Original Article

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Effects of a Futsal Sports-Specific Program on Cognitive Intelligence in Youth Male Futsal Players

Thanyawat Homsombat, Ph.D.[1], Pongsakorn Tunintaraarj, M.Sc.[2]

[1]Faculty of Sports Science and Health, Thailand National Sports University, Udon Thani Campus, Udon Thani 41000, Thailand.
[2]Faculty of Education, Thailand National Sports University Udon Thani Campus, Udon Thani 41000, Thailand.

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Abstract:

Objective: The purpose of this pre-experimental research was to compare the effects of novel futsal sports-specific training on cognitive intelligence before and after 4 and 8 weeks of training in youth male futsal athletes.

Material and Methods: Participants included 26 youth male futsal athletes via a systematic random sampling method. The experiment instrument was novel futsal sports-specific training that combined specific futsal training and plyometrics three days a week, for eight weeks. The instruments used to collect data were the standard simple reaction time task to assess processing speed, and the standard cognitive flexibility test consisted of a trail-making test part A and trail-making test part B. Descriptive statistics including percentages, means, standard deviations, and inferential statistics; including one-way analysis of variance with repeated measures and the Bonferroni test. Statistical significance was set at the 0.05 level.

Results: The results found that when conducting a one-way ANOVA with repeated measures, both processing speed and cognitive flexibility were significantly different before, during the 4th week and after the 8th week of training. Comparing the mean pair, it was found that both processing speed and cognitive flexibility decreased significantly before and after the 4th week, before and after the 8th week, and after the 4th week and after the 8th week.

Conclusion: Futsal players' performance is influenced by a sophisticated program called: 'Novel futsal sports-specific training', which focuses on cognitive intelligence traits; including cognitive flexibility and processing speed.

Keywords: cognitive flexibility, futsal sports-specific program, plyometrics, processing speed

Contact: Thanyawat Homsombat, Ph.D.
Faculty of Sports Science and Health, Thailand National Sports University,
Udon Thani Campus, Udon Thani 41000, Thailand.
E-mail: cmu_kku@hotmail.com

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Introduction

Futsal is a popular sport around the world that is similar to indoor football. According to the International Football Federation (the Federation International de Football Association; FIFA), futsal is in both male and female professional and amateur categories[1]. There are 5 players per team on the field, with 1 of the 5 being the goalkeeper. The match is divided into two halves of 20 minutes each, on a field measuring 15–25 meters wide and 25–42 meters long. During the competition, each athlete has a total running distance of at least 4,500 meters[2], and in 1 minute, each athlete performs approximately 9-speed directions of high-intensity exercise every 23 seconds[3]. There is an average maximum heart rate of 85–90% of HRmax and 75% of an average maximum oxygen consumption[4]. Futsal is mostly an aerobic sport; however, it starts with a high-intensity workout wherein the participant uses their anaerobic metabolism to get the most energy possible. For these reasons, the nature of the futsal game is that athletes use energy from an aerobic system developed from an anaerobic system[5].

According to experimental and clinical studies, it has been reported that sports-specific programs induce structural and functional changes in the human cerebellum[6]. Similarly, a study by Best (2019)[7] found that children between the ages of 7 and adolescence that engaged in moderate-intensity aerobic exercise result in increased amounts of gray matter and myelin. The frontal lobes increase the speed and accuracy of processing, working memory, and response inhibition. In addition, Kun and Toth (2019)[8] conducted a study on the cognitive intelligence of youth football players and found that children who played football had to sort, classify, and organize the information they perceived. Hence, they developed the ability to understand the connection between information and the use of formal thinking. Adolescent football players are not only able to respond to the game and apply the technical rules, but they also train in tactical perception and cognitive intelligence, which can improve their perception. There are also studies that indicate that aerobic exercise is strongly associated with increased cognitive intelligence[9]. On the contrary, anaerobic exercise has been found to have a significant effect on processing speed and cognitive flexibility. There are also studies that confirm that exercise has a positive effect on brain function in adults[10], children[11], and adolescents[12]. However, the relationship between exercise and brain function is a complex mechanism, as there are avariety of exercise programs, intensities, durations, ages, physical fitness, and brain function measurement methods[13]. Some studies have found that bouts of exercise lasting up to 45 minutes have no positive effect on working memory[14]. Only one study has confirmed that moderate-intensity exercise for 60 minutes has an effect on the brain's inhibitory control[14]. However, there are no studies that have studied exercise durations longer than 1 hour in adolescents, due to the difficulty in preparing experimental equipment for testing in schools currently not very convenient. Recent studies have reported that high-intensity interval training for sprinting, change of directions, basketball performance, and football ability is positively related to cognitive intelligence; especially knowledge, working memory, and cognitive flexibility[13]. In addition, some studies have found that futsal competition for up to 20 minutes at a high intensity can increase cognitive intelligence; especially inhibitory control[13]; however, there are no studies on working memory.

Sports cognitive intelligence is strongly defined as the ability to reason for the highest goal, plan team play, solve problems in real-life situations, think abstractly, comprehend complex thinking, learn and respond quickly as well as learn from previous experience[15]. Sports cognitive intelligence consists of processing speed and cognitive flexibility; the general definition of processing speed is the brain's ability to receive, comprehend, and react to information quickly. The capacity to vocally recall information from long-term memory in response to verbal or visual cues is commonly referred to as verbal processing speed. It is also known as fluency in verbal responses to information. Cognitive flexibility is truly defined as skills that allow people to switch between different concepts, adapt their behavior to changing environments, and adjust strategies to make the best decisions. Athletes with cognitive flexibility know that what they are doing does not always lead to success and know how to adjust their behavior to achieve that goal[16]. Previous studies have demonstrated the important role of cognitive intelligence, or so-called sports intelligence, despite its popularity; however, few studies have focused on the intellectual abilities of futsal athletes. Because futsal athlete training is considered a combination of strength, speed, change of direction, and the functioning of the neuromuscular system, most of these previous studies discussed game analysis or players' physiological needs during futsal playing and training[17]. However, few studies have investigated the effectiveness of futsal sports-specific programs in relation to the cognitive intelligence of futsal athletes. This may result in futsal athletes having more intellectual ability and being able to remember playing patterns more effectively than less intellectually talented players[18]. Moreover, having the intellectual abilities of futsal players may help coaches convey useful information to the players more easily.

Therefore, the researcher was investigating the effects of a novel futsal sports-specific program on cognitive intelligence before and after the 4th and 8th weeks of training in youth male futsal athletes. The hypothesis that a novel futsal sports-specific program results in the cognitive intelligence of youth male futsal athletes in Sakon Nakhon Province after the 4th week and after the 8th week of training was different. Despite the importance of developing knowledge, there is still a need for personnel who need to study and understand every aspect of knowledge continuously and thoroughly, so that sports personnel; particularly futsal, can apply it appropriately.

Material and Methods

Participants

This study was approved by the Institutional Review Board of Thailand National Sports University: No. 081/2565 in Thailand, and was conducted in accordance with the Declaration of Helsinki.

This study included twenty-six youth futsal players aged between 15 and 17 that were registered as athletes of the Sakon Nakhon Province Sports Association. In summary, selecting youth futsal players aged 15 to 17 as the target population allows researchers to investigate the intersection of neuromuscular coordination. By focusing on this age group, the study can provide valuable insights for improving training strategies, reducing injury risks, and maximizing the athletic potential of young futsal players. Systematic random sampling was from this formula; $k=\frac{240}{16}$ =15; therefore, athletes with numbers 1, 16 (1+15), 31 (16+15), 46 (31+15) and 61 (46+16) will be the sample and the samples will be randomly drawn systematically until the number is reached; as derived from the calculation formula. This is used to estimate the mean population size in cases where the population size is known[19]. Specified confidence (1.96), is the variance (0.60)[20], d is the effect size value (2.54); with an estimated influence size value (0.5)[21], and n is the population (313). To prevent dropout, the researcher increased the sample size by 30 percent, resulting in a new sample size of 26. The calculation formula is as follows:

$$n=\frac{NZ_{a/2}^{2}\sigma^{2}}{d^{2}(N-1)+Z_{a/2}^{2}\sigma^{2}} \qquad n=\frac{313(1.96^{2})6^{2}}{2.54^{2}(313-1)+1.96^{2}(6^{2})}$$

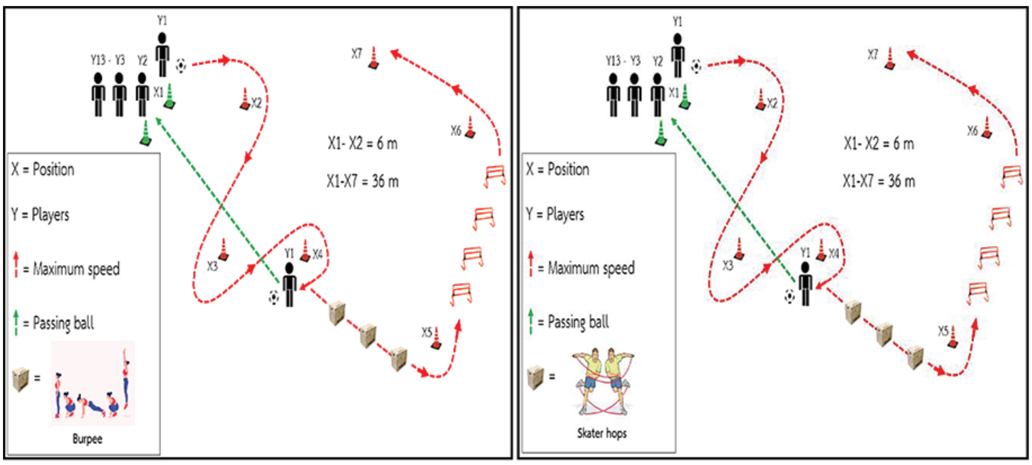
Intervention

The futsal sports-specific program training was performed three times per week for 8 weeks (Monday, Wednesday, and Friday). Initially, players were warmed up at 50–60% of HRmax and 6–8 of the rating of perceived exertion (RPE) for 10 minutes, then during weeks 1–2 they performed futsal sports-specific program training at 60–70% of HRmax and 9–11 of RPE. During weeks 3–8 they performed futsal sports-specific training at 70–80% of HRmax and 12–16 of RPE for 40 minutes and cooled down for 10 minutes. The RPE scale is a presentation of the perceived exertion scale (Borg RPE 15 points, 6–20)[20]. The minimum effort should elicit a rating of 6 (absence of any effort), while an RPE rating of 19 should elicit the maximum effort required to perform maximum repetitions (extremely hard).

Each week, players performed program 1 (20 minutes), followed by program 2 (20 minutes), which was then divided into 4 groups (6-7 players each): standing at designated points X1, X2, X3, X4 and X5.

Program 1: Firstly, start with player 1 of each group (Y1) they dribble the ball at maximum speed around the cones of positions X1, X2, and X3, then stop the ball at position X4. Then they pass the ball back to the next player (Y2) at position X1, then speed to position X5 while performing skater hops. After this, they maintain maximum speed to position X6 while performing high knee raises, then they proceed at maximum speed to position X7 before returning to the end of the line to wait for the next round of training. Finally, the next players (Y2-Y13) perform the same as player Y1 until everyone has completed the tasks within the specified time (Figure 1a).

Program 2: Firstly, starting with player 1 of each group (Y1), they dribble the ball at maximum speed around the cones at positions X1, X2, and X3, then stop the ball at position X4, and pass the ball back to next player (Y2) at position X1, then speed to position X5, while performing burpees. After this, at maximum speed, they proceed to position X6 while performing high knee raises. They then, again at maximum speed, move to position X7 and return to the end of the line to wait for the next round of training. Finally, the next players (Y2-Y13) perform the same as player Y1 until everyone has completed this within the specified time (Figure 1b).



1a 1b

figure 1 The futsal sports-specific program training

Outcome measurement

Initially, the participants were evaluated for processing speed and cognitive flexibility, which consists of trail-making test parts A (TMT A) and B (TMT B) by a Computerized Cognitive Test Battery[21]. Across all variables, the participants took measurements using standardized protocols (pre-test), and all variables were re-evaluated at 4 weeks and 8 weeks.

1. The Simple reaction time task is used to assess brain processing speed abilities. The testing method has the following details: First, the participants must look at the computer screen, and whenever the red circle appears in the middle of the computer screen, participants must press the "/" key on the computer keyboard with their index finger as quickly as possible. The target objects (stimuli) will appear a total of 20 times. The results that will be used in the analysis are the average response time of the correct response and the accuracy rate (%).

2. The cognitive flexibility test is a test of inhibiting or switching thoughts, consisting of trail-making test part A (TMT A) and trail-making test part B (TMT B). Created and developed by the Adjutant General's Office, War Department, US Army as part of the Halstead-Reitan battery test[21] (Zhongmi et al., 2021, pp.1–18).

2.1 The TMT A test involves participants drawing lines of numbers in order from least to highest, 1 to 25, for example, starting from number 1, connecting to number 2, then connecting to number 3, etc. Data is recorded by measuring the time from drawing the lines from the starting point and connecting the numbers in sequence until the last number in sequence (seconds) (Figure 2).

2.2 The TMT B test involves participants drawing a series of numbers alternating with letters. The numbers are 1–13, and the letters are A–L. For example, start the line with the number 1, which is a number, and link to the letter A, followed by the number 2, and link to the letter B in that order until the specified number is completed. Data is recorded by measuring the time taken from the line to the starting point and connecting the numbers in order until the last one (seconds) (Figure 2).

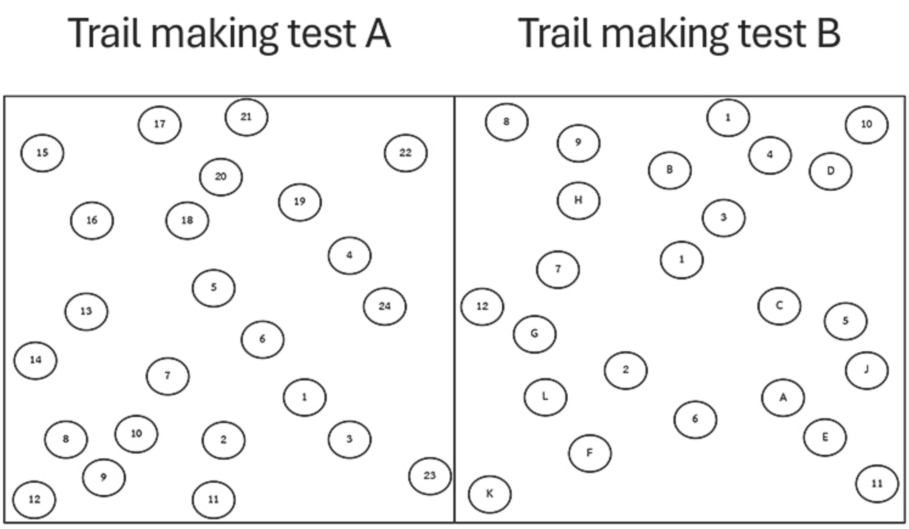


Figure 2 Trail-making test part A (TMT A), Trail-making test part B (TMT B)

Statistical analysis

Statistical analysis used STATA 13 (Texas, USA, 2007). The Swilk test was used to test the normal distribution of values. Descriptive statistics included: frequency, percentage, mean, and standard deviation to express age, body mass index (BMI), and futsal experience. The inferential statistic was a one-way ANOVA, with repeated measures and a Bonferroni test to compare processing speed as well as TMT A and TMT B before, after the 4th week, and after the 8th week of training (post-test), at a 95% confidence interval. We used α=0.05 as the cut-off point for statistical significance.

Results

The assumption test results found that processing speed and cognitive flexibility have normal distributions (p-value=0.74 and 0.14, respectively), which is in accordance with the assumption of using parametric statistics.

Characteristics

The players had an average age of 16.81 (S.D.=0.40), an average weight of 60.66 kilograms (S.D.=4.76), an average height of 169.92 centimeters (S.D.=5.61), an average body mass index of 20.99 (S.D.=0.98), and 3.46 years of experience playing futsal (S.D.=0.51)

Heart rate and rating of perceived exertion

During exercise, players had their heart rates increased accordingly; from 149 to 163 beats per minute (bpm) (63.90–64.1% of HRmax) in weeks 1-2, and in weeks 3–8, the average heart rate while exercising was 163–176 times per minute (75.18–76.69% of HRmax). They had a rating of perceived exertion of 9.80–10.07 in weeks 1–2, and in weeks 3–8, the average rating of perceived exertion while exercising was 12.88–15.11.

Processing speed

The average processing speed in simple reaction time before training was 304.38; after the 4th week, it was 282.23, and after the 8th week, it was 257.42. The ability to achieve accuracy before training was 92.88%; after the 4th week, it was 97.69%; and after the 8th week, it was 98.65%.

Cognitive flexibility

The cognitive flexibility in trail-making test part A before training was 33.00; after the 4th week, it was 30.58; and after the 8th week, it was 28.40. Trail-making test part B before training was 68.09; after the 4th week, it was 62.13; and after the 8th week, it was 56.99.

Comparison of cognitive intelligence by one-way ANOVA with repeated measures

One-way ANOVA with repeated measures comparison found that both intellectual intelligence in processing speed (p-value<0.001) and trail-making test part A (p-value=0.007) and trail-making test part B (p-value<0.001) before training, after the 4th week, and after the 8th week were significantly different. Therefore, the means had to be compared for each pair using the Bonferroni test (Table 1).

The bonferroni test

Comparing the mean pair of processing speeds by the Bonferroni test found that, before and after week 4, before and after week 8, and after week 4 and after week 8, there was a significant decrease (p-value<0.001, p-value<0.001, and p-value<0.001, respectively) (Figure 3). Trail-making test part A found that, only before and after week 8, there had been a significant decrease (p-value=0.004) (Figure 3). Trail-making test part B found that, only before and after week 8, there was a significant decrease (p-value<0.001) (Figure 3).

Table 1 Comparison of cognitive intelligence by one-way ANOVA with repeated measures

Source	SS	df	MS	F	p-value
Processing speed					
Within group	28700.54	2	14350.27	31.18	0.000
Error	34513.11	75	460.18		
Total	63213.65	77			
Cognitive flexibility					
Trail making test part A					
Within group	275.50	2	137.75	5.37	0.007
Error	1923.39	75	25.65		
Total	2198.89	77			
Trail making test part B					
Within group	1601.90	2	800.95	8.738	0.000
Error	6874.75	75	91.66		
Total	8476.65	77			

SS=the sum of squares, df=degrees of Freedom, MS=mean squares, F=F ratio

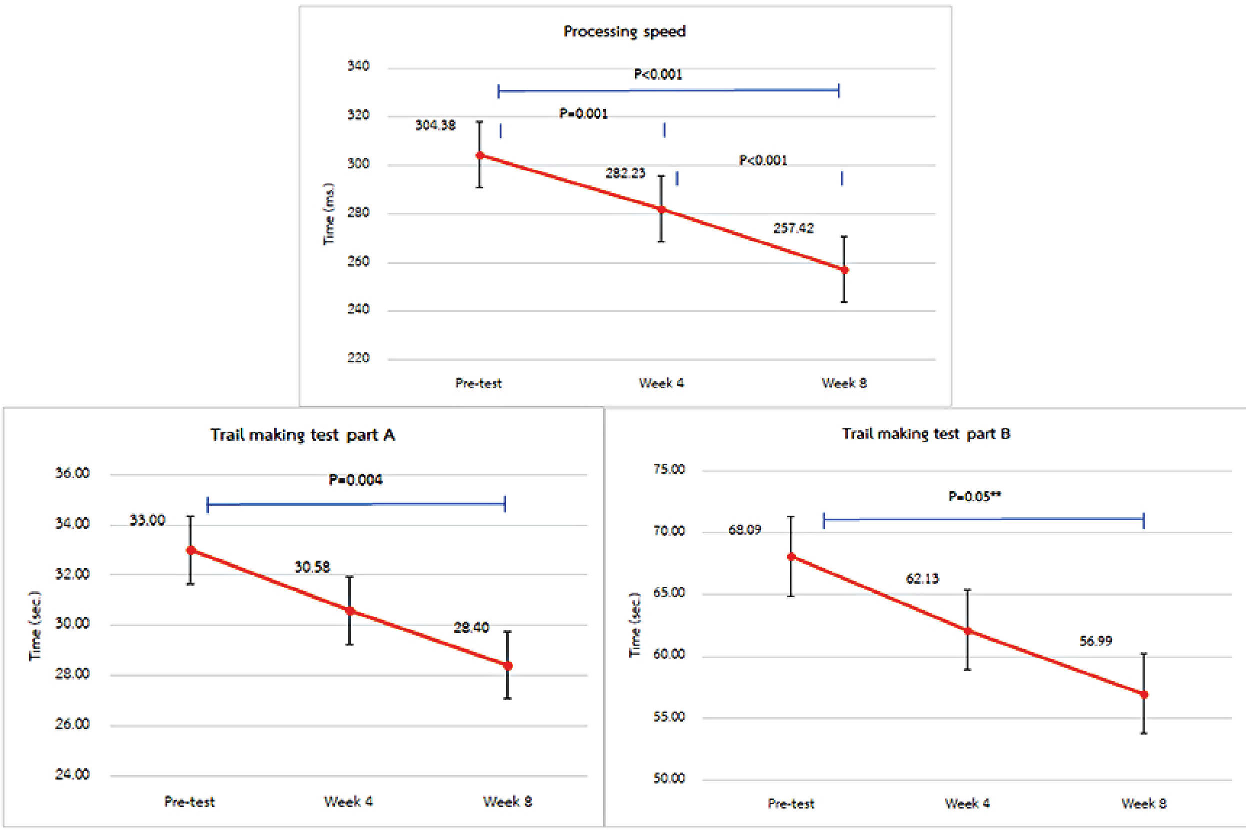


Figure 3 Processing speed of A) Trail making part A, and B) Trail making part B

Discussion

A one-way repeated-measures ANOVA test on processing speed, utilizing a simple reaction time test and cognitive flexibility in both trail-making test part A and trail making test part B during before training, after the 4th week, and 8th week, showed significantly different differences. Therefore, the means must be compared by pair using Bonferroni's method, which found that processing speed between before the 4th week and the 8th week of training, showed the 4th week and the 8th week decreased as statistically significantly because futsal-specific programs are futsal-specific programs combined with plyometrics at a moderate-to-high intensity exercise. Heart rates during exercising on weeks 1–8 were increased accordingly. In weeks 1-2, the average heart rate during exercising was 149–163 bpm (63.90–65.41% of HRmax), in weeks 3-8, the average heart rate during exercising was 163–176 bpm (75.18–76.69% of HRmax). The rating of perceived exertion between weeks 1–8 increased accordingly. In weeks 1-2, the average rating of perceived exertion was 9.80–10.07, and weeks 3–8 had an average rating of perceived exertion of 12.88–15.11. Exercise directly promotes cognitive intelligence by increasing the functioning of the nervous system, the number of nerve cells increases and increases the speed of transmission of nerve impulse signals[22], so regular exercise can indirectly increase the level of cognitive intelligence of athletes by increasing the quality of sleep, reducing stress and anxiety levels; including cardiovascular fitness[23]. In addition, it also increases memory levels and the learning process in healthy middle-aged athletes. During exercise, cellular mechanisms at the molecular level of the nervous system occur, including growth factors such as brain-derived neurotrophic factor (BDNF). The role of BDNF is to increase the number of nerve cells and the speed of transmission of nerve impulse signals; additionally, including preventing injury to nerve cells and the degeneration of nerve cells[24]. The action of BDNF in the hippocampus promotes the formation of new neurons from stem cells and the combination of new neurons with existing nerve cells, causing the transmission of nerve signals to be faster[14]. A cross-sectional study found that increased physical fitness was positively related to cognitive intelligence. Nevertheless, long-term studies have found that cognitive intelligence is slightly impaired in the areas of working memory, processing speed, intention, and management[25]. Some studies have found that aerobic exercise can improve cognitive and executive abilities. In addition, resistance exercise, learning movement skills, and exercise to increase the relationship between the nervous system and muscles all have an effect on intellectual ability[15]. A previous study of magnetic resonance imaging (MRI) brain found that exercise and good physical fitness in athletes are negatively associated with reductions in the hippocampus, gray matter, and white matter of the brain[7]. Moreover, aerobic exercise can increase hippocampus and cortical activity as well as increase cognitive flexibility after one year of exercise[8]. Some studies have assessed the cognitive intelligence of professional youth soccer players whence competing in competitions and noted they have higher cognitive flexibility than amateur athletes[26]. Moreover, some studies have found that cognitive intelligence is related to athletic success in youth football players. However, the knowledge gained from previous studies has limited studies on exercise programs associated with changes in cognitive intelligence in youth futsal athletes. Most of them focus on studies of football athletes only. In a study by Alesi et al.[27] that showed the effects of a football training program on the nervous system and cognitive intelligence of youth aged 7–11 years, their results found that athletes can increase both cognitive flexibility and processing speed, which includes both simple reaction time and optional reaction time. Casella et al.[28] studied the effects of sports-specific cognitive intelligence training programs on the planning ability and visual response to stimuli in youth football athletes. The results found that both the experimental and control groups had increased visual response skills and planning abilities. These results indicate that training that requires sports-specific cognitive intelligence has a positive effect on those abilities[29]. The results confirmed that the experimental group had increased cognitive intelligence more than the control group due to an increase in planning abilities and preparation; a process that will enable athletes to succeed in achieving their goals. This includes controlling the management process and being able to understand; including checking the memory that results in success. According to Alesi et al.[27] they found that specific football training has an effect on planning and inhibitory control skills. These results are in accordance with the conceptual framework of playing football. That is, skills will only occur when athletes are competing and must both think and plan. Moreover, passing a soccer ball with a goal is a gesture that requires a high level of cognitive intelligence, together with restraint control, perceptual skills, and coordination skills[25]. In fact, when competing in football, every athlete needs to analyze the games that are emerging from previous competition experiences; including new possibilities, make quick decisions on them, and plan accordingly. All of this will happen in a short time, and every athlete must have a strong emotional capacity in a pressurized environment[26].

Conclusion

A futsal sport-specific program combined with plyometrics results indicated an increase in processing speed and cognitive flexibility. Because, these sport-specific programs require a lot of wit, finesse, and immediate problem-solving during competition, they affect the brain's fast processing, resulting in better decision-making.

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Conflict of interest

No conflicts of interest.

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