ORIGINAL ARTICLE

Acute effects of high intensity interval training with step aerobics training on cognitive performance in male futsal players

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ABSTRACT

Previous studies have shown that success in sports, especially futsal is linked to higher levels of cognitive functioning. It is widely recognized that short-term, high intensity interval training exercise enhances cognitive function. Nevertheless, the impact of short-term, high-intensity aerobic exercise combined with step aerobics on cognitive function remains unclear. Thus, we aimed to evaluate the acute effects of sport-specific high-intensity interval training with step aerobics training on cognitive in professional futsal players. Here we assess cognitive performance before and after engagement in a high-intensity interval training with step aerobics exercise (HIITSA) regimen. Fifteen male futsal players aged 18-22 years were randomly assigned to one of two experimental groups: (a) an acute high-intensity with step aerobics exercise (n = 8) or (b) a non-exercise control (n = 7). Our findings show that participants in the exercise group demonstrated enhanced performance in cognitive processing tasks ($p \leq .05$). In contrast, control participants who did not engage in exercise showed no significant change over time in cognitive performance ($p \leq .05$). Additionally, we observed that there was no significant muscle hypertrophy following the HIITSA training over a 4-week period ($p \leq .05$). In conclusion, indicate that a brief training period incorporating HIITSA sessions promoted as a time-efficient enhance cognitive performance in elite young futsal players.
Keywords: Performance analysis, Cognitive performance, High intensity interval training, Step aerobics training, Futsal players.

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INTRODUCTION

Cognitive factors encompass the characteristics of an individual that influence both performance and the learning process. These factors are integral in modulating cognitive function and overall brain performance (Danili & Reid., 2006). Cognitive factors strongly impact athletic performance by influencing the execution of motor skills, attention, and decision-making in a match (Filgueiras et al.,2023). Most recently, evidence suggests that cognitive flexibility were linked to levels of competitiveness in athletes, especially in futsal is linked to higher levels of cognitive functioning (Filgueiras et al.,2023; Arslan et al.,2022). Futsal players depend on working memory to interpret complex strategic plans and adapt to rapidly changing game conditions in real time, a necessity driven by the sport's fast-paced nature (Sehrish Shiraz et al., 2024).

High-Intensity Interval Training (HIIT), a training approach characterized by brief intervals of intense physical activity followed by short recovery or low-intensity periods, at intensities ranging from 80–95% of maximum heart rate or 80–90% of VO_{2max} (Neves et al., 2023), has garnered considerable attention for its capacity to induce substantial improvements in both physiological function and neural adaptations in a relatively short time frame (Atakan et al.,2021; Gómez et al.,2023; Arslan et al.,2022). It is widely accepted that it has gained popularity as a time-efficient method.

Previous studies have shown that high-intensity exercise also seems to increase brain-derived neurotrophic factors (BDNFs), a molecule important for synaptic connections and learning and memory (Fernandez-Rodriguez et al., 2022; Vaynman et al.,2004), Additionally, Step Aerobics (SA), which involves rhythmic movement patterns, involves a variety of movements that are relatively complex by stepping up and down, turning, dancing, and various other coordinated movements with (Charee etal.,2022; Behrens et al.,2017), has shown potential in enhancing spatial awareness and memory development (Hewston et al.,2021).

Numerous studies have proposed that brain-derived neurotrophic factor (BDNF), a key protein involved in neuroplasticity and brain health, plays a crucial role in cognitive enhancements following acute exercise. BDNF supports the survival and growth of neurons, and exercise has been shown to elevate its levels, thereby fostering neural connections that may improve cognitive function. The observed association between increased BDNF levels and cognitive benefits suggests that acute bouts of exercise may stimulate neurophysiological changes, contributing to improved memory, attention, and executive function (Silakarma et al.,2019). This principle provides a foundational understanding of how exercise can serve as a stimulus for brain health and cognitive performance. (Sudo et al.,2022; Hwang et al.,2016; McIlvain et al.,2024). The research provides evidence for HIIT's significance in cognitive learning, highlighting the more complex character of HIIT regarding neurological activities. Griffin et al.,2011 demonstrated that acute high-intensity cycling exercise was effective in cognitive function by increased concentration of BDNF in young adult males (Griffin et al.,2011). Thus, these studies indicate that the enhancement of cognitive processes may be a factor contributing to athletes' rapid response during high-intensity competitive games. Systematic HIIT exercise also affects cognitive aspects while increasing shortest reaction time, best anticipation, perception, and optimal decision making (Chmura et al.,2023), such an effect is extremely desirable, as it allows players to perform actions efficiently at extremely intense moments of a match.

A recent review summarized that improvements in cognitive performance following high-intensity aerobic exercise are frequently accompanied by the changes in brain activation assessed by Psychomotor task, Executive function, Memory task, Attentional task, Motion Object Tracking Test, and Perceptual Load Test in healthy younger adults, Basketball, and Soccer players. (Herold et al.,2022; Sehrish Shiraz et al.,2024). Despite its established advantages, there is a lack of direct evidence regarding the combined effects of HIIT and SA, particularly focusing on futsal players. Thus, we aimed to evaluate the acute effects of sport-specific high-intensity interval training with step aerobics training (HIITSA) on cognitive in professional futsal players.

MATERIALS AND METHODS

Participants

Fifteen male professional futsal players were randomly allocated to one of two groups: One group engaged in HIITSA, while the other group continued their regular futsal training without HIITSA (CON). The resulting sample included fifteen participants, with 8 participants in the exercise group, and 7 participants in the control group that did not exercise. Both groups maintained their standard futsal training routines throughout the study. An a priori power analysis using statistical software (G*power V 3.1.9.4) was completed to determine an adequate sample size. For this sample, the statistical power was 87% (two tails t-test; effect size moderate and alpha: 5%).

The inclusion criteria in this study were as follows: (1) minimum of one year of active participation in futsal (2) age between 18 and 22 years (2) body mass index between 18.5-22.9 kg/m^2 (4) without any injury, acute illness, unstable hypertension, and angina (5) having regular futsal training sessions for at least three weeks prior to the study. Exclusion criteria included any known exercise-limiting cardiovascular or respiratory condition, lower limb fractures, or musculoskeletal injuries within three months prior to study initiation. All athletes were informed of the risks, benefits, and participation requirements of this study before signing a written informed consent form. This study was approved by the Ethics Committee of Khon Kaen University (approval number HE672108).

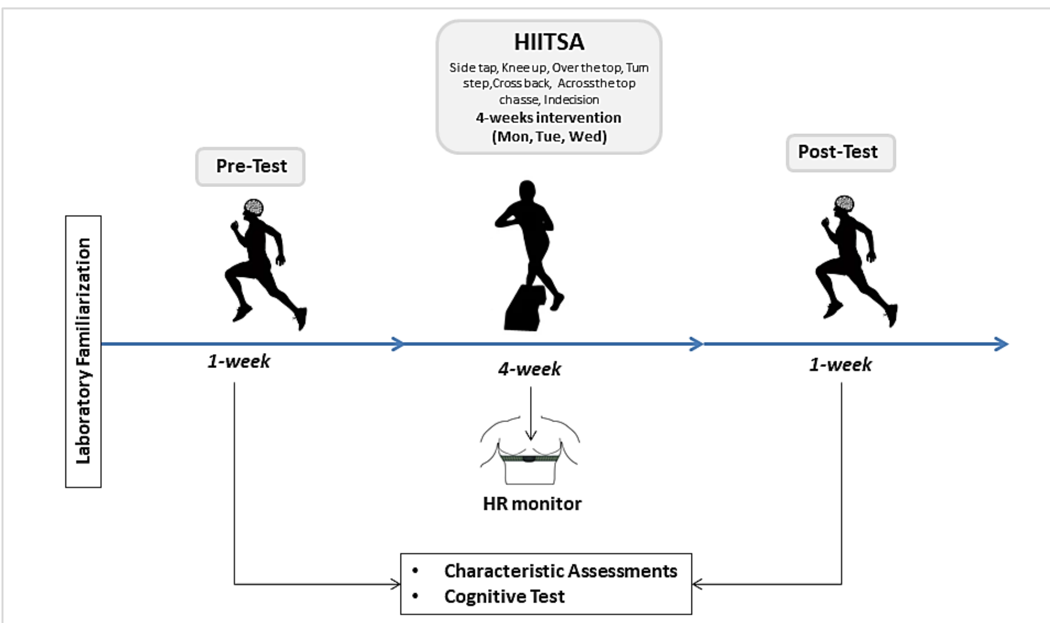


Figure1. Study design.

Experimental approach

A randomized controlled study was designed to investigate the acute effects of sport-specific high-intensity interval training with step aerobics training (HIITSA) on cognitive responses in professional futsal players. All subjects completed a pre-test cognitive test within 1 week before starting the intervention. After the pre-tests, the participants were randomly assigned to either the high-intensity interval training combined with step aerobics protocol (HIITSA), and the control group (CON) for 4 weeks of intervention. Post testing was performed 1 week after the cessation of the intervention (Figure1).

Procedures and measurements

The baseline characteristic assessments, Morphological included body height, body weight, fat mass, fat-free mass, and leg muscle mass was measured using a stadiometer and bioelectrical impedance method (InBody Body Composition Analyzer, Tanita Company). BMI was measured calculated based on body height and weight. Heart rate at rest was recorded in beats per minute (bpm) using the Polar10 (Polar H10 Heart Rate Monitor Chest Strap, Finland), were performed both 1 week before and after the training intervention.

The performance assessments including cognitive performance test the test used was inspired by the work of Sekulic et al.,2019 this study employed a cognitive test (Sekulic et al.,2019), were performed both 1 week before and after the training intervention. Measurements were performed on 3 separate days, with a 48-h interval, following the same order for both pre-tests and post-tests. All subjects were familiarized with the test protocols and experimental devices in advance. The subjects were also instructed to strenuous and prolonged exercise (lasting more than 30 minutes) 24 h before each test day. Testing was started with a warm-up consisting of 10 min of jogging and 10 min of dynamic stretches as directed by the researcher.

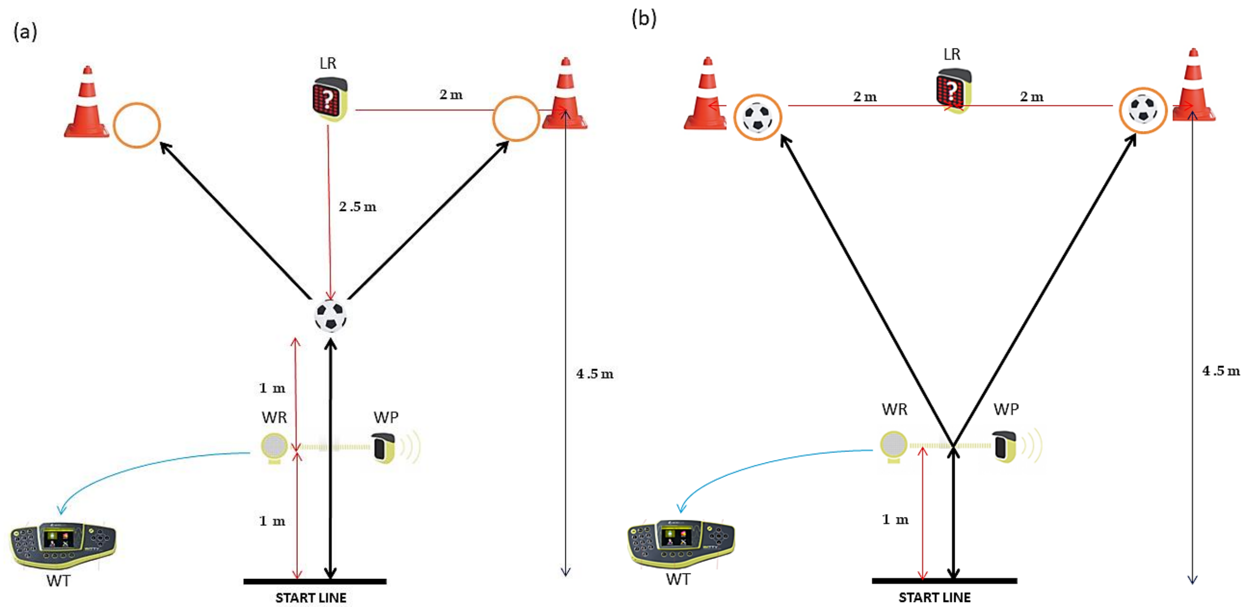
High intensity interval training with step aerobics Intervention (HIITSA)

The HIITSA included multiple functional exercises combination with 6 inch steps aerobics using training moves consisting of seven movement patterns: 1) side tap, 2) knee up, 3) over the top, 4) turn step, 5) cross back, 6) across the top chasse, and 7) indecision. Each exercise was performed to rhythmic music (170 bpm for exercise intervals and 70 bpm during recovery periods) and executed on a 6-inch aerobic step platform (Jansupom et al., 2023). In each HIITSA session, participants were required to wear Polar H10 to record heart rate and track exercise intensity in real-time. The monitor was positioned near the heart and secured with a chest strap, with heart rate data managed through the Polar team system (Polar team system, Finland). The maximum heart rate (HRmax) of each session is considered to be exercise periods by 20 s at 90% HRmax according to the Tabata protocol (Tabata., 2019), interspersed with 10-second recovery periods at 60% HRmax. Each participant's HRmax was determined using the age-predicted formula (220 - age) x percent intensity, with 90% applied to active intervals and 60% during recovery. Participants were provided with qualitative feedback, such as "*you should go faster*" or "*you did a good job*," to aid in perceiving and adjusting to the prescribed intensity levels. Each training session commenced with a standardized warm-up, followed by a 10-minute jog, and concluded with a cool-down phase that also included a 10-minute jog. Heart rate was maintained at 60% of HRmax during both the warm-up and cool-down phases. The exercise program consists of 8 sections, the total HIITSA session duration was 50 minutes.

Cognitive tests

To assess cognitive performance, the test used was inspired by the work of Sekulic et al.,2019 this study employed a cognitive test (Sekulic et al.,2019). The WittySEM photocell system (Microgate S.r.I.Via Waltraud Gebert Deeg, 3eI-39100 Bolzano, ITALY) is used to assess agility in this study (Molinaro et al.,2023), which has one photocell, each with an optical proximity sensor and a 7 × 5 LED matrix that can display different colours, arrows in several directions, numbers, letters, and other symbols.

During each trial, timing for the test commenced when participants departed from the start line 1 m behind the timing gate after seen the signal light from the traffic light of the 7x5 LED matrix display (LR; LED Reaction Smart Indicators) that can display different arrows in several directions and concluded at the first infrared signal (WP; Witty Photocell, WR; Witty Reflector) point (Figure2). For statistical analysis, each variable was tested twice, and the best performance score for each participant from each test by a tablet witty timer via a radio transmission system (Microgate S.r.l.Via Waltraud Gebert Deeg, 3el-39100 Bolzano, ITALY) was recorded for analysis in real time for the acquisition of events.



Note. WP; Witty Photocell, WR; Witty Reflector, LR; WT; Witty timer via a radio transmission system, LR; LED Reaction Smart Indicators.

Figure 2. Testing of the Cognitive tests by futsal specific change of direction speed and reactive agility including (a) dribbling and (b) ball touching Test.

Statistical analysis

Data analyses were performed with academic statistics software (SPSS, Version 28). Data were reported as mean ± standard deviation (Mean ± SD). Statistical analyses were performed using paired-sample t-tests to compare pre- and post-intervention measurements within each group. Independent-sample t-tests were used to compare differences between groups. The level of statistical significance was set at $p \leq .05$.

RESULTS

Baseline characteristic

No significant differences were found in terms of age, height, body mass, fat mass, fat-free mass, leg muscle mass, or body mass index before and after the intervention period between the two teams (HIITSA and CON) (mean: age = 19.89 ± 0.93 years; height = 170 ± 4.06 cm; body mass = 60.17 ± 3.73 kg; fat mass 13.60 ± 3.47 %; fat free mass 36.96 ± 1.68%; Leg Muscle mass 53.76 ± 1.40%; Body mass index 20.88 ± 1.03 kg/m^2.) (Table 1).

Cognitive performance assessed by cognitive test, decreased after the intervention only in the HIITSA group (RAG_DD (*p* = .037), RAG_DND (*p* = .004), RAG_TD (*p* = .033), RAG_TND (*p* = .010), CODS_DD (*p* = .007, *p* = .001), CODS_DND (*p* = .009, *p* = .003), CODS_TD (*p* = .005), and CODS_TND (*p* = .050, *p* = .001)

(Table 2). Also, the post-intervention values were higher in the CON group compared to the HIITSA group (RAG_DND (*p* = .008), RAG_TD (*p* = .042), RAG_TND (*p* = .058), CODS_DND (*p* = .001), and CODS_TD (*p* = .045). However, there was no significant effect on RAG_DD (*p* = .153), CODS_DD (*p* = .080), CODS_TND (*p* = .094) (Table 2).

Table1. The demographic and anthropometric data of the futsal players included in two groups.

Variables	**HIITSA(*n* = 8)**		**CON(*n* = 7)**	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Age (years)	19.89 ± 0.93	19.89 ± 0.93	19.78 ± 0.97	19.78 ± 0.97
Height (cm)	170 ± 4.06	170 ± 4.06	172.89 ± 5.57	172.89 ± 5.57
Body mass (kg)	60.17 ± 3.73	60.47 ± 3.53	59.71 ± 6.90	58.90 ± 4.70
Fat mass (%)	13.60 ± 3.47	11.74 ± 3.63	12.44 ± 3.41	11.64 ± 3.02
Fat free mass (%)	36.96 ± 1.68	37.61 ± 1.71	37.55 ± 1.10	37.75 ± 1.15
Leg Muscle mass (%)	53.76 ± 1.40	54.78 ± 1.48	54.52 ± 1.04	54.81 ± 1.12
BMI (kg/m^2)	20.88 ± 1.03	20.92 ± 0.68	19.95 ± 1.55	19.84 ± 1.31

Table 2. Comparison of changes in cognitive performance before and after the high-intensity interval training with step aerobics (HIITSA) of futsal players is presented. Data are shown as means ± standard.

Cognitive Variables		**HIITSA(*n* = 8)**	**CON(*n* = 7)**
RAG_DD (s)	Pre-Test	0.09 ± 0.13	0.84 ± 0.15
	Post-Test	0.82 ± 0.15*	0.90 ± 0.12
RAG_DND (s)	Pre-Test	0.84 ± 0.11	0.87 ± 0.02
	Post-Test	0.86 ± 0.10**	1.00 ± 0.07*
RAG_TD (s)	Pre-Test	0.79 ± 0.10	0.87 ± 0.08
	Post-Test	0.81 ± 0.13**	0.93 ± 0.09*
RAG_TND (s)	Pre-Test	0.80 ± 0.17	0.79 ± 0.15
	Post-Test	0.83 ± 0.06**	0.92 ± 0.10*
CODS_DD (s)	Pre-Test	0.47 ± 0.18	0.58 ± 0.21
	Post-Test	0.66 ± 0.16*	0.80 ± 0.18*
CODS_DND (s)	Pre-Test	0.54 ± 0.22	0.64 ± 0.18
	Post-Test	0.64 ± 0.11**	0.86 ± 0.11*
CODS_TD (s)	Pre-Test	0.63 ± 0.14	0.60 ± 0.07
	Post-Test	0.61 ± 0.16**	0.74 ± 0.07*
CODS_TND (s)	Pre-Test	0.65 ± 0.14	0.58 ± 0.13
	Post-Test	0.55 ± 0.19*	0.68 ± 0.14*

Note. RAG_DD — Reactive agility with dribbling on the dominant side, RAG_DND — Reactive agility with dribbling on the non-dominant side, RAG_TD — Reactive agility with ball touching on the dominant side, RAG_TND — Reactive agility with ball touching on the non-dominant side, CODS_DD — Change-of-direction speed with dribbling on the dominant side, CODS_DND — Change-of-direction speed with dribbling on the non-dominant side, CODS_TD — Change-of-direction speed with ball touching on the dominant side, CODS_TND — Change-of-direction speed with ball touching on the non-dominant side. An asterisk (*) indicates a significant difference from pre-training (p ≤ .05), (**) indicates a significant difference between groups (p ≤ .05).

DISCUSSION

We are aware of very few studies using any type of HIIT exercise with SA that have examined whether over 4-weeks duration of exercise training increases cognitive. Prior to our study, the shortest HIIT study on cognitive performance consisted of only single session of HIIT, with 6 session of sprints, each lasting 6 seconds, with a 60-second rest period between each set (Herold et al.,2022). The main finding was that 4-week of high intensity interval training with step aerobics allowed futsal players significantly improves cognitive function for the HIITSA group, while it remained reduction in the cognitive performance for the CON group.

This our finding accordance with previous studies shown that engagement in even a single session of HIIT exercise can improve cognitive performance in the short term (McIlvain et a.,2024; Herold et al.,2022) and may be explained by the relates to the nature of HIIT and SA, interaction between high-intensity exercise and enhanced cognitive processing (Samuel et al.,2017, Slusher et al.,2018; Solianik et al.,2020). Chmura et al. (2023) report that HIIT protocol intensities closer to psychomotor fatigue threshold (PFT) is significant for cognitive performance ,(Chmura and Nazar., 2010), as exercising at an intensity close to this threshold maximizes CNS efficiency (shortest reaction time, best anticipation, perception, and optimal decision making) and enhances cognitive processes. It also maintains the well-known benefits of high-intensity, repeated efforts (Chmura and Nazar., 2010; Chmura et al.,2023). Additionally, these cognitive gains are consistent with previous research by Shiraz et al. (2024), which elucidated the cognitive benefits of high-intensity interval training (HIIT) among athletes (Shiraz et al.,2024). The improvement in cognitive functions may significantly contribute to enhanced sports performance by enabling more efficient speedier decision-making, more situational awareness, and better focus during competition. Systematic research examine how rhythmic and patterned movements in dance and similar activities, such as step aerobics training also had a substantial positive effect on cognitive functions like spatial awareness and memory (Hewston et al.,2021). One plausible explanation for these outcomes according with further contribute to cognitive improvements by training spatial awareness and working memory as athletes synchronize their movements with complex patterns and rhythms. This enhancement may also be a consequence of the increased coordination required by the body during the rhythmic movements associated with the nature of SA stepping up and down. Consequently, this could be linked to the improved functionality of the brain regions responsible for motor control (Dunsky et al., 2017).

On the contrary, the findings of this study suggest that HIITSA was the absence of significant muscle hypertrophy post-training, likely due to the short duration period, which is consistent with previous research suggesting that HIIT exercise requires 6-12 weeks to observe significant muscle hypertrophy (Caparrós-Manosalva et al.,2023; Longlalerng et al.,2021; Molinari et al.,2022). Importantly, it can be surmised that the cognitive performance enhancements that were observed were likely the result was positively correlated with cognitive responses that were induced following HIITSA training, which was completed in a brief four weeks. Moreover, HIITSA has the potential to directly enhance neural system function, contributing to improved motor control and cognitive processing abilities (Yue L al et.,2023; Dincher et al.,2023, Wu Z J et al.,2021; Shiraz et al.,2024). Previous studies have demonstrated that BDNF is sensitive to exercise, which might lead to improved cognitive performance (Li et al., 2022). Our study was in agreement with the findings of Herold et al. (2022) and Sehrish Shiraz et al. (2024), who have confirmed that HIIT improves cognitive performance following high-intensity aerobic exercise. The mechanisms underlying the effects of HIITSA exercise on cognitive function are well-established. One possible explanation for this finding may be to enhance brain-derived neurotrophic factor (BDNF), which might stimulate synaptic connections and learning and memory, (Fernandez-Rodriguez et al., 2022), ultimately contributing to improvements in memory, attention, and executive function. This is achieved by enhancing the execution of motor skills, maintaining sustained focus, and supporting precise decision-making processes during high-intensity competitive matches. Due to the nature of high-intensity interval training, which involves repeated bouts of intense exercise within a limited timeframe followed by rest periods combined with stepping up and down, turning, dancing, and various other coordinated movements. These dynamic and integrative elements may provide cognitive benefits, making

HIITSA an effective training strategy for improving cognitive performance (Neves et al., 2023; Behrens et al., 2017). Accordance with previous studies have shown that this type of exercise stimulates the release of BDNF (brain-derived neurotrophic factor) in the brain (Li et al.,2023; Fernandez-Rodriguez et al., 2021; Vaynman et al.,2004). This release enhances learning processes, leading to improved brain function, specifically by increasing responsiveness to stimuli, and more efficient information processing (Sehrish Shiraz et al.,2024; Silakarma et al., 2019; Herold et al. (2022).

In futsal the total distance covered during the match consists of 13.7% high intensity running and 8.9% sprinting (Spyrou et al., 2020). Decision-making is a critical factor in determining success in the context of high-intensity games, where rapid responses and constant focus are required. Thus, in these studies indicate that the enhancement of cognitive processes may be a factor contributing to athletes' rapid response during high-intensity competitive in the fast-paced of game. Due to the small field size, this is an inevitable limitation in a dynamic sport that requires athletes to respond quickly. This approach may serve as a strategic advantage in fast sprints, better decision-making in futsal players closer to the characteristics of the sport.

CONCLUSION

In conclusion, the current study demonstrated that a short training period using HIITSA sessions can significantly improve cognition in elite young futsal players. This protocol promoted as a time-efficient alternative to improve cognition (e.g., attention, and decision-making) in a fast-paced match. For future research, it would be important to explore the exact mechanisms behind the increase in BDNF and cognitive improvements, as these may be influenced by factors such as exercise type, intensity, and individual characteristics, and help in developing exercise programs aimed at optimizing cognitive function and brain health in sports.

AUTHOR CONTRIBUTIONS

Study concept and design: N. B. and A. H. Analysis and interpretation of data: A. H., S. P., and C. J. Drafting of the manuscript: N. B. and N. R. Critical revision of the manuscript for important intellectual content: A. H., and T. K. Statistical analysis: A. H. and N. B.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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