

Speed of decision-making as a key element for professional and academy soccer players' performances La rapidez en la toma de decisiones como elemento clave para el rendimiento de los futbolistas profesionales y de cantera

*Israel Teoldo, *Eliakim Mezzadri, *,**Felippe Cardoso, *,***Guilherme Machado

*Universidade Federal de Viçosa (Brazil), **Universidade Federal de Juiz de Fora (Brazil), ***Universidad de Castilla-La Mancha (Spain)

Abstract. This study aimed to: i) compare the number of decisions made in official matches between youth academy and professional soccer players and ii) compare the quality and speed of decision-making between youth academy and professional players. In experiment 1 we assessed 12 soccer matches (7 professional and 5 academy matches) through notational analysis. In experiment 2 we assessed 138 soccer players from professional (n = 42) and academy (n = 96) levels. The TacticUP® was used to assess game reading and decision-making skills. Results indicated that professional players make around 56% more decisions than youth academy players in official matches of their respective tournaments. In addition, professional players are quicker in making decisions for all match situations: with the ball (offensive phase), without the ball (offensive and defensive phases), near and distant from the ball. Based on the results, we verified that both *in situ* (official match) and *in vitro* (controlled test) situations the speed of decision-making was a distinguishing feature of performance between professional and youth academy players.

Keywords: football; game reading; perceptual-cognitive skills; perceptual-motor skills; response time; talent development.

Resumen. El objetivo de este estudio fue: i) comparar el número de decisiones tomadas en partidos oficiales entre jugadores de la cantera y profesionales y ii) comparar la calidad y velocidad de la toma de decisiones entre jugadores de la cantera y profesionales. En el experimento 1 evaluamos 12 partidos de fútbol (7 profesionales y 5 de la cantera) a través del análisis notacional. En el experimento 2 evaluamos a 138 jugadores de fútbol de nivel profesional (n = 42) y de de la cantera (n = 96). Se utilizó el TacticUP® para evaluar las habilidades de lectura del juego y de toma de decisiones. Los resultados indicaron que los jugadores profesionales toman alrededor de un 56% más decisiones que los jugadores de la cantera en partidos oficiales de sus respectivos torneos. Además, los jugadores profesionales son más rápidos en la toma de decisiones en todas las situaciones del partido: con balón (fase ofensiva), sin balón (fases ofensiva y defensiva), cerca y lejos del balón. A partir de los resultados, comprobamos que tanto en situaciones *in situ* (partido oficial) como *in vitro* (prueba controlada) la rapidez en la toma de decisiones fue un rasgo distintivo del rendimiento entre jugadores profesionales y de cantera.

Palabras clave: fútbol; lectura del juego; habilidades perceptivo-cognitivas; habilidades perceptivo-motoras; tiempo de respuesta; desarrollo del talento.

Fecha recepción: 14-06-23. Fecha de aceptación: 24-08-23

Israel Teoldo

israel.teoldo@ufv.br

Introduction

Soccer players need to make quick and accurate decisions in a highly unpredictable environment (Assis et al., 2021; Roca & Ford, 2020; Teoldo et al., 2022; Williams et al., 2020). Consequently, they must search and process a great amount of environmental information, under time pressure and high cognitive load (Cardoso et al., 2020; Vickers & Williams, 2017). Literature indicates that most environmental information (e.g., opponents, team-mates, or empty space) utilized by the players comes from vision, and the ability to search, as well as to process, accurate information, refer to players' perceptual and cognitive skills (Cardoso et al., 2021; Machado et al., 2017; Roca et al., 2011, 2020). On the other hand, the performance of game actions at the behavioral level is associated to perceptual and motor representations of the decisions made (Williams & Ward, 2021). Thus, they are the observable elements in the game of soccer, represented by technical, physical and tactical elements (Belling et al., 2015; Casanova et al., 2022; Teoldo et al., 2022; Vaeyens, Lenoir, Williams, & Philippaerts, 2007; Vickers & Williams, 2017). In this context, decision-making can be defined as a choice of action and an outcome identified through a motor or verbal response (Bruce et al., 2012; Macmahon & Mcpherson, 2009). Therefore, for quicker and more qualified decision-making,

soccer players need to optimize their skills at both perceptual-cognitive and perceptual-motor levels (Vickers & Williams, 2017; Williams & Ward, 2007).

As for the perceptual and cognitive skills, Cardoso et al. (2021) verified that the players who are capable of making quicker and more accurate decisions are also those who possess better skills for employing visual search strategies, and more efficient information processing. Several authors indicated that expert players are capable of searching more efficiently for relevant information across the game environment, are quicker at recognizing postural cues and relevant signals, thus ensuring advantages when making decisions (Roca et al., 2011; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Ward & Williams, 2003). Previous literature has made comparisons between experts and novices, however there is lack of research that has compared professional and academy players (González-Villora et al., 2015; Roca et al., 2012; Vickers, 2016; Vickers & Williams, 2017).

With respect to perceptual and motor skills, evidence indicates that expert players are more accurate in their decisions (Machado et al., 2023a; Roca et al., 2020), are more effective at managing their physical and physiological demands (Hogarth et al., 2015) and display better technical (Buekers et al., 2015) and tactical (Andrade et al., 2020) game behaviors.

The aforementioned evidences indicate that the differences between experts and novices may be understood as key elements for success in sports, which facilitates explaining some distinct characteristics that can also be observed in the comparison of match behaviors between teams at the academy and professional levels (Serra-Olivares et al., 2020; Thomas & Thomas, 1994). An increasing number of studies have indicated that the speed of decision-making is one of the most common characteristics of players who achieve professional status (Cardoso et al., 2020; Machado & Teoldo, 2020). Hence, to be able to ascend to professional teams, academy players should be increasingly prepared for a cognitively quicker and more demanding game (Vickers & Williams, 2017).

Considering this scenario, studies that assessed the decision-making characteristics of academy and professional players are highly relevant. Understanding the differences related to the amount, quality and speed of decision-making between academy and professional players may help understanding training and intervention strategies for the development of soccer players (Canton et al., 2022; Moniz et al., 2021). In addition, these indications can help elucidating how academy players can adapt their perceptual-cognitive and perceptual-motor skills with the purpose of making better and quicker decisions, so as to meeting the demands of professional soccer (Barcellos et al., 2022).

Based upon previous research, the purposes of this study are twofold: i) compare the number of decisions made by soccer players at academy and professional levels in official matches; ii) compare the quality and speed of decision-making between academy and professional soccer players. This study comprises two experiments, each aimed at addressing one of the aforementioned purposes.

Experiment 1

The purpose of Experiment 1 is to compare the number of decisions made by soccer players at academy and professional levels in official matches. This experiment is based on the assumption that by making a decision, the first route of the process is normally of a perceptual and cognitive nature, in which the player primarily depends on/considers internal/individual and external/environmental indicators (Teoldo et al., 2022). The internal/individual indicators include: perceptual and technical skill levels, players' physical capacities, as well as their tactical knowledge about the game and their psychological traits (Vickers & Williams, 2017). As for the external/environmental indicators it is possible to observe the time-space relation the player possesses to perform a certain action, the movements of their teammates and opponents, among others (Teoldo et al., 2022). Considering these indicators, the player makes the decision that generates a perceptual and motor representation. This perspective on decision-making helps understanding that each action performed by the player refers to a perceptual and motor representation of his/her decision, i.e., this variable can be observed, analyzed and quantified in the playing field.

Therefore, among the variables gathered through notational match analysis, the number of ball touches provides an indicator of the number of decisions made in the game, considering that every touch of the ball results in new decisions/opportunity for action (Garganta, 1997). Each ball touch performed by the player, in addition to carrying in its essence of action the perceptual and motor representation, also induces the player's teammates and opponents to make decisions based on his/her behavior (Teoldo et al., 2022). As this is an observational analysis, it is understood that the number of ball touches is a measure that can be counted. Each contact with the ball generates behavioral changes in teammates and opponents, therefore new decisions. We understand that other decisions can happen throughout the game, however they are not possible to be accounted for visually in the game.

In addition to this variable, notational analysis provides other relevant information on players' decision-making, such as the assertiveness, measured through the number of received balls, which indicates the occurrence of favorable sequence for the play by the team, i.e., a decision that enabled an effective sequence for the play (Garganta, 1997).

Based on this information, this experiment hypothesizes that professional soccer players make more decisions in the game, and have greater assertiveness in decisions when compared to academy players (Roca et al., 2011; Vaeyens, Le-noir, Williams, Mazyn, et al., 2007; Ward & Williams, 2003).

Materials and Methods

Sample

The sample comprised 24 soccer teams, from which 14 were professional teams that played in the 2012/2013 UEFA Champions League, whereas 10 were U-20 academy teams that played national tournaments in Brazil. These teams were assessed during 12 official matches (7 professional matches and 5 academy matches). The assessments resulted in 25,338 analyzed actions, from which 17,365 were performed by professional players and 7,973 were performed by academy players. The project was approved by the Ethics Committee of the leading institution (Approval number: 46773721.9.0000.5153).

Video Recording and Data Collection

The present study resorted to the systematic observation of professional and academy matches, broadcasted by a TV station. All stadia from the matches analyzed have their dimensions restricted to 105 x 68 m, with vertical stripes on the grass, alternating between light and dark green, thus facilitating the identification of field sectors. As for the field corridors, the grid proposed by Teoldo, Guilherme and Garganta (2022) was used. The limitation regarding the data source does not allow a full view of the playing field during replays, which resulted in some data loss.

Data collection was carried out using notational analysis, which depends exclusively on a single observer for the

analyzed matches, and takes into account the criteria for field marking and duration of the offensive sequences. The following metrics were considered in the present study.

Chart 1.

Measures used in the study, based on Garganta (1997).

VARIABLE	DESCRIPTION
Number of Decisions Made in the Game	Refers to the number of decisions made and/or induced over the game. It is calculated from the sum of the number of ball touches in the game.
Average Number of Received Balls (NR)	Refers to the mean number of balls received in a game. The NR refers to the overall number of balls received by the players, in a given sequence of play, from a teammate.

Procedures for collecting and analyzing data

Data collection and recording were carried out using a POSITIVO T laptop, model 3300, Intel Core™ i3 processor. Gathered data were registered in spreadsheets of Excel for Windows®, 2016.

Statistical analysis

Descriptive statistics (means and standard deviation) were used in this study to describe the metrics of professional and academy teams. Normality of data distribution was verified using the Shapiro-Wilk test. Since data followed a parametric distribution, the t-test for independent samples was used to compare metrics between professional and academy teams. Effect sizes were obtained using the values of Cohen's *d*, and were interpreted as follows: insignificant effect ($d < 0.19$), small effect ($0.20 \leq d \leq 0.49$),

medium effect ($0.50 \leq d \leq 0.79$), large effect ($0.80 \leq d \leq 1.29$) and very large effect ($d \geq 1.30$) (Cohen, 1988).

Reliability was calculated using the Cohen's Kappa test. A total of 2.875 actions were reassessed, a figure that represented a higher value than the one (10%) proposed by literature (Tabachnick & Fidell, 2007). Three observers participated in this procedure, whereas values of inter-observer reliability ranged between 0.912 (se=0.032) and 1. Values of intra-observer reliability ranged between 0.864 (se=0.030) and 0.998 (se=0.002). Statistical procedures were performed using SPSS, version 28.0. The significance level was set at $p < 0.05$.

Results

Table 1 displays the means and standard deviations of the metrics used in this study, as well as the results of the inferential statistics for the comparison of professional and academy matches.

Significant differences were observed in the comparison between professional and academy soccer players for all the analyzed metrics, whereas significantly higher values were observed for the professional teams. Findings also indicate that professional players make, on average, 2,460 decisions in each match, while U-20 players make 1,573 decisions per match. Consequently, in official matches professional players made 56% more decisions than U-20 players.

Table 1.

Comparisons of match analysis measures between professional and academy soccer players.

Assessed Measures	Professional		Academy Players		<i>t</i>	<i>p</i>	<i>d</i>
	Means	SD	Means	SD			
Number of Decisions made in the Game*	2,459.93	205.75	1,573.45	291.51	-5.840	<0.001	2.79
Average Number of Received Balls (NR)*	4.65	0.78	2.78	0.49	-5.086	<0.001	2.59

*Significant Differences

Experiment 2

The purpose of experiment 2 was to compare the quality and speed of decision-making between academy and professional soccer players. This experiment takes into account the importance of understanding, from the standpoint of the perceptual and cognitive mechanisms, which elements between assertiveness and speed can be stressed for academy and professional players' decision-making.

We hypothesized that professional players are more assertive and quicker than academy players due to their better developed perceptual and cognitive skills (Cardoso et al., 2020; Machado et al., 2017; Vickers & Williams, 2017).

Materials and Methods

Sample

The sample of this study was comprised of 138 male soccer players, from which 42 were professional and 96 were young academy players (62 U-17 and 34 U-20 players). The overall number of players, as well as the subdivision in groups of professional and academy players were estimated using G

* Power 3.1.9.4®. The procedures for estimating the minimum sample size were described by Faul et al. (2007). An *a priori* power analysis estimated that a sample with 56 players in total was sufficient, with each competitive level being comprised of 28 players. Sample estimation data displayed the following values = 95% Power ($1 - \beta$), alpha (α) of 0.05 and large effect size (ES) ($d = 0.9$) (Faul et al., 2007).

In order for players to be included in the study the following inclusion criteria was required to be satisfied: players should participate of systematic training sessions in their clubs at least 5 times a week, and the duration of each session should be no shorter than 1 hour and 30 minutes. All players should be at their current clubs for at least 1 year, and have at least 10 years of soccer practice.

In order to participate in the study, all players signed an informed consent, acknowledging their participation in the study. All research procedures were conducted following the norms established by the Declaration of Helsinki for research with human beings. The project was approved by the Ethics Committee for research with human beings of the leading institution (Approval number: 46773721.9.0000.5153).

Instrument

The instrument used to assess game reading and decision-making skills was the TacticUP[®]. The TacticUP[®] is an online video-based assessment platform (www.tacticup.com.br) that enables the objective assessment of players' game reading and decision-making skills. The validity and reliability of the TacticUP video test is available on the study of Machado and Teoldo (2020). This test is based on the core tactical principles of the soccer game (Teoldo et al., 2022).

The TacticUP[®] video test is comprised of video sequences (scenes) of offensive and defensive actions from 11 vs. 11 match scenarios. The images were obtained from a bird-view perspective, thus allowing the full visualization of the field. For each scene participants had to choose the most appropriate among four possible solutions presented to them after each of the scenes. Prior to the start of the test, participants were instructed with respect to the test structures, whereas three video trials were presented to have them familiarized with the task. The final scores provided by the TacticUP[®] video test are presented in 13 items: one for each core tactical principles, in addition to the scores for the defensive and offensive phases, as well as the overall game. The test also provides information on the time the participants takes in each of the scenes (Teoldo et al., 2022).

All procedures were described to participants prior to the start of the task and the main researcher was always present to address any questions. The TacticUP[®] video test was administered individually to each participant through a laptop computer (POSITIVO T model 3300 Intel Core™ i3 processor) with a 15-inch screen in controlled and standardized conditions. Each player took around 20 minutes to complete the test.

Data Collection Procedures

In a moment prior to data collection, clubs and participants were contacted and their respective authorizations were obtained for data collection. For the experimental protocol a closed environment was set up, with controlled external interferences such as sound (maximum 13 Db),

brightness (mean values were 332 lux, with variations lower than 07 lux, during the experimental protocol) and room temperature (24°C). All procedures related to data collection always occurred with the technical support of the main researcher linked to the present research. All participants were instructed on the test characteristics and its duration. Potential doubts were addressed by the main researcher. The test was taken by participants as their first working task of the day, which means participants were rested when taking the test.

Statistical analysis

Descriptive analysis was used to verify means and standard deviations of performance and speed of decision-making. Normality was tested using the Kolmogorov-Smirnov test, and data followed a non-parametric distribution. The Mann-Whitney test was used with the purpose of comparing the performance and speed of game reading and decision-making results between professional and academy players. Effect sizes were obtained using the formula ($r = Z/\sqrt{n}$) described by Fritz, Morris and Richler (2012). Values were interpreted as follows: small effect (0.1-0.29), medium effect (0.3-0.49) and large effect (> 0.5) (Cohen, 1988). Statistical procedures were performed using SPSS, version 28.0, and the significance level was set at $p < 0.05$.

Results

Table 2 indicates significant differences in the values of decision-making performance for the principles of penetration, delay and width and length with the ball. For the principles of penetration and delay, professional players displayed better performances when compared to academy players. On the contrary, for the principle of width and length with the ball, the performance of academy players was better than that of professional players.

With respect to response time, significant differences were observed in eleven of the twelve principles assessed. Only the principle of defensive coverage did not display significant differences between both levels of players. For all the differences observed in response time, professional players displayed higher values when compared to academy players.

Table 2. Comparisons of game reading and decision-making skills and response time between professional and academy soccer players

Variables	Levels				p	r		
	Performance (a.u.)		Time (s)					
	Professional Means and SD	Academy Means and SD	Professional Means and SD	Academy Means and SD				
Offensive Principles								
Penetration	78.94±13.12	72.80±13.94	6.70±3.33	10.76±6.56	0.016*	<.001*	-0.20	-0.33
Offensive Coverage	71.44±17.20	72.37±16.30	6.99±3.96	10.04±6.00	0.893	0.004*	-	-0.25
Width and Length with the Ball	77.32±15.54	86.10±15.65	7.46±3.60	10.26±5.00	0.003*	<.001*	-0.26	-0.29
Width and Length without the Ball	93.78±5.63	92.48±9.95	6.17±3.49	7.95±4.40	0.777	0.013*	-	-0.21
Mobility	66.32±15.43	64.56±14.98	6.36±4.23	9.76±7.20	0.503	<.001*	-	-0.33
Offensive Unity	47.22±22.67	41.98±23.14	5.64±2.66	8.01±4.43	0.272	<.001*	-	-0.28
Defensive Principles								
Delay	77.05±21.25	69.66±17.14	6.62±3.74	9.87±6.80	0.017*	0.002*	-0.20	-0.27
Defensive Coverage	58.53±20.58	56.60±17.71	8.43±4.70	10.20±5.51	0.430	0.076	-	-
Recovery Balance	63.98±22.43	68.08±19.44	7.74±4.35	11.16±7.82	0.385	0.002*	-	-0.27
Defensive Balance	71.48±23.76	67.79±20.55	6.87±3.69	10.01±6.13	0.167	<.001*	-	-0.30
Concentration	73.98±23.06	80.92±15.74	6.32±3.27	8.84±4.62	0.192	<.001*	-	-0.31
Defensive Unity	52.18±11.37	50.80±12.52	5.93±3.44	7.66±4.03	0.295	0.002*	-	-0.26

*Significant differences; a.u. arbitrary units.

Table 3 displays the results of performance and speed of game reading and decision-making in offensive and defensive actions. With respect to the performance variable, no significant differences were observed for any of the measures.

As for the assessment of speed of decision-making, significant differences were observed for all variables. Profes-

sional players were quicker in situations both inside (offensive $p<0.001$, defensive $p=0.011$) and outside (offensive $p=0.002$, defensive $p<0.001$) the center of play. In addition, professional players were quicker in making decisions for offensive actions with ($p<0.001$) and without the ball ($p<0.001$). Also, professionals were quicker to make decisions in all defensive actions ($p<0.001$).

Table 3.

Comparisons of game reading and decision-making skills and response time between professional and academy soccer player.

Variables	Levels				p		r	
	Performance (a.u.)		Time (s)		Performance	Time	Performance	Time
	Professional Means and SD	Academy Means and SD	Professional Means and SD	Academy Means and SD				
Offensive Actions								
Inside the Center of Play	75.90±8.32	77.06±9.35	7.05±3.33	10.35±4.89	0.490	<.001*	-	-0.34
Outside the Center of Play	69.11±10.77	66.34±11.13	6.06±3.14	8.58±4.60	0.327	<.001*	-	-0.30
With the Ball	78.13±11.04	79.41±9.69	7.08±3.27	10.51±5.22	0.680	<.001*	-	-0.34
Without the Ball	69.69±8.23	67.85±9.07	6.29±3.24	8.94±4.68	0.260	<.001*	-	-0.32
Defensive Actions								
Inside the Center of Play	66.52±12.43	64.75±10.87	7.60±3.72	10.41±5.37	0.401	0.003*	-	-0.25
Outside the Center of Play	65.88±12.39	66.50±10.10	6.37±3.23	8.84±3.97	0.837	<.001*	-	-0.33
Without the Ball	66.20±9.51	65.92±6.64	6.99±3.35	9.62±4.45	0.724	<.001*	-	-0.30

*Significant differences; a.u. arbitrary units.

Discussion

The purposes of this study were: i) to compare the number of decisions made official matches between professional and academy soccer players; and ii) to compare the quality and speed of decision-making between academy and professional soccer players. So as to address these objectives, this study was comprised of two experiments, conducted to tackle each of the aforementioned purposes. In addition, to the best of our knowledge, this study is the first to compare decision-making between professional and academy soccer players using a behavioral metric in official matches (*in situ*) and a perceptual and cognitive one, through laboratory tests (*in vitro*). The first experiment indicated that professional players made more decisions in official matches (with 90-minute duration) when compared to academy players. The second experiment verified that professional players made quicker decisions than academy players in offensive and defensive actions, inside and outside the center of play, and both with and without the ball. Also, professional players made better decisions for the principles of penetration and delay, whose emotional load related to hot decision-making is more present (Gonzaga et al., 2014), whilst academy players made better decisions for the principle of width and length with the ball.

Results from experiment 1 indicated that professional players made, on average, 56% more decisions per match than academy players (very large effect size). In experiment 2, this difference was also observed, particularly for the speed of decision-making for the different match situations: offensive, defensive, near and distant from the ball. This finding indicates that speed of decision-making is an element that distinguishes academy from professional players. In other words, taking into account that the official matches analyzed in this study have the same duration (90 minutes) for both levels (academy and professional), professional

players were capable of responding quicker to the situational demands, i.e., increase the cognitive speed of the game.

It is noteworthy that this greater demand related to professional players' decisional skills generates higher cognitive overload throughout the match, as indicated by previous studies (Cardoso et al., 2020; Fortes et al., 2020). This greater cognitive overload may affect players' performances, leading to a higher number of mistakes when making decisions and to negative impacts on their technical and physical performances (Kunrath et al., 2020). However, recent studies indicate that adaptations in the perceptual and cognitive processes over the training routine can minimize the overload generated by the need to make countless successive decisions in a short period of time, such as in a soccer match (Kunrath et al., 2020; Machado et al., 2022; Silva et al., 2021; Thompson et al., 2021).

In the study by Cardoso et al. (2020), the authors verified that young elite soccer players (16.7 ± 3.1 years old) with quicker perceptual and cognitive skills to make decisions, when compared to their slower counterparts: 1) possessed better game reading skills, through the use of more efficient visual search strategies; and 2) employed lower cognitive effort to make decisions. These advantages were related to a better capacity to process information, due to the capturing of more relevant environmental information and to the integration of such information to previous knowledge acquired over the several years of sports practice.

In addition, there is evidence that better perceptual and cognitive skills are also associated to better match performances by the players. In a recent study, Assis et al. (2020) verified that players who were tactically more efficient in matches possessed better game reading skills, due to the utilization of better visual search strategies and more assertive decision-making in offensive situations, when compared to

less efficient players. Considering the findings reported in both studies, it is possible to infer that perceptual and cognitive skills are positively associated to players' match performance, as well as to lower cognitive effort.

Based on these literature findings, experiment 2 sought to explore this hypothesis and provide a deeper understanding about these elements. In this experiment we compared the perceptual and cognitive decision-making skills of professional and academy players with respect to the quality and speed of decision-making. Due to a greater demand by the number of decisions made in a match by professional players, when compared to academy players, we hypothesized that professional players would display advantages in perceptual and cognitive decision-making. This hypothesis was confirmed, as professional players displayed such an advantage, particularly with relation to the speed of decision-making. Among the 12 variables assessed related to decision-making time, professional players were quicker in 11 of them, with medium and small effect sizes, whereas one of the variables did not differ significantly between both groups of players.

This advantage displayed by professional players compared to academy players regarding the speed of decision-making can be explained through the interaction of perceptual-cognitive, and perceptual-motor skills. Recent studies have reported positive associations between tactical performance in match situations and perceptual-cognitive skills related to: 1) anticipation (Assis et al., 2021); 2) peripheral perception (Gonçalves et al., 2020); 3) visual search strategies (Assis et al., 2021, 2020); and 4) attention (Andrade et al., 2020; Gonçalves et al., 2021). In addition, a meta-analysis on invasion sports (including soccer) reported that expert players were, on average, 37% quicker in their motor responses in comparison to less expert players (Mann et al., 2007); and that players with quicker perceptual-cognitive skills are also quicker in agility field tests (Altmann et al., 2021; Vääntinen et al., 2010). Therefore, these findings indicate that such advantages have a positive impact on both cognitive and physical performances. Hence, the development of perceptual and cognitive skills, such as visual search strategies, peripheral perception, attention, anticipation and decision-making is really effective for quicker decisions in the match.

Broadly speaking, considering the results from experiments 1 and 2 in this study, it is possible to infer that: 1) official professional matches demand greater cognitive speed when compared to academy matches, as they require around 56% more decisions over the same period of time (experiment 1); and 2) the advantages in decision-making by professional players compared to academy players are related to their ability to make quicker decisions in offensive and defensive situations, near and distant from the ball (experiment 2). Taken together, these results showed a significant difference between academy and professional players in relation to the speed of decision-making, taking into account the demands of competitive matches (*in situ*) and controlled conditions (*in vitro*).

Henceforth, through the identification of this gap between academy and professional players and considering the demands of the dynamics of the game and players' decision-making skills, the adoption of strategies aimed at developing the speed of decision-making of academy players is key for the ideal development of such players. Among some of the strategies that can be employed to minimize this difference are: 1) the design of training activities at the academy level that simulate a demand for the number of decisions similar to the one observed in professional matches; 2) utilization of training methods and teaching strategies that benefit the development of decision-making in academy players, particularly in relation to the speed of decision-making; and 3) constant assessment of the evolution of players' game reading and decision-making skills, in order to adjust training methods and activities according to players' needs.

With respect to the first strategy, one could design training activities that generate a demand of approximately 41 decisions per minute. It is the mean value observed for professional matches, by dividing the total number of decisions by an average time of 60 minutes of actual play. This may be used as reference by coaches, which would facilitate the adaptation of training activities towards the achievement of this "cognitive intensity" which resembles competitive professional matches. The advantage of this approach is the progressive application of games with this "external cognitive load", which may have their amount of time increased or decreased in a gradual fashion, over a season. For a more objective assessment of this "cognitive intensity" generated in training activities, notational analysis can be used to measure, for instance, the number of ball touches, similar to the procedure adopted in this study. This would require the creation of training analysis protocols, normally carried out by the clubs' performance analysts, as suggested by Teoldo, Guilherme and Garganta (2022). This kind of approach could resort to analyses carried out following training sessions, in order to facilitate the identification of activities that normally generate this cognitive demand. On the other hand, this process could also evolve towards the utilization or analysis protocols that allowed an online measuring of this external cognitive load. This could be accomplished in a similar way as the one used to control physical and physiological variables during training, through the utilization of electronic devices such as GPS or other devices that allow assessing the internal and external load.

As for the second proposition, i.e., the utilization of training methods that enhance the development of decision-making in soccer, scientific literature has provided indications that can help in this process, such as the utilization of small-sided and conditioned games based on players' individual characteristics (Barcellos et al., 2022; Cardoso et al., 2021; Davids et al., 2013; García-Calvo et al., 2021; Silva et al., 2021; Teoldo et al., 2022). The utilization of this kind of activity allows the coupling of the perceptual-cognitive and perceptual-motor processes that promote better transfer of the acquired skills to the context of the game, when compared to more traditional and analytic teaching

methods (Roca & Ford, 2020). A recent study suggested which training activities promoted the development of offensive and defensive decision-making by young male soccer players (Machado et al., 2020). In this study, the utilization of small-sided games aimed at group (2 vs. 2 up to 4 vs. 4), and collective tactics (5 vs. 5 onwards) were the main activities associated to the development of decision-making skills, compared with other training activities, such as individual, in pairs and analytical drills. Therefore, there are indications on which kind of activities designed during sports training are likely to contribute to the development of decision-making in soccer players.

The third strategy requires the implementation of objective and scientifically validated assessments related to players' game reading and decision-making skills (Machado et al., 2023a). Carrying out these assessments over players' development process and in professional teams will allow the identification of the aspects to be improved and the strengths regarding the way players read the game and make their decisions. This information may be useful in the interventions made in training, so as to increase the quality of the activities towards the athletes' individual needs for improvement, which, by their part, contribute to the collective progress of the team (Teoldo, Guilherme & Garganta, 2022). Additionally, it is important to resort to assessments that allow the direct transfer for training contents and activities, consequently enabling the identification of which situations need to be simulated to promote the improvement of the player (e.g., offensive situations with the ball, supporting movements near the player in possession, defensive movements of direct opposition to the player in possession) (Machado et al., 2023b). For this purpose, there are assessments that allow to examine the speed and quality of game reading and decision-making, such as TacticUP®, which was used in the present study. Lastly, we stress the need to implement periodic assessments as follow-ups for developing these game reading and decision-making skills, similar to what is already employed by the clubs when monitoring physical and physiological variables (e.g., speed, strength of lower limbs, cardiorespiratory fitness).

Conclusion

The findings of this study revealed that professional (UEFA Champions League and FIFA World Cup) and academy (National Championships) soccer matches pose different demands to the players regarding the number of decisions made during matches. Professional players make around 56% more decisions than academy players. Since matches at both levels have the same duration, it means that professional players need to make more decisions per minute, thus implicating in quicker game reading and decision-making. In addition, this study also showed that quicker decisions occur for all game situations: with the ball (offensive phase), without the ball (offensive and defensive phase), near and distant from the ball. Thus, this study

demonstrates that speed of decision-making is a performance differentiator between academy and professional players.

Funding

This study was supported by the Sports incentive law of the Government of Minas Gerais, by the Academy & Football Program of the Ministry of Citizenship, through the National Secretariat of Football and Defense of Fans' Rights; the SEESP-MG, FAPEMIG, CNPq, Funarbe, the Dean's Office for Graduate and Research Studies and the Centre of Life and Health Sciences from Universidade Federal de Viçosa, Brazil, and by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior- Brasil (CAPES) – Finance Code 001.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

- Altmann, S., Neumann, R., Härtel, S., Kurz, G., Stein, T., & Woll, A. (2021). Agility testing in amateur soccer: A pilot study of selected physical and perceptual-cognitive contributions. *PLoS ONE*, *16*(6 June), 1–9. <https://doi.org/10.1371/journal.pone.0253819>
- Andrade, M., González-Villora, S., Casanova, F., & Teoldo, I. (2020). The attention as a key element to improve tactical behavior efficiency of young soccer players. *Revista de Psicología Del Deporte*, *29*(2), 47–55.
- Assis, J., Costa, V., Casanova, F., Cardoso, F., & Teoldo, I. (2021). Visual search strategy and anticipation in tactical behavior of young soccer players. *Science and Medicine in Football*, *5*(2), 158–164. <https://doi.org/10.1080/24733938.2020.1823462>
- Assis, J., González-Villora, S., Clemente, F., Cardoso, F., & Teoldo, I. (2020). Do youth soccer players with different tactical behaviour also perform differently in decision-making and visual search strategies? *International Journal of Performance Analysis in Sport*, *20*(6), 1143–1156. <https://doi.org/10.1080/24748668.2020.1838784>
- Barcellos, A., Teoldo, I., & Machado, G. (2022). The influence of 25 training sessions on the decision-making skill of U-12 soccer players. *Psicologia: Teoria e Pesquisa*, *38*, e38211. <https://doi.org/https://doi.org/10.1590/0102.3772e38211.en>
- Belling, P. K., Suss, J., & Ward, P. (2015). Advancing theory and application of cognitive research in sport: Using representative tasks to explain and predict skilled anticipation, decision-making, and option-generation behavior. *Psychology of Sport and Exercise*, *16*(P1), 45–59. <https://doi.org/10.1016/j.psychsport.2014.08.001>
- Bruce, L., Farrow, D., Raynor, A., & Mann, D. (2012). But I can't pass that far! The influence of motor skill on decision making. *Psychology of Sport and Exercise*, *13*(2), 152–161.

- <https://doi.org/10.1016/j.psychsport.2011.10.005>
- Buekers, M., Borry, P., & Rowe, P. (2015). Talent in sports. Some reflections about the search for future champions. *Movement and Sports Sciences - Science et Motricite*, 12(88), 3–12. <https://doi.org/10.1051/sm/2014002>
- Canton, A., Torrents, C., Ric, A., & Hristovski, R. (2022). Desarrollo y evaluación de la creatividad motriz en el fútbol: estado de la cuestión. *Retos*, 13(1), 93–103.
- Cardoso, F., García-Calvo, T., Patrick, T., Afonso, J., & Teoldo, I. (2021). How Does Cognitive Effort Influence the Tactical Behavior of Soccer Players? *Perceptual and Motor Skills*, 128(2), 851–864. <https://doi.org/10.1177/0031512521991405>
- Cardoso, F., Neves, J., Roca, A., & Teoldo, I. (2020). The association between perceptual-cognitive processes and response time in decision-making in young soccer players. *Journal of Sports Sciences*, 39(8), 926–935. <https://doi.org/10.1080/02640414.2020.1851901>
- Casanova, F., Esteves, P. T., Padilha, M. B., Ribeiro, J., Williams, A. M., & Garganta, J. (2022). The Effects of Physiological Demands on Visual Search Behaviours During 2 vs. 1 + GK Game Situations in Football: An in-situ Approach. *Frontiers in Psychology*, 13: 885765. <https://doi.org/doi:10.3389/fpsyg.2022.885765>
- Cohen, J. (1988). *Statistical power analysis for the behavioral science*. Psychology Press.
- Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How small-sided and conditioned games enhance acquisition of movement and decision-making skills. *Exercise and Sport Sciences Reviews*, 41(3), 154–161. <https://doi.org/10.1097/JES.0b013e318292f3ec>
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191.
- Fortes, L. S., De Lima-Junior, D., Fiorese, L., Nascimento-Júnior, J. R. A., Mortatti, A. L., & Ferreira, M. E. C. (2020). The effect of smartphones and playing video games on decision-making in soccer players: A crossover and randomised study. *Journal of Sports Sciences*, 38(5), 552–558. <https://doi.org/10.1080/02640414.2020.1715181>
- Fritz, C., Morris, P., & Richler, J. (2012). Effect size estimates: Current use, calculations, and interpretation. *Journal of Experimental Psychology: General*, 141(1), 2–18. <https://doi.org/10.1037/a0024338>
- García-Calvo, T., Pulido, J. J., Ponce-Bordón, J. C., López-Gajardo, M. Á., Costa, I. T., & Díaz-García, J. (2021). Can rules in technical-tactical decisions influence on physical and mental load during soccer training? A pilot study. *International Journal of Environmental Research and Public Health*, 18(8). <https://doi.org/10.3390/ijerph18084313>
- Garganta, J. (1997). Modelação táctica do jogo de futebol - estudo da organização da fase ofensiva em equipas de alto rendimento [Universidade do Porto]. In *Faculdade de Ciências do Desporto e de Educação Física*.
- Gonçalves, E., Noce, F., Barbosa, M. A. M., Figueiredo, A. J., Hackfort, D., & Teoldo, I. (2020). Correlation of the peripheral perception with the maturation and the effect of the peripheral perception on the tactical behaviour of soccer players. *International Journal of Sport and Exercise Psychology*, 18(5), 687–699. <https://doi.org/10.1080/1612197X.2017.1329222>
- Gonçalves, E., Noce, F., Barbosa, M. A. M., Figueiredo, A. J., & Teoldo, I. (2021). Maturation, signal detection, and tactical behavior of young soccer players in the game context. *Science and Medicine in Football*, 5(2), 158–164. <https://doi.org/10.1080/24733938.2020.1851043>
- Gonzaga, A. S., Albuquerque, M. R., Malloy-Diniz, L. F., Greco, P. J., & Teoldo, I. (2014). Affective decision-making and tactical behavior of under-15 soccer players. *Plos One*, 9(6), e101231. <https://doi.org/10.1371/journal.pone.0101231>
- González-Villora, S., Serra-Olivares, J., Pastor-Vicedo, J., & Teoldo, I. (2015). Review of the tactical evaluation tools for youth players, assessing the tactics in team sports: football. *Springerplus*, 4(663), 1–17. <https://doi.org/https://doi.org/10.1186/s40064-015-1462-0>
- Hogarth, L. W., Burkett, B. J., & McKean, M. R. (2015). Neuromuscular and perceptual fatigue responses to consecutive tag football matches. *International Journal of Sports Physiology and Performance*, 10(5), 559–565. <https://doi.org/10.1123/ijspp.2014-0355>
- Kunrath, C. A., Nakamura, F. Y., Roca, A., Tessitore, A., & Teoldo, I. (2020). How does mental fatigue affect soccer performance during small-sided games? A cognitive, tactical and physical approach. *Journal of Sport Science*, 38(15), 1818–1828. <https://doi.org/10.1080/02640414.2020.1756681>
- Machado, G., Cardoso, F., & Teoldo, I. (2017). Visual search strategy of soccer players according to different age groups. *Motriz*, 23(3), e101748. <https://doi.org/10.1590/S1980-6574201700030022>
- Machado, G., González-Villora, S., Sarmiento, H., & Teoldo, I. (2020). Development of tactical decision-making skills in youth soccer players: Macro- and microstructure of soccer developmental activities as a discriminant of different skill levels. *International Journal of Performance Analysis in Sport*, 20(6), 1072–1091. <https://doi.org/10.1080/24748668.2020.1829368>
- Machado, G., González-Villora, S., & Teoldo, I. (2022). Contribution of deliberate practice, play, and futsal to the acquisition of decision-making skills in Brazilian professional female soccer players. *International Journal of Sport and Exercise Psychology*. <https://doi.org/10.1080/1612197X.2022.2161101>
- Machado, G., González-Villora, S., & Teoldo, I. (2023a). Selected soccer players are quicker and better decision-makers in elite Brazilian youth academies. *International Journal of Performance Analysis in Sport*, 23(2), 65–82. <https://doi.org/10.1080/24748668.2023.2181609>
- Machado, G., González-Villora, S., & Teoldo, I. (2023b). The relationship between deliberate practice, play, and futsal in childhood and adolescence and the development of different decision-making skills in professional female soccer players. *Psychology of Sport and Exercise*, 68. <https://doi.org/10.1016/j.psychsport.2023.102470>
- Machado, G., & Teoldo, I. (2020). TacticUP Video Test for

- soccer: Development and validation. *Frontiers in Psychology*, 11(1690), 1–12. <https://doi.org/10.3389/fpsyg.2020.01690>
- Macmahon, C., & Mcpherson, S. U. E. L. (2009). Knowledge base as a mechanism for perceptual- cognitive tasks: Skill is in the details! *International Journal of Sport Psychology*, 40(4), 565–579. Williams, A. M., Ford, P. R., & Drust, B. (2020). Talent identification and development in soccer since the millennium. *Journal of Sports Sciences*, 38(11–12), 1199–1210. <https://doi.org/10.1080/02640414.2020.1766647>
- Mann, D. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology*, 29(4), 457–478. <https://doi.org/10.1123/jsep.29.4.457>
- Moniz, F., Clemente, F. M., Praca, G. M., & Costa, I. T. (2021). Effect of outside floaters on soccer players tactical behaviour in small-sided conditioned games. *Retos*, 42, 767–773. <https://doi.org/10.47197/retos.v42i0.86346>
- Roca, A., & Ford, P. R. (2020). Decision-making practice during coaching sessions in elite youth football across European countries. *Science and Medicine in Football*, 4(4), 263–268. <https://doi.org/10.1080/24733938.2020.1755051>
- Roca, A., Ford, P. R., McRobert, A. P., & Williams, A. M. (2011). Identifying the processes underpinning anticipation and decision-making in a dynamic time-constrained task. *Cognitive Processing*, 12, 301–310. <https://doi.org/10.1007/s10339-011-0392-1>
- Roca, A., Ford, P. R., & Memmert, D. (2020). Perceptual-cognitive processes underlying creative expert performance in soccer. *Psychological Research*, 0123456789. <https://doi.org/10.1007/s00426-020-01320-5>
- Roca, A., Williams, A. M., & Ford, P. R. (2012). Developmental activities and the acquisition of superior anticipation and decision-making in soccer players. *Journal of Sports Sciences*, 30(15), 1643–1652. <https://doi.org/10.1080/02640414.2012.701761>
- Silva, A. F., Ramirez-Campillo, R., Sarmiento, H., Afonso, J., & Clemente, F. M. (2021). Effects of training programs on decision-making in youth team sports players: A systematic review and meta-analysis. *Frontiers in Psychology*, 12(May), 663867. <https://doi.org/10.3389/fpsyg.2021.663867>
- Serra-Olivares, J., Prieto-Ayuso, A., Pastor-Vicedo, J. C., & González-Villora, S. (2020). Propuesta de evaluación multidisciplinar del talento de jóvenes futbolistas. *Retos*, 38, 157–164. <https://doi.org/10.47197/retos.v38i38.73118>
- Silva, D., Lopes, M., González-Villora, S., Sarmiento, H., & Teoldo, I. (2021). Tactical behaviour differences of high and low-performing youth soccer players in small-sided and conditioned games. *International Journal of Performance Analysis in Sport*, 21(1), 33–50. <https://doi.org/https://doi.org/10.1080/24748668.2020.1843214>
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (6th ed.). Harper e Row.
- Teoldo, I., Guilherme, J., & Garganta, J. (2022). *Football Intelligence: Training and Tactics for Soccer Success*. Routledge.
- Thomas, K. T., & Thomas, J. R. (1994). Developing expertise in sport: The relation of knowledge and performance. *International Journal of Sport Psychology*, 25(3), 295–312. <https://www.researchgate.net/publication/232444616>
- Thompson, C. J., Smith, A., Coutts, A. J., Skorski, S., Datson, N., Smith, M. R., & Meyer, T. (2021). Understanding the Presence of Mental Fatigue in Elite Female Football. *Research Quarterly for Exercise and Sport*. <https://doi.org/10.1080/02701367.2021.1873224>
- Vaeyens, R., Lenoir, M., Williams, A. M., Mazyn, L., & Philippaerts, R. M. (2007). The effects of task constraints on visual search behavior and decision-making skill in youth soccer players. *Journal of Sport and Exercise Psychology*, 29, 147–169. <https://doi.org/10.1123/jsep.29.2.147>
- Vaeyens, R., Lenoir, M., Williams, A. M., & Philippaerts, R. M. (2007). Mechanisms underpinning successful decision-making in skilled youth soccer players: An analysis of visual search behaviors. *Journal of Motor Behavior*, 39(5), 395–408. <https://doi.org/10.3200/JMBR.39.5.395-408>
- Vänttinen, T., Blomqvist, M., & Häkkinen, K. (2010). Development of body composition, hormone profile, physical fitness, general perceptual motor skills, soccer skills and on-the-ball performance in soccerspecific laboratory test among adolescent soccer players. *Journal of Sports Science and Medicine*, 9(4), 547–556.
- Vickers, J. N. (2016). The Quiet Eye : Reply to sixteen commentaries. *Current Issues in Sport Science*, 1(1), 1–18. <https://doi.org/DOI.10.15203/CISS>
- Vickers, J. N., & Williams, A. M. (2017). The role of mental processes in elite sports performance. *Oxford Research Encyclopedia of Psychology*, 1, 1–25. <https://doi.org/10.1093/acrefore/9780190236557.013.161>
- Ward, P., & Williams, A. M. (2003). Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. *Journal of Sport and Exercise Psychology*, 25(1), 93–111. <https://doi.org/10.1123/jsep.25.1.93>
- Williams, A. M., & Ward, P. (2007). Anticipation and Decision-making in Sport. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of Sport Psychology* (3rd ed., pp. 203–223). John Wiley & Sons.
- Williams, A. Mark, Ford, P. R., & Drust, B. (2020). Talent identification and development in soccer since the millennium. *Journal of Sports Sciences*, 38(11–12), 1199–1210. <https://doi.org/10.1080/02640414.2020.1766647>
- Williams, A. M., & Ward, P. (2021). Anticipation and decision-making in sport exploring new horizons. *Visual Perception and Action in Sport*, 113–160. <https://doi.org/10.4324/9780203979952-10>