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RESEARCH ARTICLE



Contribution of deliberate practice, play, and futsal to the acquisition of decision-making skills in Brazilian professional female soccer players

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ABSTRACT

Previous research showed that deliberate practice and play contribute to developing decision-making skills in male soccer players. However, there is no evidence for female players. Therefore, this is the first study to analyse the contribution of deliberate practice, play, and futsal to develop decision-making skills in female soccer players. The purpose of this study was twofold: (1) to analyse whether elite Brazilian professional female soccer players with different levels of decision-making skills can be differentiated based on their engagement in various types and amounts of soccer activities during their development; (2) to discuss what sport's pathway in female soccer characterised the group with high decision-making skills. The sample comprised 77 Brazilian professional female soccer players. Decision-making skill was assessed based on a video-based test (TacticUP[®]). We used a retrospective questionnaire to collect information about previous participation in different soccer activities. We found differences among high skill (HS) and low skill (LS) decision-making groups regarding their participation in developmental activities in every period assessed (childhood, early, and late adolescence). In summary, we found that in every period set, the HS group accumulated more percentage time of their participation in soccer activities in practice compared to the LS group. Moreover, the HS group gathered more hours of practice in futsal and total practice (i.e., considering practice time in soccer and futsal) in early adolescence (13–15 years) compared to the LS group. We concluded that the specialised diversification pathway is the one that best characterises the sports involvement of better decision-makers during childhood.

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Female soccer; female sport; deliberate practice/play and futsal; tactical awareness; perceptual-cognitive skills

Introduction

The performance in soccer depends on an individual's competence to make efficient decisions, which can be divided into perceptual-cognitive and perceptual-motor skills, where both contribute to the development of expertise in the sport (McPherson &

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Kernodle, 2003; Williams et al., 2020). Perceptual-cognitive skills can be considered to be what one is able to perceive and understand, while perceptual-motor skills refer to what one is able to perceive and do through movement (Materniuk, 1976; Starkes, Cullen, & MacMahon, 2004). In this context, decision-making can be defined as the ability of the performer to select and execute an appropriate action in a given situation (Roca et al., 2012; Williams et al., 2011). In the last few years, the study of perceptual-cognitive skills has received increasing attention in the field of talent identification and development in soccer, as many studies have shown the association of such components with game performance (Andrade et al., 2021; Cardoso et al., 2019; Gonçalves et al., 2020).

In this context, the acquisition of superior decision-making skills in invasion sports (e.g., invasive games like soccer, futsal and rugby) is associated with sport-specific experience (e.g., team practice, competition, and play activities) and the quality of the experiences players have had during their sports pathway (Berry et al., 2008; Machado et al., 2020; Roca et al., 2012). For instance, Roca et al. (2012) found that adult male soccer players who possessed better decision-making skills than their colleagues from the same competitive level accumulated more hours in soccer activities (i.e., team practice, competition, and play activities) during their childhood. Moreover, Machado et al. (2020) found that youth male soccer players with superior decision-making skills compared to their counterparts from the same competitive level accumulated more hours of team practice during their formation and engaged in more hours of activities with higher decision-making opportunities in the microstructure of the team practice. The studies mentioned above highlight the importance of developmental activities along the sports pathway to attain better decision-making skills.

Regarding the phases of sports development, the theoretical model proposed by Côté (1999; Côté et al., 2007; Côté & Vierimaa, 2014), known as the Development Model of Sport Participation (DMSP), has been widely used in the world to understand the process of sport development in different sports (Murata et al., 2022), including several studies in soccer (Ford et al., 2020; Roca et al., 2012). In addition, this model has been used in research that seeks to optimise and direct public investment policies to qualify sports training systems in different countries (Côté & Vierimaa, 2014; Godbout & Gréhaigne, 2020).

This theoretical model divides sports development into different stages, which are classified as: (1) sampling years (6–12 years old); (2) specialisation years (13–15 years old); (3) investment years (from 16 years old to adulthood); and (4) early specialisation (from 6 years old to adulthood). These different stages are characterised by the type of activities involved in the practice of the sport(s). It also considers the age of the individuals and the number of sports practiced. The types of activities are called deliberate practice and deliberate play. The deliberate practice is characterised by activities performed to improve performance (and not necessarily to generate satisfaction) and require a high cognitive and/or physical effort, besides being positively associated with the development of specific abilities (e.g., systematized practice with the team led by the coach) (Ericsson et al., 1993). On the other hand, deliberate play is characterised by a form of intrinsically motivating sports activity that provides immediate gratification and is specifically designed to maximise satisfaction in the activity (e.g., playing soccer in the park with friends) (Côté, 1999). Thus, the initial DMSP proposed by Côté presents two possible main trajectories in sport to reach elite performance which are: (1) participation in elite

performance, through early sampling (in other sports) and high amounts of deliberate play; and (2) participation in elite performance, through early specialisation (in the main sport) and high amounts of deliberate practice.

Based on the proposal of the DMSP model, in recent years, researchers from different countries proposed to investigate which sports trajectory was associated with the achievement of elite performance in soccer, considering especially the initial years of sport participation (6–12 years) (Ford et al., 2009, 2020; Sieghartsleitner et al., 2018). These works found an alternative trajectory to those proposed by the DMSP for the sport's development of soccer players who reached an elite performance and higher competitive level compared to those who did not reach such high-performance levels. This alternative trajectory, called the early engagement hypothesis, is characterised by involvement in the primary sport (soccer) in both activities of deliberate practice and deliberate play since the early years of sports participation (6–12 years), as well as by a low sampling (participation) in other sports (Ford et al., 2009). In other words, this sports trajectory argues that involvement from early ages in soccer activities of structured practice, when accompanied by the accumulation of experiences of deliberate play in soccer, leads to higher performance in soccer in the future.

Subsequently to the proposal of this alternative trajectory mentioned above, a new interpretation for the concept of sports diversification during the sampling years was proposed by Côté and Erickson (2015). The understanding of this term came to be related to the diversification of the types of activities in different sporting contexts (e.g., playing beach soccer, futsal, soccer in the park, or participating in structured practice). Therefore, the understanding of “diversification” (or sampling) was no longer exclusive to the diversification of sports played (e.g., volleyball, handball, and basketball), as was initially proposed in the DMSP (Côté, 1999). Together with several studies, this new understanding has demonstrated the importance of both deliberate play and deliberate practice to achieve elite performance and a higher competitive level (Ford et al., 2009; Ford & Williams, 2012; Haugaasen et al., 2014; Roca et al., 2012) that supported the proposal of another sports trajectory in soccer. This new trajectory proposed by Sieghartsleitner et al. (2018) is the specialised diversification. This trajectory advocates the engagement in both deliberate play and deliberate practice activities from the early years of sports development (6–12 years) – as proposed in Ford et al. (2009). However, it also advocates diversification of soccer activities in different contexts, such as street soccer, beach soccer, futsal, and structured team practice.

In this line, recent research suggests the potential of engagement in futsal practice to contribute to talent development in soccer (Oppici et al., 2019; Travassos et al., 2018; Yianaki et al., 2018). Futsal is an indoor version of soccer, composed of teams of four outfield players and a goalkeeper that plays in a court of 20 × 40 m. The characteristics of futsal, such as fewer players and dimensions compared to soccer, may contribute to a wide range of technical and tactical abilities development (Travassos et al., 2018). In addition, there is empirical evidence that futsal practice promotes the transfer of tactical-technical skills (e.g., passing skills) to soccer due to similarities between perceptual-cognitive and perceptual-motor skills of both sports (Oppici et al., 2019). Therefore, research about talent development could assess players' previous futsal participation to further understand its association with the acquisition of decision-making skills (Machado et al., 2020; Sweeney et al., 2021).

It indicates that we must consider the different types of activities experienced during the sport's development of soccer players and the different proposals of sport's trajectories presented above to understand which contribute most to the attainment of expert decision-making skills. Several studies have shown that the interaction of both activities (deliberate play and practice) is essential for the development of decision-making in athletes (Berry et al., 2008; Machado et al., 2020; Roca et al., 2012). However, there is no consensus on the ideal period or age to focus on accumulating these different types of activities (Machado et al., 2020; Roca et al., 2012; Sieghartsleitner et al., 2018). Therefore, knowing individuals' previous experiences in soccer is necessary to understand which contexts they have experienced during their sports training, especially in the childhood (6–12 years).

Although some studies have already sought to investigate which activities contribute to the attainment of superior decision-making skills in soccer players, the focus has been on male samples (Machado et al., 2020; Roca et al., 2012). To the best of our knowledge, we found no research that evaluated the association of decision-making skills with previous activities in soccer in female soccer players, considering the assessment of both offensive and defensive aspects (Barquero-Ruiz et al., 2020). Therefore, the evaluation should be based on the contribution to the game as a whole and not only on individual performance where the players are assessed just in situations with the ball. Moreover, there has been much more research on men's sports (Scharfen & Memmert, 2019) and men's soccer (Ivarsson et al., 2020). To give a picture of such discrepancy, a recent systematic review and meta-analysis on psychological factors associated with future performance in soccer (Ivarsson et al., 2020) found that the total sample size included in the selected studies was 3070 males and only 26 female players. In other words, male samples were more than 100 times overrepresented in studies in this research area.

Researchers generally have good intentions and even include that studies should be done with female samples in their future research prospects. However, then we find out that this is not happening. For instance, a recent work published by Williams et al. (2020), related to the talent development in soccer found that little research has been conducted on female athletes in soccer and South American athletes during the last 20 years. Therefore, this recent and important work, concluded that there is a need to broaden the scope of research to cover female athletes and the South American context, based on theory driven assumptions (e.g., DMSP model) regarding this theme.

There is also a need for research that can subsidise the construction of a structured curriculum that favours the attainment of expert decision-making skills throughout the sports development of female soccer players. For that, it is necessary to understand how previous experience in different soccer activities (e.g., deliberate practice and deliberate play) may contribute to the acquisition of decision-making skills in elite female soccer players. Therefore, the purpose of this study was twofold: (1) to analyse whether the engagement in various types and amounts of soccer activities during childhood and adolescence can differentiate elite Brazilian professional female soccer players with different levels of decision-making skills; and (2) to discuss what sport's pathway in female soccer characterised the group with high decision-making skills.

Although previous studies on this topic with soccer players are scarce and carried out only with male samples, we hypothesise that female players with superior decision-making skills would show a similar pattern to males and engage during childhood in

higher amounts of practice activities in soccer (Machado et al., 2020) and play activities in soccer (Roca et al., 2012).

Materials and methods

Study design

In this study, we used a retrospective design. We examine the type and amount of soccer developmental activities that contributed to distinguishing Brazilian professional soccer players with different levels of decision-making skills. Players' decision-making skills were assessed based on an objective video-based test – TacticUP® (Machado & Teoldo, 2020). With the aim of comparing players with different decision-making skills, we empirically tested them with TacticUP®. Scores in the test were used to create groups with high and low decision-making skills based on a tertile split approach. In addition, we used a retrospective questionnaire (Ford et al., 2010; Haugaasen et al., 2014) to collect information about previous participation in different soccer activities.

Participants

The sample comprised 77 elite Brazilian professional female soccer players ($M = 23.4$, $SD = 4.2$ years of age; and $M = 15.7$, $SD = 4.7$ years of experience in soccer) from six soccer teams in three different states in Brazil. Sample size was calculated using G*Power 3.1.9.6® with a target effect size = 0.80, alpha = 0.05, power = 0.80, and allocation ratio = 1.0, determined an estimated total sample of 42 participants (21 for each group). Participants should be competing in the professional national league in Brazil for inclusion criteria. Data collection was carried out with previous approval from club officials and athletes. The present study was approved by the Ethics Committee for Research with Human Beings from the leading institution (Approval number: 4.924.597) and is following the norms established by the National Health Council (466/2012) and by the Declaration of Helsinki (2013) for research with human beings. Participants provided signed and informed consent.

Measures and procedures for data collection

Decision-making skills (TacticUP®)

TacticUP® is an online platform (www.tacticup.com.br) that assesses players' decision-making skills (Machado & Teoldo, 2020). It is a video-based test using a temporal occlusion paradigm. Participants had to respond as quickly as possible, "what the observed player should do?" and choose the most appropriate solution from four possible scenarios at the end of each scene. This decision-making test was developed based on tactical aspects of the game grounded on tactical principles (Teoldo et al., 2022). Therefore, it allows the assessment of response accuracy of decision-making in offensive and defensive actions in situations with and without the ball. The validity and reliability of the test were shown in Machado & Teoldo (2020).

Before the start of the test, the online platform displays instructions to participants regarding the test structure and procedures, and three trial scenes are exhibited to

familiarise the subjects with the assessment, thus excluding the possibility of low performance due to a lack of comprehension of the task. These three trial scenes include two offensive sequences (one in which the player being observed is in possession of the ball and another in which he is not in possession) and one defensive sequence (the player being observed is in the defensive phase of play). These three conditions enable participants to familiarise themselves with the characteristics of the video sequences they were about to watch. The test was carried out using laptop computers with internet, to enable the access to the tests in the TacticUP® platform. The test took around 20 min per player. The measure used in this study was the decision-making general index, which is comprised by the average of the offensive and defensive indexes (Machado & Teoldo, 2020).

Developmental activities (Participant History Questionnaire)

The Participant History Questionnaire (PHQ), used in several studies (Ford et al., 2010; Haugeaasen et al., 2014; Roca et al., 2012), including studies with Brazilian youth samples (Ford et al., 2012; Machado et al., 2020), was used to measure the soccer activities undertaken by players. We used the Portuguese version of the questionnaire already used in previous studies with Brazilian youth samples (Ford et al., 2012; Machado et al., 2020). Reliability and validity of such retrospective methods in general, and the use of similar variables as in the current investigation, have been shown to be acceptable for different cultures (i.e., English, German, Norwegian, and Swiss participants) (Ford et al., 2010; Güllich, 2014; Haugeaasen et al., 2014; Memmert et al., 2010; Sieghartsleitner et al., 2018) including the original version in English of this questionnaire (Ford et al., 2010) and its Norwegian version (Haugeaasen et al., 2014).

This questionnaire allowed us to gather information on engagement in soccer developmental activities. Five variables related to developmental sports activities, also included in previous studies (Ford et al., 2012; Helsen et al., 1998; Hendry & Hodges, 2018), were assessed: (1) practice in soccer; (2) play in soccer; (3) percentage of time in play; (4) practice in futsal; (5) number of other sports. Team practice in soccer was related to soccer activities under the supervision of coaches or adults in which the goal is to enhance performance (e.g., training with the team). Deliberate play activities in soccer are related to play-type games with specific rules created and supervised by participants, in which the primary goal is enjoyment (e.g., playing a soccer game with friends in the park). The % time in play was calculated considering the percentual time spent in play activities in soccer, considering the total amount accumulated in practice and play in soccer. For example, a player who spent 400 h in practice activities and 600 h in play activities would possess a % time in play of 60%. Team practice in futsal was related to futsal activities under the supervision of coaches or adults in which the goal is to enhance performance (e.g., training with the team). The number of other sports considered the participation in other sports than soccer, where participants were involved for more than three months in contexts that were not physical education classes.

In addition to these five variables mentioned above, we proposed the inclusion of a sixth variable in this study. This variable comprises the time spent in soccer practice plus futsal practice, which we call “total practice”. It was a composite metric calculated based on variables collected through the questionnaire. We proposed the inclusion of such a variable, considering two main points: (1) the new interpretation of sports

diversification through the opportunity to play activities related to the primary sport in different settings and contexts (Côté & Erickson, 2015; Sieghartsleitner et al., 2018); and (2) the cultural aspect in Brazil, where most soccer players have played futsal during their sports formation since childhood (Ford et al., 2012).

Therefore, to complete the questionnaire, participants should provide the number of hours per week and the number of months per year they spent in those soccer activities since they started participating in soccer. They also provided information about the number of weeks from each year they were injured and unable to participate in soccer activities. This information was given retrospectively, from the present season, going backward in a one-year interval up to 5 years of age, or the age they started participation in soccer activities. The calculation of the accumulated hours in soccer activities was performed by multiplying hours reported per week by weeks per year, minus weeks per year that players reported injuries that prevented them from participating in soccer activities. For the number of weeks per year, we considered a 40 weeks season for practice, as used in a previous study (Roca et al., 2012).

This retrospective questionnaire was applied online, using a mobile phone, tablet, or computer with internet access, where the researcher in charge explained how to fill out the questionnaire. After the initial explanation, the participants answered the questionnaire, while the researcher was available to answer any questions that arose during the completion of the form. The application took approximately 60 min per player.

Statistical analysis

Comparisons between the HS and LS groups for their developmental activities were carried out for three age periods: (1) 6–12 years of age (i.e., childhood); (2) 13–15 years of age (i.e., early adolescence); and (3) 16–18 years of age (i.e., late adolescence) to match the developmental stages outlined by Côté (1999). Afterward, considering the data distribution, we verified the between-group differences in all the variables measured by the PHQ using an independent *t*-test or Mann–Whitney *U*-test. Distributions were checked with a Kolmogorov–Smirnov test. The effect size used for the independent *t*-test was Cohens's *d* (Cohen, 1988), and for Mann–Whitney tests was calculated through the formula described by Fritz et al. (2012) as ($r = Z/\sqrt{n}$). The interpretation of the effect size value was made as follows by Cohen (1988): small effect (.1–.29); medium effect (.3–.49); and large effect (>.5). For statistical procedures was utilised the software SPSS (Statistical Package for Social Sciences) 22.0.

Results

Decision-making skills

Soccer players were ranked according to their decision-making skills and a tertile split approach was used to create two groups from the rank order. The top 33% ranked players were classified as high skill (HS) group ($n = 25$; $M = 23.8$, $SD = 4.5$ years of age; and $M = 16.0$, $SD = 5.5$ years of experience in soccer) whereas players ranked in the bottom 33% were classified as low skill (LS) group ($n = 25$; $M = 22.6$, $SD = 3.9$ years of age; and $M = 15.5$, $SD = 4.6$ years of experience in soccer). The participants ranked in the middle 26–52 were

excluded from further analysis. This procedure was used to ensure that the division criteria of participants in different skill subgroups (based on the general index score of the TacticUP®) were based on objective criteria that statistically differentiated both groups analysed, as used in previous research (Machado et al., 2020; Roca et al., 2018, 2021; Williams et al., 2012). Importantly, all the participants in the current study, in both the HS and LS groups, were regular players in the same professional national league in Brazil.

The high skill (HS) group possessed better decision-making skills ($M = 74.0$, $SD = 2.4$) compared to the low skill (LS) group ($M = 59.9$, $SD = 4.8$), $t(48) = 3.563$, $p < .001$, $d = 3.932$, *large effect*. Moreover, the focus of our study was to understand the differences in sports pathways between elite Brazilian professional female soccer players with different levels of decision-making skills since childhood (6–12 years), passing through the phase of sports development during early adolescence (13–15 years) up to the step to “semi-professionalization” in late adolescence/young adulthood (16–18 years). Therefore, we present our results of the retrospective self-reported (subjective) hours of participation in different types of activities divided into three different age periods as follows.

Developmental activities – childhood (6–12 years)

The HS group showed statistically lower values in the % *time in play* ($M = 53.9$, $SD = 31.5$) compared to the LS group ($M = 79.9$, $SD = 25.7$), $t(40) = 2.911$, $p = .006$, $d = .909$, *large effect* (see Table 1). In other words, it means that during this period, the HS group spent, on average, 53.9% of the time in play activities in soccer and 46.1% of the time in practice activities in soccer. On the other hand, during this period, the LS group spent more time in play activities in soccer, which was, on average, 79.9% of the time and only 20.1% in practice activities in soccer.

Developmental activities – early adolescence (13–15 years)

It was the period where we found the most differences among both groups. The HS group showed statistically lower values in the % *time in play* ($M = 38.6$, $SD = 29.5$) compared to the LS group ($M = 59.2$, $SD = 32.6$), $t(45) = 2.273$, $p = .028$, $d = .660$, *large effect* (see Table 1). It means that the HS group spent, on average, 38.6% of the time in play activities in soccer and 61.4% of the time in practice activities in soccer. In contrast, the LS group spent, on average, 59.2% of the time in play activities in soccer and 40.8% in practice activities in soccer.

Moreover, considering the amount of time (h) spent in *practice in futsal*, the HS group showed statistically higher values ($Mdn = 305.6$, $SE = 110.7$) compared to the LS group ($Mdn = 54.0$, $SE = 75.8$), $U = 202.5$, $z = -2.001$, $p = .045$, $r = .282$, *small effect*. The last statistically difference found for this period was the amount of time (h) spent in *total practice* (soccer + futsal), where the HS group showed statistically higher values ($Mdn = 864.0$, $SE = 174.3$) compared to the low skill (LS) group ($Mdn = 364.5$, $SE = 148.9$), $U = 198.5$, $z = -2.212$, $p = .027$, $r = .312$, *medium effect*.

Developmental activities – late adolescence (16–18 years)

The HS group showed statistically lower values in the % *time in play* ($M = 22.3$, $SD = 21.3$) compared to the LS group ($M = 39.2$, $SD = 26.1$), $t(47) = 2.467$, $p = .017$, $d = .713$, *large effect*

Table 1. Comparisons between high and low decision-making skill groups based on different types of soccer developmental activities.

Developmental activities	High decision-making skills (<i>n</i> = 25)				Low decision-making skills (<i>n</i> = 25)				<i>p</i>	Effect size
	Mean	Median	SE	95% CI	Mean	Median	SE	95% CI		
Childhood (6–12 years)										
Practice in soccer (h) ¹	550.8	297.0	147.9	245.5; 856.0	322.1	0.0	139.1	34.8; 609.2	0.090	–
Play in soccer (h) ¹	994.7	270.0	290.0	395.9; 1593.3	1909.9	1093.5	452.7	975.6; 2844.3	0.303	–
% time in play ^{2,3}	53.9	49.1	6.7	39.9; 67.8	79.9	91.1	5.7	67.8; 91.2	0.006*	0.909 (large)
Practice in futsal (h) ¹	558.6	171.0	195.5	153.9; 963.2	357.3	0.0	132.5	83.7; 630.8	0.221	–
Total practice (soccer + futsal) (h) ¹	1087.0	540.0	250.7	569.5; 1604.5	679.3	182.3	210.8	244.3; 1114.5	0.076	–
Number of other sports ¹	1.1	1.0	0.2	0.6; 1.6	0.8	1.0	0.2	0.4; 1.2	0.396	–
Early adolescence (13–15 years)										
Practice in soccer (h) ¹	640.0	396.0	125.6	380.6; 899.3	458.5	301.5	122.6	205.4; 711.6	0.167	–
Play in soccer (h) ¹	490.5	216.0	139.6	202.2; 778.7	963.6	373.5	237.1	474.2; 1453.0	0.214	–
% time in play ^{2,3}	38.6	36.7	6.0	26.1; 51.1	59.2	65.5	6.8	45.1; 73.3	0.028*	0.660 (large)
Practice in futsal (h) ¹	487.8	305.6	110.7	258.9; 716.8	236.9	54.0	75.8	80.4; 393.3	0.045*	0.282 (small)
Total practice (soccer + futsal) (h) ¹	1108.0	864.0	174.3	748.5; 1468.2	695.4	364.5	148.9	388.1; 1002.7	0.027*	0.312 (medium)
Number of other sports ¹	1.2	1.0	0.2	0.9; 1.7	1.4	1.0	0.2	0.9; 1.8	0.693	–
Late adolescence (16–18 years)										
Practice in soccer (h) ¹	973.4	729.0	140.5	683.3; 1263.5	833.7	607.5	142.3	539.9; 1127.4	0.313	–
Play in soccer (h) ¹	318.3	121.5	113.7	83.4; 553.1	703	216.0	174.2	343.5; 1062.5	0.127	–
% time in play ^{2,3}	22.3	21.0	4.4	13.3; 31.3	39.2	37.9	5.2	28.4; 50.0	0.017*	0.713 (large)
Practice in futsal (h) ¹	319.8	270.0	83.8	146.9; 492.8	236.2	54.0	74.2	82.9; 389.3	0.297	–
Total practice (soccer + futsal) (h) ¹	1293.2	1174.5	149.0	985.8; 1600.7	1069.8	1053.0	176.0	706.6; 1433.0	0.218	–
Number of other sports ¹	0.8	1.0	0.1	0.5; 1.0	1.2	1.0	0.2	0.8; 1.6	0.102	–

¹Analyzed with Mann-Whitney *U*-test; ²analyzed with independent *t* – test; ³% time in play was calculated considering the percentual time spent in play activities in soccer, considering the total amount accumulated in practice and play in soccer.

* Significant differences (*p* < 0.05).

(see Table 1). It means that the HS group spent, on average, 22.3% of the time in play activities in soccer and 77.7% of the time in practice activities in soccer. On the other hand, the LS group spent, on average, 39.2% of the time in play activities in soccer and 60.8% in practice activities in soccer.

Discussion

The purpose of this study was twofold: (1) to analyse whether the engagement in various types and amounts of soccer activities during childhood and adolescence can differentiate elite Brazilian professional female soccer players with different levels of decision-making skills; and (2) to discuss what sport's pathway in female soccer characterised the group with high decision-making skills.

We found differences among high skill (HS) and low skill (LS) decision-making groups regarding their participation in developmental activities in every period that was assessed (childhood, early, and late adolescence). In summary, we found that in every period set, the HS group accumulated more percentage time of participating in soccer activities in practice compared to the LS group. Moreover, the HS group gathered more hours of practice in futsal and total practice (i.e., considering the accumulated practice time in soccer and futsal) in early adolescence (13–15 years), compared to the LS group. Our hypothesis was partially supported, as we found a higher percentage of time spent by the HS group in practice activities during childhood. On the other hand, our results did not support the hypothesis that the HS group would engage in more hours of play activities during childhood. Discussion on these topics will be provided in the following paragraphs.

In the childhood period, we found differences in only one variable assessed: the percentual time in play. We highlight that this variable was the one that showed a larger effect size among all variables assessed (large effect) to differentiate both HS and LS groups, which shows its importance during this period of sport formation. This variable considers the percentual time spent in play activities in soccer, considering the total amount accumulated in practice and play in soccer. The HS group accumulated less time in play activities (average 53.9%) than the LS group (average 79.9%). It shows that the HS group was more involved in structured practice in soccer during this sport developmental phase than the LS group. Similar results were found in a study that assessed elite male youth players from the UK (~15 years) (Hendry et al., 2018). In this study, a greater percentage of time spent in practice in childhood was positively associated with higher ratings of creative and tactical skills. In the same vein, another study carried out with youth male players from Brazil (~14.9 years), found that players who possessed better tactical decision-making skills accumulated more hours of practice in soccer during their sport formation compared to players with lower decision-making skills (Machado et al., 2020). Moreover, both groups (high and low decision-makers) assessed in the study above also possessed higher amounts of time spent in play activities compared to practice activities in soccer, which is similar to the finds of our results. These results altogether suggest that high amounts of time spent in practice in soccer (~45% on average) during childhood, when coupled with a considerable amount of time spent in deliberate play (~55% on average) are associated with better decision-making skills in older ages, such as adolescence and adulthood.

In turn, early adolescence was the period where we found the most differences among the HS and LS groups. In this period, we found that the HS group showed a lower percentage of time spent in play soccer activities (average of 38.6%) than the LS group (average of 59.2%). It means that in the early adolescence period, the HS group had a shift in the type of activities they participated most in soccer compared to childhood. The involvement was mainly focused on practice activities in soccer (~ 60% on average) and less on play activities in soccer (~ 40% on average). On the other hand, the LS group continued their involvement in soccer activities, more focused on play activities (~ 60% on average) and less on practice activities (~ 40% on average). Furthermore, the HS group showed a similar pattern of participation in soccer activities for the early adolescence period compared to a study carried out with professional female soccer players who participated in their country's national squad (Ford et al., 2020). In this study, the female players accumulated during early adolescence more hours of practice activities in soccer compared to play activities in soccer.

In addition, a previous study on decision-making skills development carried out with male samples showed a different pattern than found in our results (Roca et al., 2012). They found that male soccer players with better decision-making skills accumulated more deliberate play hours during adolescence. These differences could be due to several socio-cultural factors. Among them, two aspects are highlighted. The first is related to cultural differences considering that such a study was conducted with United Kingdom clubs, and previous research showed differences in developmental activities in soccer between male Brazilian and UK soccer players (Ford et al., 2012). Secondly, such differences could be related to differences among genders. In such a case, it suggests that it requires a different pedagogical treatment than men's sports or that male coaches working with women's teams need to develop distinct coaching philosophies during different phases of sport formation (O'Brien-Smith et al., 2020).

Moreover, we found that the HS group accumulated more hours of practice in futsal and more hours of total practice (futsal + soccer) than the LS group. These results align with recent research that advocates the potential of futsal practice engagement to contribute to soccer talent development (Oppici et al., 2019; Travassos et al., 2018; Yiannaki et al., 2018). Yiannaki et al. (2018) found that a large majority (~ 90%) of soccer coaches interviewed in their study considered futsal useful in soccer talent development and would consider using it in their coaching/game provision. It is because futsal can aid the acquisition of skills that could transfer to soccer environments and, consequently, enhance players' performance in soccer. Moreover, there is empirical evidence that futsal practice promotes the transfer of tactical-technical skills (e.g., passing skills) to soccer (Oppici et al., 2019). This potential for positive transfer between futsal skills to soccer skills has been attributed to similarities between perceptual-cognitive and perceptual-motor skills of both sports.

Furthermore, due to the characteristics of futsal, such as fewer players and dimensions compared to soccer, it may contribute to a wide range of technical and tactical abilities and decrease the game's complexity (Travassos et al., 2018). Therefore, it has been suggested that futsal has a great potential to promote diversification in contexts (e.g., ball, surface, number of players, or dimension) within the "soccer" sport, especially in earlier phases of sport formation. Additionally, it can be used as an alternative training methodology in soccer, similar to small-sided games. Interestingly, recent research with

male youth soccer players found that the use of small sided-games in soccer practice, such as 2×2 up to 4×4 activities, during early adolescence was positively associated with the development of offensive tactical decision-making skills (Machado et al., 2020). Therefore, considering our results during the early adolescence period, it suggests that a greater prevalence of participation in structured activities in soccer and futsal in this period of sport development may be associated with better decision-making skills in female soccer players at older ages.

Considering the late adolescence period, we found just one difference among both groups: the HS group showed a lower percentage of time spent in play soccer activities (average of 22.3%) than the LS group (average of 39.2%). The results found for the HS group show a more likely pattern excepted for this phase of sport formation, known as the investment phase. High amounts of deliberate practice in the primary sport are expected, and low amounts of deliberate play (Côté et al., 2007). In other words, we found that the involvement of the HS group was mainly focused on practice activities in soccer (~ 80% on average) and almost four times less on play activities in soccer (~ 20% on average). On the other hand, although the LS group showed a prevalence of involvement in practice activities in soccer (~ 60% on average), this amount is not even twice as much time their involvement in play activities in soccer (~ 40% on average). In other words, this percentual shown by the LS group in late adolescence looks very similar to the pattern found by the HS group during its early adolescence (see Table 1).

Moreover, the pattern showed by the HS group in this period, which was around four times more time spent on practice activities compared to play activities, was much more similar to the pattern found by Ford et al. (2020) with female adult soccer players from senior national teams. In this study, the players from their national squads showed that during their late adolescence, they possessed almost six times more time (on average) spent on practice activities compared to play activities in soccer. These results indicate that a greater prevalence of involvement in practice activities in soccer during late adolescence is associated with higher performance levels in soccer, such as reaching a national squad and is linked to the attainment of better decision-making skills.

We will now discuss which pathway, especially in childhood (6–12 years), best characterise the sport's formation of elite professional female soccer players from Brazil with higher decision-making skills. We found that players with higher decision-making skills during their childhood participated in a diversity of contexts related to “soccer” games, such as play and practice in soccer and practice in futsal. In contrast, we found that in terms of engagement in other sports, there was no diversification, once the players participated on average in only 1.1 other sports apart from soccer. Moreover, they engaged in great amounts of play activities in soccer (~ 1000 h on average) and practice activities in both soccer (~ 550 h on average) and futsal (~ 550 h on average). It means they were involved in similar amounts of play activities (~ 1000 h on average) and practice activities when we couple soccer and futsal (~ 1100 h on average).

Therefore, the specialised diversification pathway, proposed by Sieghartsleitner et al. (2018), is the one that best characterises the sports involvement during the childhood of professional female soccer players from Brazil with higher decision-making skills. This result suggests that the diversification of sports contexts in the primary sport during childhood may favour the attainment of better decision-making skills of soccer players at older ages. Moreover, our findings partially support the early engagement

pathway proposed by Ford et al. (2009) once we found a balanced involvement in play (~ 55% on average) and practice (~ 45% on average) activities in soccer during childhood. However, this pathway does not consider participation in similar sports apart from soccer (e.g., futsal) as we found in our study. In general, our results indicated that engaging in a balanced percentual time in both practice and play during childhood enhances the probability of possessing better decision-making skills in adulthood and keeping engaged on greater percentual time in practice during adolescence.

Other important finds of our study are related to the early adolescence period (13–15 years), known as specialising years by the DMSP (Côté, 1999). The players with higher decision-making skills still participated in various contexts related to “soccer” games, such as play and practice in soccer and practice in futsal. However, during this phase, we found a shift in the prevalence of activities they participated in soccer compared to childhood, as expected by the DMSP. It means that participation was focused more on structured activities, such as practice activities in soccer (~ 650 h on average) and futsal (~ 500 h on average). In other words, it means a prevalence of practice activities considering both soccer and futsal (~ 1100 h on average) compared to play activities (~ 500 h on average). These results highlight the importance of enhancing the volume of practice activities during early adolescence, coupled with a considerable amount of play activities, to favour the attainment of decision-making skills, as found in previous research (Baker et al., 2003; Berry et al., 2008; Machado et al., 2020; Roca et al., 2012).

Considering the impact of deliberate play and practice in the development of decision-making skills among sexes, we found more differences than similarities between male and female players when contrasting our results with previous research. In terms of differences, play in soccer during childhood and practice in soccer during early adolescence were associated with better decision-making skills in male UK players (Roca et al., 2012), differently from our results. Moreover, practice in soccer during childhood and adolescence of Brazilian male players was related to better decision-making skills (Machado et al., 2020), which is different from our findings.

In turn, we found a similar pattern of the % time in play during childhood in male UK players (Hendry et al., 2018), compared to our results. We partially found a similar pattern in terms of the positive association between practice activities during early adolescence and decision-making skills, although our study considered the total practice of soccer and futsal and other studies with male players considered only practice in soccer (Machado et al., 2020; Roca et al., 2012). Therefore, our results indicate that results from male soccer players may not translate directly to female sport, and it requires a different pedagogical treatment than men’s sports. It may impact in different coaching philosophies during distinct phases of sports formation for women’s teams (O’Brien-Smith et al., 2020). Future studies could address such a question by comparing the developmental activities of female and male players from the same countries.

An exciting find in our study is that the proportion of percentage time of player’s participation in soccer activities, considering play and practice, was the one that differentiated both groups of high and low decision-making skills in every developmental phases. Furthermore, we highlight that this variable was the one that showed a larger effect size among all variables assessed (large effect) to differentiate both HS and LS groups during every period assessed (6–12, 13–15, and 16–18 years). Therefore, it shows a potential of such a variable for future research focused on talent development

studies in sports. In this research field, it is more common to compare the total amount of accumulated hours in different activities, such as practice and play (Erikstad et al., 2018; Ford et al., 2020; Forsman et al., 2016; Haugaasen et al., 2014; Hendry et al., 2019; Machado et al., 2020; Roca & Ford, 2021), instead of the proportion of them (Hendry et al., 2018; Hendry & Hodges, 2018).

Moreover, sports institutions could use this metric to enhance the learning and development of talented young female players as a low-cost assessment method. However, we recognise that it is needed to build more scientific knowledge considering different sports contexts, such as continents, countries, ages, gender, and competitive levels. Additionally, it would be interesting to investigate other aspects of decision-making skills in future studies, such as decision time and perceptual-motor skills, once the literature indicates that cognitive and motor skills may develop in different manners during sports development (González-Víllora et al., 2013; Williams et al., 2020). We also acknowledge that several limitations of this study should be noted. First, the possible memory inference related to self-reported data on remembering what was being practiced several years ago (e.g., recall bias, retrospection effect) needs to be considered when interpreting the results. Second, although the Portuguese version of the retrospective questionnaire has been used previously in Brazilian and Portuguese samples (Ford et al., 2012; Machado et al., 2020), the information about the validity and reliability is available only for the original version in English (Ford et al., 2010) and its Norwegian version (Haugaasen et al., 2014). Third, we used a retrospective study design, and only longitudinal studies would allow for comparing (de facto) hours spent playing soccer in earlier years. These limitations could be addressed in future studies using more longitudinal designs to avoid memory error and inference and video/training analysis to characterise the nature of the practice, jointly with the employment of questionnaires. Moreover, the validity and reliability of the Portuguese version of this questionnaire should be tested in the future for Brazilian samples.

In summary, to the best of our knowledge, our study was the first to compare the engagement in different soccer activities during childhood and adolescence of elite professional female soccer players with different levels of decision-making skills. Another novelty of research with female soccer players was assessing decision-making skills based on an objective test that assesses both offensive and defensive skills based on collective tactical aspects (TacticUP®). It provides a broader profile of players' decision-making skills instead of tests that only assess offensive situations with the ball or those focused on just individual actions. Moreover, our findings show a potential to be used by governing bodies and soccer stakeholders, such as the Brazilian Soccer Confederation (CBF), CONMEBOL, and Federation Internationale de Football Association (FIFA). It might subsidise the construction of an "equity and equality" structured curriculum that favours the acquisition of decision-making skills throughout sports development during the childhood and adolescence of female soccer players. We also suggest future studies to replicate this methodological approach with different youth female samples, such as U-21, -19, -17, and -15 female soccer players.

Conclusions

It is concluded that previous types and amounts of soccer activities performed during all formation stages (from 6 years to 18 years old) differentiate Brazilian professional female

soccer players with different levels of decision-making skills. We found differences in every period assessed (childhood and early and late adolescence). In every period set, players with better decision-making skills accumulated more percentage time of their participation in soccer activities in practice than players with lower decision-making skills. Moreover, during early adolescence (13–15 years), the group with high decision-making skills accumulated more hours of practice in futsal and total practice (i.e., considering the accumulated practice time in soccer and futsal) compared to players with low decision-making skills. Therefore, it seems beneficial that young female players practice these two sports during their sports development, as there is a positive transfer between them, and later on, the players decide which sport to continue their involvement.

Moreover, the sports developmental pathway during childhood that best characterises players with high decision-making skills is the specialised diversification pathway. It means that the diversification of sports contexts in the primary sport, such as involvement in practice and play in soccer plus practice in futsal during childhood, may contribute to the attainment of better decision-making skills of elite female soccer players in adulthood.

Practical applications

- During childhood (6–12 years), involvement in a variety of contexts on the primary sport, such as play activities in soccer (~ 1000 h on average), practice in soccer (~ 650 h on average), and practice in futsal (~ 500 h on average) are related to better decision-making skills in adulthood. It means involvement in similar amounts of play activities (~ 1000 h on average) and practice activities when we couple soccer and futsal (~ 1100 h on average).
- During early adolescence (13–15 years), a prevalence of practice activities in soccer (~ 650 h on average) and futsal (~ 500 h on average) compared to play activities (~ 500 h on average) are related to better decision-making skills in adulthood. It means more than twice the time spent in practice activities than play activities when we couple soccer and futsal (~ 1100 h on average).
- Our findings show a potential to be used by governing bodies and soccer stakeholders, such as CBF, CONMEBOL, and FIFA, to subsidise the construction of a structured curriculum throughout sports development that contributes to the development of female soccer players with better decision-making skills.

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Data availability statement

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

Disclosure statement

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