturing peers. Since testosterone modulates several processes related to growth and maturation, improved physical performance should also be expected for boys with advanced maturing. For example, Gravina et al. [17] reported that salivary testosterone [sT] concentration at the beginning of the season was correlated with improvement in physical performance during the season in a sample of young soccer players. It was also demonstrated that sT concentration influenced the physical performance [Yo-Yo and Vertical jump] in pre-adolescent soccer players [18]. More recently, Moreira et al. [19] also revealed a moderate to large relationship between the technical performance and sT concentration, maturity stage and physical performance in young soccer players. Collectively, previous research shows that sT concentration influences physical and technical performance in youth soccer players. It seems logical to suggest that these advantages may mediate advantages through the selection process in elite youth soccer players, but this has not yet been investigated directly.

Both biological maturity and the RAE appear to influence the youth soccer players' selection process. Despite these claims and the fact that soccer is a major sport in Brazil, there is still little data available regarding the influence of biological maturation and RAE on selection processes of youth soccer players in Brazilian professional soccer clubs. Therefore, the aim of this study was to examine the influence of birth date, sT concentration, sexual maturity, anthropometric profile, and hand grip strength on selection process in elite youth soccer players. It was hypothesized that biological maturation-related parameters and birth date would strongly influence the selection process results.

MATERIALS AND METHODS

Experimental design

The present study described a selection process of a major soccer club in Brazil in order to compose its first competitive age category [U-14]. The selection process was divided in 2 phases [see Figure 1]. The players assessed in the first phase of the process were drawn from high performance national soccer academies [located throughout Brazil], which had partnerships with the professional soccer club investigated. As part of the standard monitoring practices of this development pathway the players were evaluated by the club staff coaching every 3 months during a 12-month period (1st phase). These evaluations included technical and tactical analysis, as well as anthropometric parameters. Approximately 3,000 players participated in this first phase, and data from this phase, was not included in the present study. The present investigation commenced at the start of the second phase; 143 of the 3,000 players were pre-selected to participate in the official selection process [Draft]. In a 2-week period following the draft, the players [n = 143] were submitted to specific evaluations by coaches, club staff and researchers. Due to the aim of the present investigation, data from anthropometric measurements, sT concentration, sexual maturity assessment, hand grip strength test, and birth date recordings were retained for analysis. Following this period [2 weeks], 100 players were dismissed [DIS; first cut-off, n = 100] and 43 players were selected to train in the club's under-14 squad. After a further ~12 months of training, the final under-14 team was then assembled. To meet the purposes of both the official competition and the aims of the present investigation, the selected 43 players were divided into two groups named "selected" [SEL, n = 34] and "starters" [STA, n = 9]. The STA players (2 strikers, 4 midfielders, and 3 defenders; n = 9) were those chosen by coaches and designated "starters" in all matches of the first official competition.

Participants

The participants included initially 143 soccer players belonging to the academy of one of the major professional soccer clubs in Brazil. At senior level, the present club has previously won Brazilian National Championships, Intercontinental Cups, and FIFA Club World

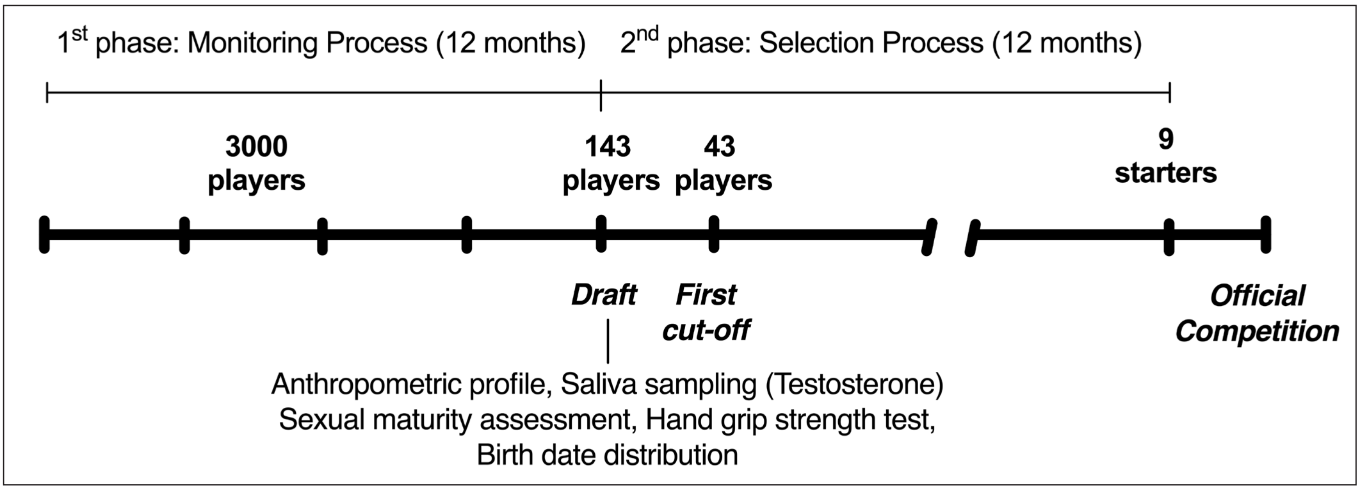

FIG. 1. Experimental time line.

Cup. The club has an academy that consists of several youth teams in various age-categories aiming to develop future top-level professional soccer players. Prior to the start of the study, all players underwent a thorough medical screening to assess health status. All players were free from illness and none were taking any prescribed medication. After being informed of the experimental procedures, including benefits and potential risks, the participants and their parents, gave written consent for participation in the study. The research procedures were approved by the local University Research Ethics Committee.

Procedures

Salivary testosterone assessment

The players provided resting saliva samples approximately 15–20 min before the anthropometric measurements and performance tests. The subjects abstained from food and caffeine products for at least 1.5 h prior to saliva collection. Saliva collection was performed after lunch, at the same time of the day for all time-points collection, and 48 hours after the last exercise session (on Mondays), at the team's training facility. In a seated position and with the head tilted slightly forward, unstimulated saliva samples were collected by passive drool into sterile 15-ml centrifuge tubes over a 5 min period. The saliva samples were then stored at -80°C. sT concentration was determined in duplicate, using an enzyme-linked immunosorbent assay [ELISA, Salimetrics™ sT expanded range kit] in accordance with the manufacturer instructions and with the procedure used by Moreira et al. [15]. The average intra-assay coefficient of variation for sT assay verified in the present analysis was 3.2%. The minimum detection limit for the sT assay, in accordance with the manufacturer, was 21 $pmol \cdot L^{-1}$.

Date of Birth

The young soccer players were divided into 4 groups according to the quarter in which they were born: 1st quarter: January, February, and March; 2nd quarter: April, May, and June; 3rd quarter: July, August, and September; 4th quarter: October, November, and December. The reference population consisted of live births that occurred in the State of São Paulo between 1991 and 2001, the age group corresponding to the categories analyzed. The data of the reference population were provided by the SEADE Foundation [Fundação Seade – Sistema Estadual de Análise de Dados, São Paulo, Brazil], an agency of the Department of Planning and Regional Development of the State of São Paulo [Secretaria Estadual de Planejamento e Desenvolvimento Regional do Estado de São Paulo, São Paulo, Brazil].

Anthropometric measurements

Anthropometric parameters included stature and body mass. Stature was measured with a vertical stadiometer, 210 cm long and 0.1 cm precision [Welmy®, São Paulo, Brazil]. Body mass was assessed using a digital platform scale [Welmy®, São Paulo, Brazil], calibrated, graduated from zero to 150 kg and precision of 0.1 kg.

Stage of pubic hair and genitalia development

A medical doctor assessed the stages of secondary sex characteristic development by clinical observation. The rating of the stages of sexual maturation was made using the criteria described by Tanner [20] following the procedures adopted by Moreira et al. [18]. Briefly, stage 1 indicates the prepubertal state [absence of each characteristic]. Stage 2 indicates the initial development of each secondary sex characteristic. Stages 3 and 4 indicate continued maturation in which the adolescent can be considered as sexually maturing. Stage 5 indicates an adult [mature] state for each sex characteristic. Importantly, using these two parameters (stage of pubic hair and genitalia development) are thought to reflect a combination of the phases of adrenarche and gonadarche, respectively.

Handgrip Strength Test

The maximum isometric strength of the hand and forearm muscles was assessed by a hang grip dynamometer [21]. The protocol was conducted following the Hand grip – EUROFIT Test [22].

Statistical Analysis

Frequencies were used to report the number and proportion of the players born in each quarter. The chi-squared [χ^2] distribution was used to compare observed [values from players] and expected [values form the reference population] distributions of birth quarter. Data normality was verified by the Shapiro-Wilk test and the homoscedasticity by the Levene's test. A one-way ANOVA was used to examine differences among groups for anthropometric measurements [stature and body mass], sT concentration, and hand grip strength test. To locate differences, the Bonferroni *post hoc* test was used. The partial η^2 was used to represent effect size [ES from ANOVA, considering the criterion proposed by Ferguson [23]: recommended minimum effect size representing a "practically" significant effect [ES = 0.04], moderate effect [ES = 0.25] and strong effect [ES = 0.64]. For sexual maturity, the Kruskal-Wallis test by ranks was adopted for each variable [pubic hair and gonadal development], separately. The Dunn' test of multiple comparisons was used as a *post hoc* test to locate differences. For all statistics tests a $p < 0.05$ was considered significant.

RESULTS

Figure 2 shows the date of birth distribution for DIS, SEL, STA and the reference population groups. A significant difference was observed for the percentage of birth-date distribution of all players [(DIS; $x^2 = 18.4$; $p = 0.0004$), (SEL; $x^2 = 26.6$; $p < 0.0001$); (STA; $x^2 = 55.9$; $p < 0.0001$)] and the percentage of birth-date distribution of general reference population. In addition, a significant difference was detected for birth-date distribution between STA players and DIS players [$x^2 = 17.4$; $p = 0.0006$], and between STA players and SEL players [$x^2 = 10.1$; $p = 0.01$]. A greater percentage of players born in the first trimester was observed when compared to DIS and SEL players.

TABLE 1. Stature, body mass, sexual maturity, hand grip strength, and salivary testosterone of young soccer players assessed during the selection process (mean ± SD).

	DIS (n = 100)	SEL (n = 34)	STA (n = 9)	F-value# H-value*	p-value
Stature (cm)	168.8 ± 8.6	166.8 ± 7.0	169.3 ± 9.5	0.69#	0.50
Weight (kg)	56.3 ± 8.6	52.5 ± 6.2	54.9 ± 5.2	2.55#	0.08
Hand grip strength (kgf)	33.0 ± 6.8	29.4 ± 6.7	32.9 ± 4.0	2.90#	0.06
Salivary testosterone ($pmol \cdot L^{-1}$)	390.9 ± 84.9	415.5 ± 117.9	516.0 ± 129.9	6.28#	0.003[b]
Pubic hair	3.2 ± 0.8	3.4 ± 0.5	3.7 ± 0.5	5.68*	0.06
Gonadal development	3.1 ± 0.7	3.2 ± 0.5	3.5 ± 0.5	6.37*	0.04[a]

[a]significant difference between groups [Starters (STA) to Dismissed (DIS), p = 0.001]; [b]significant difference between groups [Starters (STA) to Selected (SEL), p = 0.03; Starters (STA) to Dismissed (DIS), p = 0.002]. # F-value for Stature, Weight, Hand grip strength, and Salivary testosterone (sT) measurements. *H-value for Gonadal development and Pubic hair stage measurements.

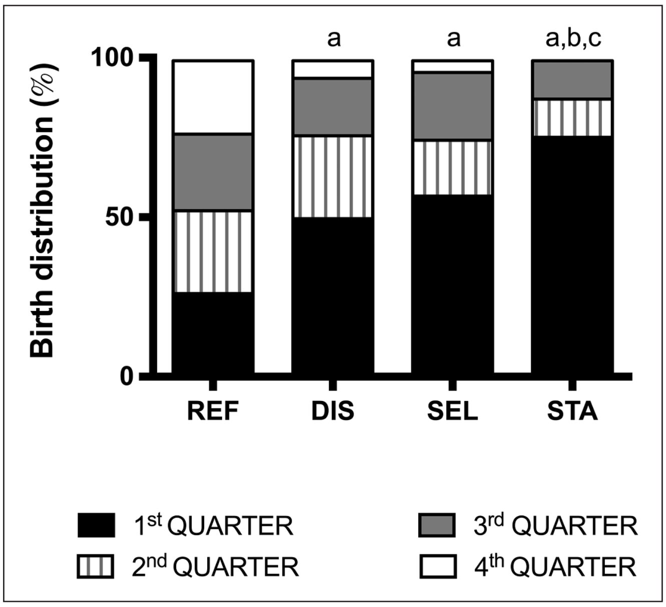

FIG. 2. Birth month distribution (%) of reference population and young soccer players based on the 4 quarters of the year. [a]significant difference between the experimental groups [Starters (STA) p = 0,0001, Selected (SEL) p = 0.0001, Dismissed (DIS) p = 0.0004] and the general reference population; [b]significant difference between Starters (STA) and Selected (SEL), p = 0.01; [c]significant difference between Starters (STA) and Dismissed (DIS), p = 0.0006].

Table 1 shows the stature, body mass, sexual maturity, hand grip strength and sT concentration of the soccer players assessed during the selection process. A significant difference was observed among groups for sT concentration [F = 6.28; df = 2; p = 0.003: partial η^2 = 0.11]. A higher sT concentration was observed for STA compared to both, DIS [p = 0.002] and SEL [p = 0.03] groups. Moreover, a significant difference was also observed for gonadal development [H = 6.37; df = 2; p = 0.04]. The difference was located between STA [higher gonadal development] and DIS groups [p = 0.001], but not between STA and SEL [p = 0.11], or SEL and DIS groups [p = 0.43]. However, no difference was observed for pubic hair [STA vs. DIS; p = 0.06], and no difference among STA, DIS and SEL groups was observed for stature, body mass or hand grip strength [p > 0.05].

DISCUSSION

The aim of this study was to examine the influence of birth date, sT concentration, sexual maturity, anthropometric profile, and hand grip strength on the selection process in elite youth players. The current results showed different birth date distributions between STA and DIS players with a greater participation of players born in the first trimester in the STA group. It was also revealed a higher sT concentration in STA compared to DIS and SEL groups. Additionally, a difference in gonadal development was identified between STA and DIS groups. These findings suggest that the selection process of youth soccer players is therefore largely influenced by androgenic hormonal status, sexual maturity, and the relative age effect.

The present findings of a strong RAE corroborate many earlier studies that have shown the occurrence of RAE in different samples of youth soccer players in different countries [3, 6, 24]. For instance, Mujika et al. [24] demonstrated a RAE in 13,519 Basque soccer players of different age groups and competition levels (i.e. senior professionals [n = 114] and elite youth players [U-11 to U-18; n = 189], regional youth federated players [U-11 to U-14; n = 4,382] and youth school players [U-10 and U-11; n = 8,834]). Similarly, Helsen et al. [3] investigated the occurrence of RAE in 10 European youth soccer teams [U-15 to U-18; n = 763], for the national youth squads performing at major international youth tournaments for the U-16, U-18, U -21, and the women's U-18 age groups, and the Meridian Cup championship organized by the European governing soccer body (UEFA, *Union des Associations Européennes de Football*) [n = 735]. The authors detected a clear RAE for all the national youth selections in the U-15, U-16, U-17 and U-18 age categories, as well as for the UEFA U-16 tournaments and the Meridian Cup. The findings from Helsen et al. [3] show an over-representation of players born in the first quarter of the selection year for all the national youth selections at the U-15, U-16, U-17 and U-18 age categories, as well as for the UEFA U-16 tournaments and Meridian Cup. Accordingly, Hill et al. [6] reported that 54.8% of youth soccer players (n = 202; from the U-9 to U-16 age-groups) who participated in selection process of an English professional soccer academy over an 8-year period were born in the first quarter of the year across all age groups.

In the present study, all group players [DIS, SEL and STA] showed a higher distribution of date of birth in the 1st trimester compared to the reference population, confirming the presence of the RAE. In addition, a significant difference was detected for birth-date distribution between STA and DIS, and between STA and SEL groups. As can be seen in figure 2, a higher proportion of STA players were born in the 1st trimester compared to the DIS and SEL groups. These results are in accordance with Gil et al. [14] who previously demonstrated that a higher proportion of selected U-14 Basque soccer players were born during the first 6 months of the year. The unique design of the present study extends on these studies, showing that RAE influences decisions on selection of the players, also during a 24-month selection process. The present findings show that even with a 24-month selection process (including the 1st and 2nd phase of the assessed club selection process), that might minimize the influence of RAE, this condition did not alter. This 24-month selection process of the assessed club may be considered as a long-term approach compared to other processes habitually conducted in Brazil. In addition, it should be highlighted that this approach is used to provide a more detailed and comprehensive information on a variety of players attributes and abilities throughout the selection period, rather using a limited observation periods (i.e. only one or a few matches) which is a common approach for players selection in Brazil. However, despite this deliberate approach, it was unable to mitigate the impact of RAE in player selection.

Among the analyzed variables, sT concentration was shown as discriminating factor for long-term selection. The hypothesis of the present study that sT concentration and biological maturation would influence soccer player selection process was based on previous investigations conducted with youth players [17, 18, 19]. The early hypothalamic-pituitary-gonadal axis activation and the progressive secretion of testicular sex hormones are associated with the changes in biological, morphological and psychological aspects during puberty [8] that might provide an advantage for early mature players. The findings of the present study showing a higher sT concentration for the final starting group compared to the 2 other groups [SEL and DIS groups] corroborate the initial hypothesis.

Whilst the role of sT on soccer performance in youth soccer players requires additional investigation, the higher sT concentration observed in the STA in the present study suggests that this hormone favorably influences factors that underpin performance (and therefore selection). These observations may be related to the greater sT concentration detected in these players. Indeed, it is well established that gonadal development is associated with a greater testosterone concentration [25], and that gonadal steroids, including, testosterone, are responsible for genital growth [26]. The magnitude of the difference in sexual maturity status [gonadal development] between STA and DIS, also suggests that those earlier maturate players may have increased the likelihood of being selected throughout the process. In conjunction, the observed higher sT concentration for starters (STA compared to DIS and SEL) and gonadal development (STA compared to DIS) in the present study indicate a significant difference for maturation, favoring selection of those early maturing players.

These findings also suggest that adding data of sT concentration to sexual maturity parameters, in particular to genital development (genital staging) may be more insightful than either method alone, and could ultimately aid in the selection decision-making process. It is worth mention that genital staging might be relied on more than pubic hair staging to assess pubertal development and maturity status in youth soccer, because of the independent maturation of the adrenal axis [26]. Based on the results of the present study, and that from the literature regarding gonadal hormones and gonadal development, it could be suggested to staff coaches to use data from sT concentration and gonadal development stage in tandem to avoid equivocal deselection of later pubertal youth players, who might be in physical and performance disadvantages compared to their pubertal advanced peers, at a given moment. Doing so, and incorporating these players in a training process, the likelihood of committing errors (i.e deselection potential late maturity players) might be reduced.

Moreover, adopting a regular salivary sampling, for examining sT concentration across the season, and over different seasons in youth players, may be considered as a robust approach due to the well-known stability of the component of a hormone level and rhythm, which are truly stable across days and years [27]. Moreira et al. [18] reported a sT stability during 21 weeks in preadolescent male soccer players despite changes in training volume. Indeed, Shirtcliff et al. [28] showed a correlation between the physical exam for maturational stages with 82 boys' testosterone concentration of 9–14 years of age. In addition, these researchers reported that the mean sT level did not differ for puberty stage 1 and 2 (physical exam breast stage). These findings indicate that controlling for confounding factors (i.e time of sampling, exercise, collection methods, storage, food intake) as adopted in the present study, and taking into account the reported sT stability across days and years, using the sT concentration to evaluate pubertal development seems to be a valid method.

Interestingly, no difference between groups was observed for stature, body mass and the general strength [hand grip], showing these variable does not play a role at this stage of the selection process. It is reasonable to assume that differences in stature, body mass, and general strength had influenced the selection at an earlier stage. As the assessed club is a top professional club – which usually acts at the apex of the soccer talent pathway – the initial stage of the selection process is initiated after a primary selection process has occurred. The result of this is that the smaller and weaker players are commonly de-selected at the early stages of the soccer talent pathway and the selection pool at the final stages consists of athletes with more homogenous but developed physical characteristics. Accordingly, at this stage of the process, these variables cannot explain the results of the selection.

It is important to acknowledge that sT concentration plays a role in mediating strength performance in adolescent athletes [17, 18]. Based on these findings, it could be reasonable to expect that general strength performance would also be different between the assessed groups in the present study. Indeed, previous studies in youth soccer players demonstrated a positive association between sT concentration and a better performance in physical tests in young soccer players [17, 18]. Despite not observing differences between groups herein, the possible impact of strength on the selection process could not be ruled out. Perhaps, additional more specific strength assessments could aid in a better explaining the effect of this capacity on the selection process results. Such tests might have better discriminatory characteristics for detecting selected and de-selected players from the process.

The present results are in contrast to other studies that have demonstrated the influence of anthropometric on selection success in talented youth soccer players [10, 14] For instance, Gil et al. [14] demonstrated that selected youth soccer players were taller, heavier, leaner and faster and had higher absolute or relative VO_2max in comparison to non-selected players. Similarly, Coelho-e-Silva et al. [10] reported that selected players had an advanced maturity status, were heavier and taller; performed better in explosive power, repeated sprints and ball control; and were more ego oriented. However, despite the lack of difference in the anthropometric characteristics among the 3 groups of players in the present study, it is important to highlight that the mean height and body mass of all players investigated were above of percentile 85 in the WHO Growth Curves for their age-group – demonstrating their advanced physical size. The initial study sample [n = 143] was pre-selected during the monitoring process [12 months] among more than 3,000 players from all Brazilian States. It is most likely that the pre-selection that occurs before the players took part in official club selection process in the study was favorable for players with increased physical size. It is reasonable to speculate that these players were already pre-selected based on anthropometric characteristics, explaining why no significant difference in height and body mass was observed during the draft conducted in the club.

It is important to acknowledge some limitation of the present study. First, any generalization of the current results should be done with caution since the study was conducted in one club. As a result, the study should be considered as a case study. In addition, only one assessment was conducted during the study. A more comprehensive data could be obtained from a multiple evaluation time-points during the whole process. Despite these limitations, the current data set still relevant to help to understand the effect of biological maturation on selection process of youth elite soccer players.

The findings of the present study show that soccer coaches working with talent pathway for elite youth soccer players should be aware of the influence of these factors [RAE, sT level, and sexual maturity] on decision-making. Whilst are unable to confidently comment on the efficacy of this approach for selecting players with a greater level of long-term soccer success, it appears that biological maturation influences selection decisions in youth players. Interestingly, a recent study [29] reported that soccer coaches have a high efficacy expectation from early-born players, and the inferential analysis indicated likely to very likely worthwhile differences between the coaches' efficacy expectations for youth soccer players early-born and those born in the fourth quartile of the year. The current results suggest that a multidimensional approach to selecting elite youth players should be implemented and that any assessment of future playing potential of young players be made with the understanding of the influence of these biases.

CONCLUSIONS

The current findings indicate the occurrence of RAE in the selection process for the elite U-14 soccer team. A representative percentage of STA players was born in the first trimester of the year. In addition, a higher sT concentration and advanced biological maturation (gonadal development) also seemed to influence the selection process. Taking these results into account, it appears that biological maturity exerts a strong influence on young soccer players' selection process. Considering these results, soccer coaches should be aware of the impact of these variables in order to increase efficacy in the selection of the players. Interestingly, the results showed that, anthropometric measurements and general physical tests [as such hand grip strength test] did not differentiate players into the selection process at the final stage of the soccer talent pathway in the investigated club. It seems prudent to infer that at this level of youth in soccer training program, these variables are not viable explanations for the identifying possible differences between those who are selected and those who are not selected to advance. Specific tests and more ecological assessments might help in advancing the knowledge on factors that may influence coaches' selection of youth players. Further work investigating the influence of other variables [i.e. technical, tactical and emotional components] in the selection of youth players is needed.

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Conflict of interest

The authors report no conflict of interest.

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