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Enhancing Soccer-Specific Motor Skills Through Visual Training: A Quasi-Experimental Study in Young Soccer Players

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ABSTRACT

In team sports like soccer, the ability to make quick decisions is essential for successful performance. Players must perceive and understand the available affordances in their environment to effectively utilize the information and make accurate decisions on the field. Visual exploratory actions play a crucial role in acquiring the necessary information, allowing players to anticipate action possibilities and plan their subsequent actions. This study aimed to evaluate the effectiveness of an innovative training protocol based on visual exercises in improving soccer-specific motor skills of U12 soccer players. Thirty young male soccer players participated in the study and were randomly assigned to one of three groups: Technique Group (T-G), Visual-Technique Group (VT-G), and Control Group (C-G). The T-G received technical training, the VT-G received the same training with the addition of visual stimuli, and the C-G received regular in-season training. Pre- and post-test measurements were conducted on soccer-specific motor skills. The results showed that the VT-G demonstrated significant improvements in motor skills compared to the T-G and C-G. These findings suggest that incorporating targeted visual training into soccer training programs can enhance perceptual-cognitive and visual skills, leading to improved agility and overall on-field performance.
Keywords: soccer, agility, visual training, youth sports, motor skills.

INTRODUCTION

In time-constrained, uncertain, complex and dynamic environments, such as in team sports, the speed of decision-making is crucial for successful performance. Players are expected to promptly make the most appropriate decisions in order to execute a successful action (Baker et al., 2003). In order to act, team sport players perceive environmental information about the availability of space, the teammates, the opponents and other contextual cues. Gibson (2014) introduced the term 'affordances' aiming to describe action opportunities which are implied by the relationship between player's abilities and the relevant information of the specific environment. Thus, the ability of players to make quick decisions is reliant on their ability to identify the multiple affordances acquired through their early knowledge. Players discover the available affordances mainly through visual exploratory actions. Visual exploratory actions play a crucial role in acquiring and processing the necessary information. Players engage in head movements and temporarily direct their faces away from the ball to gather visual information from the surrounding environment. This visual exploration allows them to gather relevant information about the positions and movements of teammates, opponents, and the spatial layout of the playing field (Jordet et al., 2020). By engaging in these exploratory actions, players can anticipate potential action possibilities and plan their subsequent actions accordingly. This helps them prepare for upcoming situations and make quicker decisions when engaging with the ball (Eldridge et al., 2013; Jordet et al., 2013; McGuckian et al., 2019; McGuckian et al., 2018a; Smirniotou et al., 2023). By temporarily shifting their attention away from the ball, players can acquire a broader awareness of the overall game situation, which enhances their ability to identify and utilize available affordances. Furthermore, visual search behaviors adopted during decision-making vary according to the experience, level and the specific constraints of the task (Vaeyens et al., 2007). It has been found that high-skilled players indicate superiority in visual and perceptual functions (Mann et al., 2007; Scharfen & Memmert, 2019; Vaeyens et al., 2007; Voss et al., 2010). Furthermore, high-skilled players are able to move their eyes more quickly, efficiently and effectively (Memmert et al., 2009; Wilson & Falkel, 2004). Overall, the concept of affordances and the use of visual exploratory actions highlight the important role perception plays in the decision-making process of team sport players. By perceiving and understanding the available affordances, players can effectively utilize the information from their environment to make quick and accurate decisions on the field.

Soccer is a team sport in which players perform physical movements, such as tackling, jumping, sprinting, and direction changing, while also integrating technical skills (Paul et al., 2016). The dynamic and interactive nature of the sport necessitates a wide range of skills that involve both perceptual and motor components, all of which must be executed within a limited time frame (Slimani et al., 2016; Williams et al., 2020). Perceptual-cognitive functions play a crucial role in soccer performance, and these functions are closely tied to visual search and decision-making behaviors (Slimani et al., 2016; Young et al., 2015). Before gaining possession of the ball, players rely on visual exploratory behaviors to gather information about their surroundings, allowing them to make faster decisions and execute appropriate motor actions (McGuckian et al., 2019). However, the time period for visual exploration is typically limited to one to three seconds, which places constraints on a player's ability to process information and choose the most effective course of action. Research has shown that skilled soccer players are adept at efficiently using their limited visual exploration time to extract important information from the environment (Jordet et al., 2013; McGuckian et al., 2019).

The acknowledged importance of perceptual-cognitive skills for soccer performance is also found in the concept of agility, which is broadly defined as a rapid whole body movement with change of direction or velocity in response to a sport/task specific and context sensitive stimulus (Paul et al., 2016; Sheppard & Young, 2006; Young & Farrow, 2013). Agility in soccer encompasses both physical and perceptual elements, with physical components involving change of direction and sprinting, while perceptual elements include reactive agility in response to unpredictable stimuli. These aspects of agility are closely integrated with ball control and synchronized movements (Huijgen et al., 2010; Lloyd et al., 2015; Paul et al., 2016; Serpell et al., 2011; Trecroci et al., 2016). Agility is often considered a crucial factor in talent identification programs, as it can differentiate between players at different competitive levels (Gil et al., 2014; Reilly et al., 2000; Unnithan et al., 2012). To enhance agility, it may be important to expose young players to exercises that combine both physical and perceptual components. By integrating perceptual-cognitive skills into training programs, such as visual ability and decision-making, players can refine and develop their perceptual strategies and improve their performance. Previous studies have indicated that visual intervention programs and in-situ visual exercises can lead to improved technical performance in soccer (Afshar et al., 2019; Bekris et al., 2018a; SHabaan, 2015). By targeting visual skills and incorporating them into training, players can enhance their perceptual-cognitive abilities and optimize their decision-making processes (Afshar et al., 2019; Sowden et al., 2000; Ste-Marie et al., 2012; Williams & Ericsson, 2005). The development of perceptual-cognitive skills, including visual ability and decision-making, can be a valuable aspect of training for young soccer players. By focusing on these skills alongside physical training, players can improve their agility and overall performance in the game.

Despite the fundamental role of perceptual and motor skills on performance, traditional focus of training plans in sport often prioritize technical and physical aspects of performance while neglecting the significance of perceptual and visual training (Murgia et al., 2014; Wilson & Falkel, 2004). This may be due to limited knowledge about the importance of visual skills or constraints related to limited training time (Abernethy & Wood, 2001). Furthermore, visual training programs are often conducted in laboratory settings, which can be expensive and primarily focused on clinical conditions rather than sports performance (Ghasemi et al., 2009; Wilson & Falkel, 2004). However, it is worth noting that elite soccer clubs are increasingly recognizing the value of players with exceptional perceptual-cognitive and visual skills. As a result, there has been a growing interest in improving technical skills that encompass these abilities (Burris et al., 2018; Formenti et al., 2019; Scharfen & Memmert, 2019; Walton et al., 2018). Therefore the aim of the current study was to evaluate the effectiveness of an innovative training protocol based on visual exercises on soccer-specific motor skills of U12 soccer players. This research seeks to address the gap in training programs by incorporating targeted visual training to enhance the perceptual-cognitive and visual skills of soccer players, ultimately improving their overall motor performance on the field.

METHODS

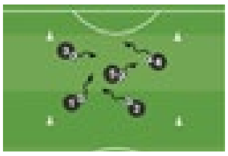
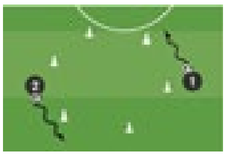
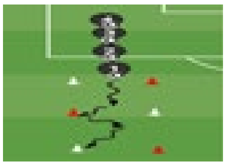
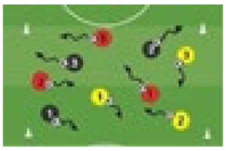
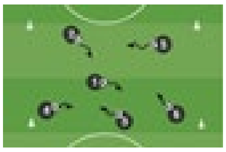
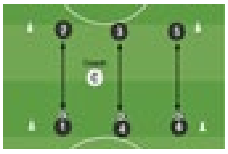
Participants. A total of thirty young male soccer players, playing in youth Greek league, voluntarily participated in this study (Mage = 11.55, SD= 0.49; Mexp = 3.39, SD = 0.86). The players were members of the same team, which trained three times a week for one hour and fifteen minutes per session. All the players and their parents/legal guardians were informed of the research risks, benefits, requirements and procedures before providing a written informed consent. The study was carried out according to the Declaration of Helsinki and approved by the ethics committee of the local University.

Measures and procedures. A quasi experimental dependent pre- and post- test design was applied in order to measure the impact of an intervention training program on physical and perceptual-cognitive functions of players. The participants were randomly classified in three groups (two experimental and one control group) by their coaches. Three groups were assessed during in-season phase, before and after an eight-week period of training. The Technique Group (T-G; n = 10, Mage = 11.50, SD = 0.5) performed 24 sessions of 30-min specific technical training; the Visual-Technique Group (VT-G; n = 10, Mage = 11.50, SD = 0.50) performed 24 sessions of 30-min specific training session with the use of visual stimuli; the Control Group (C-G; n =10, Mage = 11.60, SD = 0.50) performed the regular in-season training (Table 1). All the groups completed the pre- and post- measurements on the same day, in the following order: anthropometric characteristics (body height, body weight, body mass index, sitting height, calf length, peak height velocity, body fat), balance of dominant and non-dominant leg, vision reaction time of dominant and non-dominant leg, and dribbling agility. Prior to testing, the players performed a 15-min standardized warm-up protocol including moderate pace jogging, passing and dynamic stretching.

An intervention training program for each 75 minutes of training was administered as follows for the three groups (T-G, VT-G, and C-G): (a) 10-min of with-ball warming up and 5-min of dynamic stretching; (b) 15-min of regular technical drills and small-sided games; (c) 30-min of specific technical drills (T-G); 30-min of the same with group 1 training drills with the use of visual stimuli (VT-G); 30-min of 5vs5 SSG (C-G); (d) 10-min of playing game; (e) 5-min of jogging and stretching recovery.

The following table shows an example of daily intervention program with visual stimuli (VG). Players of the Technique Group executed exactly the same drills without any visual stimuli in the rules but only with oral stimuli when necessary.

Table 1. **Example of 30-min training exercises of VT-G.**

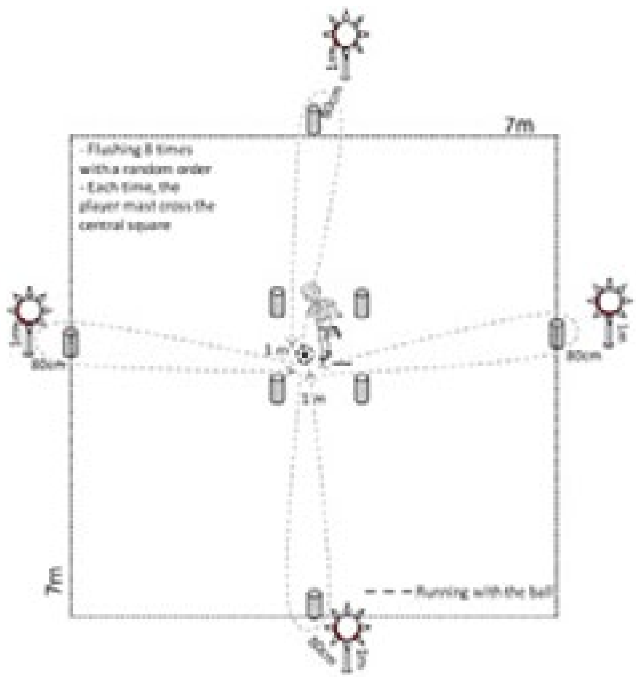
Drills	Figure	Duration	Description
1		5-min	All the players dribble their ball within designated field and change their dribbling leg every time player number 4 does. The coach frequently changes the 'leader' player.
2		5-min	Player number 1 dribbles the ball around the circle and tries to catch player number 2. When coach shows green color they run around the circle on the left side and when he shows yellow they change their direction on the right side. The coach change roles of the players every minute.
3		5-min	Players dribble through the designated zone and pass from each cone the coach shows (red or yellow) before the finishing line.
4		5-min	Three teams of players who dribble their balls inside the designated field. When the coach shows a color (red, yellow, blue) the team of this color is to 'attack' and touch their opponents while dribbling. The coach frequently changes the color of 'attackers'.
5		5-min	All the players dribble their ball inside the designated field. They have to mimic the movements and technical patterns of player number 1. The coach frequently changes the target player.
6		5-min	Players in pairs are passing to each other. Coach frequently shows four different colors and players have to change the technical patterns as follows: Green- Change positions without ball, Yellow- Change positions with ball, Blue- Change positions with ball and pass it in the middle of their route, Red- 1vs1.

Anthropometric and motor skill measurements. All the anthropometric assessments were obtained using standardized laboratory procedures. Anthropometric characteristics were measured with the Tanita calibrated weighting scale (BC1000 model) to the nearest 0.1kg (body weight and body fat), and body height was measured to the nearest 0.1cm using a fixed stadiometer. In addition body mass index (BMI) was calculated as body mass (kg) divided by height (m2). Sitting height was measured to the closest 0.1cm by adapting a removable 60cm box to the stadiometer. The players were sitting with a straight back, with the trunk erect, the head in the sagittal plane, and upper surface of the thighs horizontal and feet on the footrest. Finally, calf length was measured with an anthropometry tape from the lateral malleolus of the fibula and the lateral condyle of the tibia while the player was sitting on a seat with the left ankle crossed over. Peak Height Velocity (PHV): For the measurement of maturity offset the following predictive equation was used: $- 9.236 + 0.0002708 * (\text{leg length} * \text{sitting height}) - 0.001663 * (\text{age} * \text{leg length}) + 0.007216 * (\text{age} * \text{sitting height}) + 0.02292 * (\text{weight} / \text{height})$ (Mirwald et al., 2002).

Players' dynamic balance was measured through Shark, which is considered a reliable and valid method (Gatz, 2009). The researchers drew a box consisting of 9 small squares, 30cm each, in which the players had to stand on the central square on one leg and hop in a row inside the other squares while returning back to the central square before each hop. Two researchers manually activated two stopwatches immediately after their starting signal and stopped when the participants finished the last jump. A penalty time of 0.10sec was added each time the participants touched the lines of the squares, failed to return to the starting square, or touched the ground with the non-hopping leg. The players executed one familiarization and two main trials with 1 min recovery between them while the mean time of the best trial of two researchers was used for further analysis.

The motor reaction time to a visual stimulus was measured by the mean flight time, recorded with the optical device OptoJump System (Microgate, Bolzano, Italy). OptoJump System is a measurement system consisting of two bars, the transmitter and the receiver, that contain photocells (2mm from the ground) which are constantly communicating. The device detects and calculates the duration of any interruption in communication between bars. The participants were required to be in standing position and had to raise their leg and bring it to the ground as fast as possible following an optical signal in a computer (a red spot which turned to green). Then the flight time was detected and recorded to the system. The players executed three familiarization and three main trials with each leg, the mean of which was recorded for each leg. The dribbling agility test (DAT) which assesses dribbling skill under unpredictable visual stimuli was used to evaluate the agility skill of players (Figure 1). In particular, four lights and four photocells were placed 7m apart from each other in a square shaped area, thus "constructing" four gates 80cm wide. Another small square, 1m long-each side, was shaped with four cones in the centre of the big square. The test starts with the player in the small central square and when a visual signal appears he starts to run with the ball and pass the gate whose light is on between the cone and the photocells. Immediately when passing the gate, the light turns off and another light turns on (never the same one). The player then has to step on the central square, and after this, to run as fast as possible in order to pass the new gate whose light is on. The lights are switched on 8 times, and in the last pass, the time is stopped and recorded automatically by the system. The players executed one familiarization and two main trials with a 20-min break between them (Bekris et al., 2018b).

Figure 1. **Dribbling Agility Test (DAT) {derived from Bekris and collegues (2018b)}.**



Analysis. Data of the current study were analyzed using IBM SPSS Statistic package 23.0 (IBM Inc., Chicago, IL, USA). All results are expressed as means (M) ± standard deviations (SD) and statistical significance was set at $p < .05$. The assumption of normality and homogeneity were verified using the Kolmogorov-Smirnov and Levene's test respectively ($p > .05$). Then an analysis of covariance (ANCOVA) was executed to detect differences between groups (one control group and two experimental groups) by controlling for covariates (maturation level) in the format of p values and partial etas squared (η2p) from the output (Porter & Raudenbush, 1987). The magnitude of differences between groups was tested using the standardized Cohen's d effect sizes along with the 95% confidence intervals (95% CI) of the change score which were interpreted with the following criteria (Cumming, 2014): d = 0.0 - 0.19 (trivial), d = 0.20 - 0.49 (small), d = 0.50 - 0.79 (moderate), d = 0.80 - 1.0 (large). To further assess the differences between groups, post hoc multiple comparisons were applied using the Bonferroni test.

RESULTS

The means (M) ± standard deviations (SD) pre and post intervention training program of the measurements are presented in Table 2. A One-way ANCOVA was conducted to determine a statistically significant dribbling ability difference between visual, technique and control groups after an intervention program controlling for index maturation. The training program had a significant effect on dribbling ability after controlling for index maturation $F(2, 26) = 18.72$, $p < .001$. It can be seen that the effect size of the difference is moderate (η2p = 0.59). Similarly a One-way ANCOVA was conducted to determine a statistically significant balance difference between visual, technique and control groups after an intervention program controlling for index maturation. The training program had a significant effect on balance after controlling for index maturation for both non-dominant $F(2, 26)= 3.90$, $p < .05$ and dominant leg $F(2, 26) = 8.27$, $p < .001$. It can be seen that the effect size of the difference is small for both non-dominant (η2p = 0.23) and dominant legs (η2p = 0.39). In particular, pairwise post-hoc comparisons showed that the visual group improved more than the control group (p = .01) and the technique groups (p = .05) in balance on the non-dominant leg. Regarding the balance on the dominant leg, the visual group improved more than the control group (p = .00) and the technique group improved more than the control group (p = .01).

Table 2. **Pre-test measurements of anthropometric and soccer-specific motor skills.**

Variables	Pre			
	Group			
	C-G	T-G	VT-G	%95 CI
Height	150.3±5.5	149.0±4.3	148.0±6.2	144.2 -153.8
Weight	44.0±7.3	41.3±6.1	39.1±3.6	nm36.9-48.8
Sitting height	74.5±3.0	73.4±2.6	72.6±2.9	70.8-76.5
Calf length	39.1±1.5	39.0±1.7	38.6±2.0	37.4-40.1
PHV	-3.0±0.5	-3.1±0.4	-3.2±0.4	-3.5 - -2.7
Body Fat	16.7±5.6	16.9±4.0	15.7±2.5	13.0-20.3
BMI	20.6±3.0	18.6±2.0	17.9±1.2	17.1-22.5
Balance n-D	8.9±0.8	9.5±1.7	8.1±2.2	6.7-10.5
Balance D	9.0±1.4	9.2±2.7	7.8±2.1	6.6-10.7
Reaction-T n-D	0.4±0.0	0.5±0.0	0.4±0.0	0.4-0.5
Reaction-T D	0.5±0.0	0.5±0.0	0.5±0.0	0.4-0.5
Dribbling agility	30.4±1.0	31.7±2.2	31.1±2.1	29.7-33.0

Table 3. **Post-test measurements of anthropometric and soccer-specific motor skills.**

Variables	Post			
	Group			
	C-G	T-G	VT-G	%95 CI
Height	151.1±5.5	150.0±4.5	149.4±6.4	145.4 - 154.7
Weight	44.2±7.0	41.7±6.2	40.0±3.6	37.8 - 48.8
Sitting height	74.9±2.9	73.8±2.6	73.2±3.0	71.3 - 76.8
Calf length	39.5±1.5	39.5±1.7	39.3±2.0	38.0 - 40.6
PHV	-2.9±0.5	-3.1±0.4	-3.1±0.5	-3.4 - -2.6
Body Fat	16.8±5.7	16.5±3.9	16.2±3.1	13.1 - 20.5
BMI	20.5±2.9	18.6±2.0	18.0±1.3	17.2 - 22.5
Balance n-D	8.9±0.9	9.0±2.5	6.8±1.1	6.1 - 10.4
Balance D	9.0±1.6	8.0±2.1	6.6±0.9	6.0 - 10.0
Reaction-T n-D	0.5±0.0	0.5±0.0	0.5±0.1	0.4 - 0.5
Reaction-T D	0.5±0.0	0.5±0.0	0.5±0.0	0.4 - 0.5
Dribbling agility	30.4±1.3	30.3±1.9	28.3±1.7	27.3 - 31.4

Variables	Pairwise comparisons
Height	
Weight	
Sitting height	
Calf length	
PHV	
Body Fat	
BMI	
Balance n-D	VT>C**VT>T*
Balance D	VT>C***T>C**
Reaction-T n-D	
Reaction-T D	
Dribbling agility	VT>T***VT>C***T>C*

Notes: sig. p < .05*, p <.01**, p <.001***

Abbreviations: Balance non-Dominant leg (Balance n-D), Balance Dominant leg (Balance D), Reaction Time non-Dominant leg (Reaction-T n-D), Reaction Time Dominant leg (Reaction-T D), Body Mass Index (BMI), Peak Height Velocity (PHV), Control Group (C-G), Technique Group (T-G), Visual Technique Group (VT-G).

DISCUSSION

The findings of the study suggest that a visual-technique training program had a significant positive impact on dribbling agility, particularly when compared to technique training and regular training of a control group regardless of the maturity status. The visual-technique training group showed improvements in performance, which could be attributed to the specific nature of the training involving visual stimuli over a period of time. It seems that when visual exercises are designed to match the requirements of the task at hand, they have a heightened effect on performance.

The improvements observed in the visual-technique training group can be explained by an increase in visual exploratory actions, such as higher head movement frequency and faster, more efficient eye movements (Eldridge et al., 2013; Jordet et al., 2013; McGuckian et al., 2019; McGuckian et al., 2018a; McGuckian et al., 2018b; Memmert et al., 2009). Previous research has also shown that visual exercises can enhance various visual skills, including static and dynamic visual acuity, three-dimensional vision, mental imagery, eye movement speed, environmental perception, and visualization (Erickson, 2020; Sherman, 1980).

On the other hand, the technique training group showed significantly better dribbling agility compared to the control group. Agility is a multifaceted ability that encompasses both physical and perceptual-cognitive components, including strength, technique, visual scanning, and anticipation. The improvement in dribbling agility for the technique training group may be attributed to the development of other trainable factors related to agility, such as physical and technical aspects (Gioldasis et al., 2021; Hammami et al., 2018; Mathisen et al., 2015; Young et al., 2015).

The difference between the visual-technique and technique training groups can be explained by the notion that skill development is enhanced when cognitive functions are emphasized during learning. Permanent improvements in skill performance are often achieved when perceptual-cognitive and physical training are integrated in sport-specific tasks (Jeffreys et al., 2018; Jeffreys, 2011; Vickers, 2007).

The study also revealed a connection between training content and balance. In particular, the results demonstrated that the visual-technique group showed greater improvement in non-dominant one-leg stance compared to the technique and control groups. Additionally, both the visual-technique and the technique groups showed greater improvement in dominant one-leg stance compared to the control group, although they did not significantly differ from each other.

Balance involves the coordination of various sensory systems, such as visual input, proprioception (awareness of body position), and the vestibular system (inner ear balance). Good balance enables an individual to maintain equilibrium and stability, both in static (stationary) and dynamic (moving) situations. The connection between balance and visual skills has already been established, as players have to constantly and quickly maneuver while paying attention to elements of the surrounding environment, such as opponents. Similarly, previous studies have also indicated a significant relationship between balance and agility (Sekulic et al., 2013; Yusuf et al., 2022).

The differences between the visual-technique training group and technique and control groups in non-dominant leg suggest that the demanding nature of the exercises contributed to the improvements observed. Exercises that combine perceptual-cognitive and physical skills tend to be more demanding and therefore more effective in enhancing performance compared to one-dimensional exercises (Jeffreys et al., 2018; Jeffreys, 2011; Vickers, 2007). On the other hand, the difference between the technique and control groups for dominant one-leg stance can be explained by the fact that players in the regular training group preferred to use their dominant leg for technical skills. In contrast, during specific technique exercises, players were instructed to use both legs in order to execute the drills.

Overall, the study highlights the importance of incorporating visual training, cognitive functions, and physical aspects in team sport training programs. By integrating these elements, players can improve their decision-making abilities, agility, balance, and overall on-field performance.

CONCLUSION

In conclusion, the study demonstrated that a visual-technique training program had a significant positive impact on the dribbling agility of U12 soccer players when compared to technique training and regular training regardless of their maturity status. The visual-technique training group showed improvements in performance, which could be attributed to the specific nature of the training involving visual stimuli. Skill development is enhanced when cognitive functions are emphasized during learning. Furthermore, integrating perceptual-cognitive and physical training in sport-specific tasks can lead to improvements in skill performance.

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