

# The Effect of a Program of Fundamental Football Skill Training on the Cognitive Performance of Novice Iraqi Football Players with the Moderating Role of Age

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## ABSTRACT

The purpose of the present study was to examine the effect of a program of fundamental football skill training on the cognitive performance of boys aged 9 to 12 years. The research design was quasi-experimental using a pretest–posttest format with a control group. The statistical population consisted of male elementary school students and football academy trainees in the city of Maysan, Iraq. From this population, 60 participants were purposively selected and assigned to four groups: three experimental groups aged 9–10, 10–11, and 11–12 years (15 participants in each group) who participated in the training protocol, and one control group (15 participants) that received no intervention. The mean age of the control group was 10.6 years, which was positioned in the mid-range of the experimental age groups. The training protocol lasted eight weeks with three sessions per week and focused on fundamental football skills including dribbling, passing, shooting, coordination, and small-sided games. The research instruments included Raven's Progressive Matrices test for the assessment of cognitive performance. Data were analyzed using analysis of covariance (ANCOVA) and the Bonferroni post-hoc test. The results indicated that fundamental football skill training had a statistically significant effect on cognitive performance ( $F = 12.84$ ,  $p < .001$ ,  $\eta^2 = .27$ ). In addition, interaction effects demonstrated the moderating role of age, such that children aged 11–12 years exhibited the greatest improvement compared with the younger groups, whereas the control group showed only minimal changes from pretest to posttest. Overall, the findings indicate that fundamental football skill training enhances cognitive performance. These results highlight the importance of designing and implementing structured physical activity programs in schools and extracurricular activities and may serve as an effective model for the holistic development of children during the sensitive developmental period of 9 to 12 years of age.

**Keywords:** fundamental football skills, cognitive performance, children, quasi-experimental study

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## Introduction

Participation in organized sport during childhood is widely recognized as a critical contributor to physical, cognitive, psychological, and social development. Among team sports, football occupies a particularly prominent position due to its global popularity and its complex combination of perceptual, cognitive, and motor demands. Modern theoretical and empirical perspectives increasingly emphasize that football training is not merely a physical activity but a multidimensional developmental stimulus that simultaneously engages executive functions, perceptual–cognitive processing, decision-making, emotional regulation, and social competence (1-3). This multidimensionality renders football an especially powerful context for fostering holistic development during the sensitive developmental window of late childhood and early adolescence.

Cognitive development during ages 9–12 represents a period of rapid neural plasticity characterized by accelerated maturation of executive functions, attentional control, working memory, and processing speed. Neurodevelopmental models suggest that experiences involving complex motor coordination, real-time decision-making, and perceptual anticipation significantly influence cortical–subcortical network development, particularly within the prefrontal and cerebellar systems (4-6). Football training inherently provides such experiences through constant environmental scanning, rapid stimulus–response processing, tactical problem solving, and coordinated motor execution, thereby making it an ideal platform for cognitive enrichment during childhood.

Recent neuroscientific evidence has begun to clarify the mechanisms through which football training enhances cognitive performance. Functional neuroimaging and neurophysiological studies indicate that football players demonstrate stronger cerebellar–cortical connectivity and superior attentional modulation compared to non-athletes, reflecting enhanced neural efficiency in networks responsible for cognitive control and sensorimotor integration (6, 7). Complementary behavioral research further confirms that youth football participation is associated with improved executive functions, attentional flexibility, and inhibitory control relative to sedentary peers (8-10). These findings underscore the neurological plausibility of football-based interventions as tools for cognitive development.

Meta-analytic syntheses provide robust support for these individual findings. Mao et al. demonstrated that football training produces moderate to large effects on cognitive performance across childhood and adolescence, with particularly strong improvements in attention, working memory, and problem-solving ability (11). Similar conclusions have been reached in large-scale reviews examining school-based and community-based football interventions, which consistently report meaningful cognitive gains when training is systematically structured and developmentally appropriate (12-14). These converging lines of evidence confirm that football training constitutes a potent cognitive enrichment environment.

However, cognitive benefits are not uniformly distributed across all age groups. Developmental sport science highlights that age serves as a powerful moderator of training effects due to differences in neural maturation, motor learning capacity, hormonal profiles, and relative biological age (15, 16). Research on relative age effects further demonstrates that older children within the same chronological cohort often display superior cognitive and motor performance, not solely due to training exposure but also due to maturational advantages (8, 9). This developmental variability necessitates careful investigation of age-specific responses to football interventions.

Physical maturation is closely intertwined with cognitive development. Improvements in aerobic fitness, coordination, agility, and muscular strength have been shown to positively correlate with executive function development and academic performance in children (12, 17, 18). Football training simultaneously enhances these physical attributes while challenging perceptual–cognitive systems through complex game environments. Studies in youth populations demonstrate that physical fitness and cognitive ability interact synergistically to predict football skill acquisition and on-field performance (19-21). This bidirectional relationship suggests that cognitive improvements resulting from football training may be mediated by concurrent gains in physical competence.

Fundamental football skills constitute the foundation upon which more complex tactical and cognitive competencies are built. Training programs emphasizing ball control, passing, dribbling, shooting, and coordinated movement patterns promote not only motor proficiency but also perceptual anticipation, decision speed, and error correction mechanisms (22-24). When such skills are embedded within game-based learning environments, children are repeatedly required to process dynamic information, inhibit inappropriate responses, and select optimal actions under time pressure—core components of executive functioning (1, 3). Consequently, foundational technical training may exert substantial cognitive benefits beyond purely athletic outcomes.

The growing integration of cognitive training within football development frameworks further reinforces this perspective. Omar et al. demonstrated that structured cognitive training integrated into football practice significantly enhanced field intelligence and composite skill execution among advanced players (25). Similarly, Movahed's causal modeling revealed strong bidirectional relationships between football performance and multiple cognitive domains, highlighting cognition as both an antecedent and consequence of training adaptation (26). These models challenge traditional training paradigms that isolate physical conditioning from cognitive development and instead advocate for integrated training designs.

Technological advancements and pedagogical innovations are accelerating this integration. Transdisciplinary training models employing artificial intelligence, biofeedback, and adaptive learning systems increasingly enable individualized cognitive–physical optimization within youth sport programs (27, 28). Campus football initiatives and school-based interventions likewise demonstrate that structured football activities produce broad psychological and cognitive benefits, including enhanced self-regulation, motivation, and emotional stability (12, 28). These findings support the expansion of football-based programs beyond athletic development into formal educational and public health domains.

Despite this progress, several critical gaps remain. Much of the existing literature focuses on adolescents or elite youth players, while fewer studies systematically examine younger novice populations during early stages of skill acquisition (2, 29). Furthermore, although age is frequently acknowledged as an important variable, relatively few experimental studies explicitly model its moderating role in shaping cognitive outcomes of football training. Cross-sectional designs dominate much of the field, limiting causal inference regarding training effects across developmental stages (8, 20).

Another limitation concerns contextual diversity. The majority of available evidence originates from European and East Asian populations, with considerably less research conducted in Middle Eastern contexts. Cultural, educational, and environmental differences may influence training responsiveness, motivational

dynamics, and developmental trajectories, necessitating localized empirical investigation (29, 30). Addressing this gap is essential for constructing culturally responsive youth development programs.

Within this broader context, examining novice football players in Iraq offers valuable insights. The developmental conditions of Iraqi youth, shaped by unique socio-educational environments, underscore the importance of evidence-based sport interventions that promote cognitive and psychosocial well-being alongside physical health. Implementing structured football programs during the sensitive 9–12 age period aligns with established motor development theory and may provide a scalable model for educational systems seeking to enhance child development holistically (4, 5, 31).

Moreover, empirical attention to age-stratified training effects allows practitioners to refine pedagogical strategies. Research demonstrates that neuromuscular capacities, sprint performance, and force production increase non-linearly across late childhood and early adolescence, suggesting that identical training stimuli may produce differential cognitive and physical outcomes depending on developmental stage (15, 16, 32). Understanding these dynamics is essential for optimizing training design and maximizing developmental benefits.

Collectively, the literature strongly indicates that football training represents a powerful multidimensional developmental stimulus. Yet, the precise interaction between age, foundational skill training, and cognitive performance remains insufficiently understood, particularly in novice youth populations and underrepresented cultural contexts. Addressing this gap is both scientifically and practically imperative.

Therefore, the aim of the present study was to examine the effect of an eight-week fundamental football skills training program on the cognitive performance of novice Iraqi football players aged 9–12 years, with particular emphasis on the moderating role of age.

## **Methods and Materials**

### *Study Design and Participants*

The present study employed a quasi-experimental design using a pretest–posttest format with a control group. This methodological approach allows for a robust examination of the causal effect of the training intervention on cognitive performance by comparing changes in experimental groups with those observed in a non-intervention control group. Given that the primary objective of the study was to evaluate cognitive changes resulting from a structured physical training program in children, the quasi-experimental design was considered the most appropriate and ethically feasible approach. The research design consisted of three experimental groups and one control group. The experimental groups were composed of boys within three distinct age ranges of 9–10, 10–11, and 11–12 years, all of whom participated in an eight-week program of fundamental football skill training. The control group included participants of similar age and physical characteristics who did not receive any form of structured training during the study period. All groups underwent baseline assessment of cognitive performance prior to the intervention, followed by post-intervention assessment using identical procedures, allowing for the comparison of cognitive changes both within and between groups.

The statistical population comprised all male novice football players aged 9 to 12 years who were enrolled in elementary schools and youth football clubs in the city of Maysan, Iraq. This age range was selected

because it represents a sensitive developmental period during which cognitive, perceptual, and motor abilities undergo rapid maturation, and the effects of educational and physical interventions are especially pronounced. From this population, 60 participants were selected as the research sample. This sample size was determined in accordance with methodological standards for quasi-experimental research and provided sufficient statistical power to detect meaningful group differences. Participants were distributed into four equal groups, including three experimental groups corresponding to the defined age ranges, each consisting of 15 participants, and one control group of 15 participants matched in age and general physical condition.

Sampling was conducted using an accessible sampling approach through direct visits to selected football clubs and elementary schools. Following initial screening procedures, parental consent was obtained for all participants prior to enrollment in the study. To minimize selection bias, participants were assigned to groups based on age and homogeneity of physical characteristics, ensuring equivalence across groups at baseline. All procedures were conducted in accordance with ethical standards for research involving children, and participation was voluntary.

### *Data Collection*

Cognitive performance was assessed using Raven's Progressive Matrices Test, one of the most widely accepted non-verbal measures of general intelligence and abstract reasoning. The Raven test was selected due to its high validity, extensive use in scientific research, and suitability for individuals from diverse linguistic and cultural backgrounds. Developed by British psychologist John C. Raven in 1936, the test is grounded in Spearman's theory of general intelligence (g) and primarily measures inductive reasoning and problem-solving ability. The test consists of 60 multiple-choice items arranged in increasing order of difficulty, each presenting an incomplete abstract geometric pattern that the participant must correctly complete. The patterns are organized in matrix formats of varying dimensions, including 2×2, 4×4, and 6×6, which is why the test is commonly referred to as "progressive matrices." Participants were allotted approximately 45 minutes to complete the test, a duration that is considered appropriate for both children and adults to demonstrate their full reasoning capacity.

The psychometric properties of the Raven test have been well established. Previous research has demonstrated high test–retest reliability, with repeated administrations yielding consistent results over time. Studies have reported reliability coefficients indicating strong stability of the measure, and significant correlations have been observed between Raven scores and other verbal and performance-based intelligence tests, ranging from 0.40 to 0.75, with stronger associations typically found for performance measures. In Iranian validation research, test–retest reliability assessed over a two-month interval yielded a correlation coefficient of 0.91, confirming the strong stability of the instrument. Internal consistency analysis using Cronbach's alpha produced a coefficient of 0.82, further supporting the reliability of the test. These psychometric findings confirm that Raven's Progressive Matrices is a valid and reliable instrument for assessing cognitive performance in children.

### *Intervention*

The training intervention was designed as a structured fundamental football skills program for boys aged 9 to 12 years with the overarching objective of enhancing cognitive performance, perceived competence, and

physical capacities including strength, speed, agility, and endurance. The program was implemented over an eight-week period, consisting of three training sessions per week for a total of twenty-four sessions, with each session lasting approximately sixty minutes. During the first two weeks, the focus was placed on basic ball control, short passing, and simple game-based activities, delivered at a light to moderate intensity to facilitate technical adaptation and neuromotor engagement. In weeks three and four, the program progressed to include dribbling, passing while in motion, short-range shooting, and small-sided 3×3 games at a moderate intensity to promote coordination, decision-making, and game awareness. Weeks five and six emphasized combined technical drills, long-range shooting, and 4×4 match play at moderate to high intensity to further develop tactical understanding and physical conditioning. In the final phase, weeks seven and eight, training incorporated multi-task drills, rapid decision-making exercises, and 5×5 competitive play at high intensity, thereby maximizing cognitive load, perceptual processing, and physical demand. The gradual progression of technical complexity, tactical challenge, and exercise intensity was deliberately structured to stimulate both cognitive and physical development while maintaining age-appropriate training principles and participant safety.

*Data analysis*

Data were analyzed using SPSS version 26. Descriptive statistics were first computed to summarize participant characteristics and baseline scores. Inferential analysis was conducted using analysis of covariance (ANCOVA) to examine the effect of the training intervention on posttest cognitive performance while statistically controlling for pretest scores. This approach increases statistical precision by reducing the influence of baseline variability among participants. Following significant main effects, Bonferroni post-hoc tests were employed to identify specific group differences while controlling for Type I error associated with multiple comparisons. Statistical significance was set at  $p < .05$  for all analyses.

**Findings and Results**

The study sample consisted of sixty male participants distributed equally across four groups. The 9–10-year age group included 15 children with a mean age of 9.6 years, an average height of 136.2 cm, a mean body weight of 32.8 kg, and an average sports experience of 6.2 months. The 10–11-year group comprised 15 participants with a mean age of 10.5 years, an average height of 141.8 cm, a mean body weight of 35.6 kg, and an average training background of 8.1 months. The 11–12-year group included 15 boys with a mean age of 11.4 years, a mean height of 147.3 cm, an average body weight of 38.4 kg, and a mean sports experience of 10.3 months. The control group consisted of 15 participants with a mean age of 10.7 years, an average height of 142.6 cm, a mean body weight of 36.2 kg, and an average sports experience of 7.5 months.

**Table 1. Descriptive Statistics of Cognitive Performance (Raven Scores)**

Group	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
9–10	32.4	3.1	36.7	3.4
10–11	34.1	3.5	38.9	3.6
11–12	35.8	3.8	40.2	3.9
Control	33.5	3.3	34.2	3.5

The descriptive statistics indicate that all experimental groups demonstrated noticeable improvements in cognitive performance from pretest to posttest, whereas the control group exhibited only a minimal increase.

The greatest mean gain was observed in the 11–12-year group, followed by the 10–11-year group and the 9–10-year group, suggesting a progressive enhancement of cognitive outcomes with increasing age and training exposure.

Prior to conducting the ANCOVA, all statistical assumptions were carefully examined and confirmed. First, the assumption of linearity between the covariate (pretest) and the dependent variable (posttest cognitive performance) was evaluated through inspection of scatterplots, which demonstrated that data points were distributed around a straight regression line, indicating a stable linear relationship whereby increases in pretest scores were associated with proportional increases in posttest scores. Second, the homogeneity of regression slopes was tested using the interaction effect between group and pretest scores; this interaction was not statistically significant ( $F = 1.12, p = 0.32$ ), confirming that the relationship between the covariate and the dependent variable was consistent across groups. Third, homogeneity of variances was verified using Levene's test, which yielded a non-significant result ( $F = 1.26, p = 0.29$ ), indicating that group variances were equal. Finally, the normality of score distributions was examined using the Kolmogorov–Smirnov test for both pretest and posttest cognitive performance, and results were non-significant for all distributions (pretest:  $K-S = 0.67, p = 0.76$ ; posttest:  $K-S = 0.71, p = 0.69$ ), confirming that the data were normally distributed. Collectively, these findings confirm that all major assumptions of ANCOVA were satisfied and that the statistical analyses were conducted under appropriate and valid conditions.

**Table 2. ANCOVA Results for Cognitive Performance**

Source of Variation	Mean Square	df	SS	F	Sig.	Eta	Result
Pretest (Covariate)	45.62	1	45.62	12.38	0.001	0.18	Significant
Group	58.41	3	175.23	16.27	0.000	0.26	Significant
Error	3.59	55	197.45	–	–	–	–
Total	7.05	60	418.30	–	–	–	–

The analysis of covariance revealed a statistically significant main effect of group membership on posttest cognitive performance after controlling for pretest scores, indicating that participation in the training program significantly influenced cognitive outcomes. The effect size was large, demonstrating that a substantial proportion of variance in cognitive performance was attributable to the intervention.

**Table 3. Bonferroni Pairwise Comparisons for Cognitive Performance**

Pairwise Comparison	Adjusted Mean Difference	95% CI	Sig. (Bonf.)	Cohen's d	Result
9–10 – Control	2.3	1.1 to 3.5	0.001	0.60	Significant
10–11 – Control	4.5	3.2 to 5.8	0.000	1.11	Significant
11–12 – Control	6.0	4.7 to 7.3	0.000	1.45	Significant
10–11 – 9–10	2.2	0.7 to 3.6	0.004	0.55	Significant
11–12 – 9–10	3.7	2.3 to 5.1	0.000	0.91	Significant
11–12 – 10–11	1.5	0.1 to 2.9	0.048	0.38	Significant

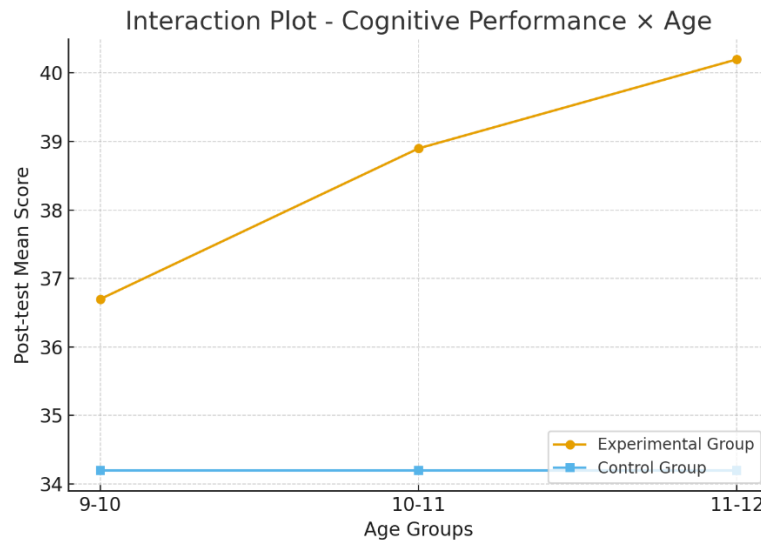
The pairwise comparisons demonstrate that all experimental groups significantly outperformed the control group, with the largest effect observed for the 11–12-year group. Significant differences were also found among the experimental age groups, confirming that older participants benefited more strongly from the intervention in terms of cognitive gains.

**Table 4. ANCOVA Results for Cognitive Performance with Moderating Role of Age**

Source of Variation	Mean Square	df	SS	F	Sig.	Eta	Result
Pretest (Covariate)	44.81	1	44.81	11.95	0.001	0.17	Significant
Age Group	26.94	2	53.88	7.18	0.002	0.12	Significant

Age Group × Training Interaction	21.36	2	42.72	5.72	0.005	0.09	Significant
Error	3.75	54	202.50	–	–	–	–
Total	5.72	60	343.91	–	–	–	–

The moderated ANCOVA analysis confirmed that age significantly influenced cognitive performance outcomes and that the interaction between age and training was statistically significant, indicating that the effectiveness of the football skills intervention varied by age. Specifically, the intervention produced stronger cognitive improvements among older participants, supporting the presence of an age-based moderating effect.



**Figure 1. Interaction Plot of Cognitive Performance × Age**

### Discussion and Conclusion

The purpose of the present study was to examine the effects of an eight-week fundamental football skills training program on the cognitive performance of novice Iraqi football players aged 9–12 years and to determine whether age moderated these effects. The findings clearly demonstrated that participation in the structured football training program led to statistically significant improvements in cognitive performance compared with the control group. Moreover, the magnitude of improvement increased progressively across age groups, with the 11–12-year-old participants exhibiting the greatest cognitive gains. These results provide strong empirical support for the hypothesis that fundamental football training can serve as an effective cognitive development intervention during late childhood and that its effectiveness is substantially influenced by developmental stage.

The significant main effect of the training program on cognitive performance is consistent with contemporary theoretical models that conceptualize sport participation as a complex cognitive–motor learning environment. Football training continuously exposes children to perceptual scanning, working memory demands, inhibitory control, rapid decision-making, and problem-solving under dynamic conditions. Such cognitive engagement aligns with evidence indicating that sport-specific training enhances executive functions and attentional networks (6, 7). The present findings further corroborate the conclusions of Mao’s comprehensive meta-analysis, which identified moderate-to-large effects of football training on multiple domains of cognitive functioning in children and adolescents (11). By extending these results to

novice players within the 9–12-year age range, the current study adds important developmental evidence that cognitive benefits are not restricted to elite or highly trained youth populations.

The observed improvements in cognitive performance across all experimental groups also support the growing body of literature emphasizing the role of physical activity in neurocognitive development. Structured physical interventions have been shown to improve attention, processing speed, and executive control in children through neuroplastic mechanisms involving the prefrontal cortex and cerebellum (12, 17). The present results align with these findings and demonstrate that football, as a cognitively demanding sport, may be particularly effective in stimulating these neural systems. Neurophysiological evidence further suggests that football participation enhances cerebellar–cortical connectivity, which is critically involved in attentional modulation and cognitive coordination (6). Thus, the significant cognitive gains observed in this study likely reflect both behavioral learning processes and underlying neurobiological adaptations.

An important contribution of the present study lies in its examination of age as a moderating variable. The results revealed a clear age-dependent pattern, with older children deriving greater cognitive benefits from the same training program. This finding is consistent with developmental sport science theories, which emphasize that maturation profoundly shapes responsiveness to training stimuli. During late childhood and early adolescence, rapid structural and functional brain development enhances the efficiency of cognitive networks responsible for executive control and information processing (4, 5). As a result, older children within this age span possess greater neurocognitive readiness to capitalize on complex training environments.

Empirical research supports this interpretation. Studies on youth football players indicate that age-related differences in executive functions, physical maturity, and attentional control strongly influence performance outcomes (8, 9). Zghal et al. demonstrated that neuromuscular and force production capacities increase non-linearly with age in young football players, suggesting parallel growth in neuromotor and cognitive systems (15). Similarly, Sun et al. documented systematic age-related increases in physical and physiological characteristics among young football players, which are closely associated with cognitive efficiency and perceptual performance (16). The present findings reinforce these conclusions by demonstrating that identical training loads yield larger cognitive improvements in more mature children.

The significant interaction between age and training further indicates that developmental stage is not merely a background variable but actively shapes the effectiveness of football-based cognitive interventions. This interaction effect is particularly relevant for talent development models and youth coaching frameworks, which increasingly advocate for age-appropriate training designs that match cognitive and physical demands to developmental readiness (1, 2). The superior gains observed in the 11–12-year-old group suggest that late childhood may represent an optimal window for maximizing cognitive benefits of football training, as children at this stage possess sufficient cognitive maturity to fully engage with the tactical, perceptual, and decision-making components of the sport.

The findings also resonate with research on perceptual–cognitive skill acquisition in football. Triggs et al. emphasized that enriched training environments, characterized by small-sided games, variable practice conditions, and decision-making challenges, are essential for developing higher-order cognitive skills in young players (1). The training protocol employed in the present study incorporated these features, including progressive increases in task complexity, multi-task drills, and competitive small-sided games, which likely

contributed to the observed cognitive improvements. This aligns with evidence from Alavi Namvar et al., who reported significant enhancements in perceptual–cognitive skills following fundamental football technique training that emphasized observational and implicit learning (22).

Furthermore, the present results complement emerging evidence on the bidirectional relationship between cognitive function and football performance. Movahed’s causal modeling analysis demonstrated that improvements in cognitive functions significantly predict football performance outcomes, while football training simultaneously enhances cognitive capacities (26). Similarly, Fajar et al. found that cognitive ability, physical fitness, and age jointly influence soccer playing skills in young athletes (19). The current study extends these findings by experimentally demonstrating that targeted football training can causally improve cognitive performance, particularly in older children.

From an educational perspective, the results also support the integration of football-based interventions within school curricula and youth development programs. Campus and school-based football initiatives have been shown to improve psychological qualities, motivation, emotional regulation, and cognitive engagement among students (12, 28). The present findings provide further justification for such programs, particularly in contexts where cognitive development and academic performance are critical policy priorities. By demonstrating that structured football training can significantly enhance cognitive functioning during a sensitive developmental period, the study highlights football’s potential as a powerful educational tool.

Another important implication concerns developmental equity and talent identification. Research on relative age effects has shown that older children within the same cohort often enjoy performance advantages due to maturational differences rather than superior talent alone (9). The present study’s age-moderated results underscore the necessity of considering developmental timing when evaluating youth performance and designing training interventions. Failure to account for these factors may lead to premature talent selection biases and suboptimal developmental outcomes.

In summary, the present findings provide strong empirical evidence that fundamental football skills training significantly enhances cognitive performance in children aged 9–12 years and that age plays a critical moderating role in shaping these effects. These results align with a wide body of multidisciplinary research spanning neuroscience, developmental psychology, sport science, and pedagogy, and they contribute new insights by experimentally confirming age-dependent cognitive benefits of football training within a novice youth population.

Despite the strengths of the present study, several limitations should be acknowledged. The sample size, although adequate for statistical analysis, was relatively small and limited to one geographical region, which may restrict the generalizability of the findings. The study focused exclusively on male participants, and therefore the results may not be directly applicable to female youth populations. In addition, the study employed a single cognitive assessment tool, which, while psychometrically sound, may not capture the full multidimensional nature of cognitive development. Finally, the absence of long-term follow-up limits conclusions regarding the durability of the observed cognitive gains.

Future research should replicate this study with larger and more diverse samples, including participants from different cultural, socioeconomic, and educational backgrounds. Investigations should incorporate female participants to explore potential gender differences in cognitive responsiveness to football training. Longitudinal designs with extended follow-up periods are recommended to examine the stability of cognitive

improvements over time. Additionally, future studies should employ comprehensive neurocognitive assessment batteries and, where possible, neuroimaging methods to further elucidate the neural mechanisms underlying training-induced cognitive changes.

Practitioners and policymakers should consider integrating structured football training programs into school curricula and youth development initiatives as a means of promoting cognitive development alongside physical health. Training designs should be developmentally tailored, with increasing cognitive and tactical complexity introduced progressively according to age and maturity level. Coaches and physical educators should receive specialized training in cognitive–motor integration strategies to maximize the developmental benefits of football-based programs. Finally, youth talent development systems should adopt age-sensitive evaluation criteria to ensure equitable opportunities for children at different stages of maturation.

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### Authors' Contributions

All authors equally contributed to this study.

### Declaration of Interest

The authors of this article declared no conflict of interest.

### Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

### Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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