

EFFECTS OF CORE-PROPRIOCEPTIVE TRAINING ON THE QUALITY OF EXECUTIVE FUNCTIONS IN U13 FEMALE BASKETBALL PLAYERS

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Abstract

Introduction: Complex scientific work to investigate and develop the factors determining performance is essential to improving sports performance. Creating the neuro-muscular connection is paramount, as it is the cornerstone of movement coordination, and the nervous system is the key to mental components.

Objective: Our study aims to demonstrate the positive effects of core-proprioceptive training on executive functions.

Method: The DEAC U13 girls' academy basketball players (n=12) participated in a 9-week core-proprioceptive training program. Before and after the program, the players' executive functions were measured with the Vienna Test System.

Result: A marked improvement in the measured parameters regarding the evolution of correct and incorrect responses and the reaction time. There is a significant reduction in the number of missed responses.

Conclusions: Core-proprioceptive training also improved nerve-muscle connectivity, affecting the quality of executive functions. The results may be implemented in designing training program.

Keywords: *executive functions, core-proprioceptive training, performance enhancement*



INTRODUCTION

Several factors influence sports performance, none of which are negligible; for an athlete to perform well, whether, in training or a competitive situation, it is essential to balance physical, mental, and environmental factors. A key component in enhancing performance is providing high quality and complex scientific background.

It is no longer enough to rely on the experience and routine of a coach and the talent of the athlete. In addition to measuring and developing motor skills, choosing the right tactics, and consciously structuring training sessions, it is also essential to monitor and train psychological factors.

Our previous research examined and demonstrated an inverse relationship between cognitive ability and physical activity. Still, it is crucial to be precise about the type of physical activity, as different training can have other effects.

The brain must process and correctly respond to a range of proprioceptive information. The quality of this information is crucial for the quality of sports performance. Proprioception has been defined as the ability of an individual to determine the position and movement of body segments in space based on sensory signals (from muscle, joint, and skin receptors to the brain) (GOBLE, 2010). Proprioception, or joint position sense, plays a vital role in the dynamic stability and protection of the joint. Joint stabilization requires the co-activation of agonist and antagonist muscles. There is no single definition in the literature; several authors have tried to define proprioception and kinesthesia. Proprioception is the conscious and involuntary perception of joint position. Kinesthesia is the sense of displacement and acceleration of joints. There are four critical elements of restoring neuromuscular control and functional stability. These are the functioning of proprioception and kinesiology, dynamic stability, the characteristics of preparatory and response muscle actions, and conscious and subconscious (reflex) motor patterns." (SZABÓ, 2009) Researchers have not yet clarified the peripheral and central mechanisms behind proprioceptive control, but peripheral adaptation and neural plasticity play a significant role. (GOBLE, 2009; ASHTON-MILLER, 2001; RIBEIRO, 2007; RIBEIRO, 2011; PROSKE, 2012; HAN, 2014). The importance of this ability has been demonstrated in the prevention of sports injuries, post-injury rehabilitation, and selection (HAN, 2016; LIN., 2006). The executive function(s) (EF) is a cognitive construct (SCHNEIDER, 2005). Their joint functioning enables conscious behavior and regulation and thus plays an important role in higher-order cognitive processes.

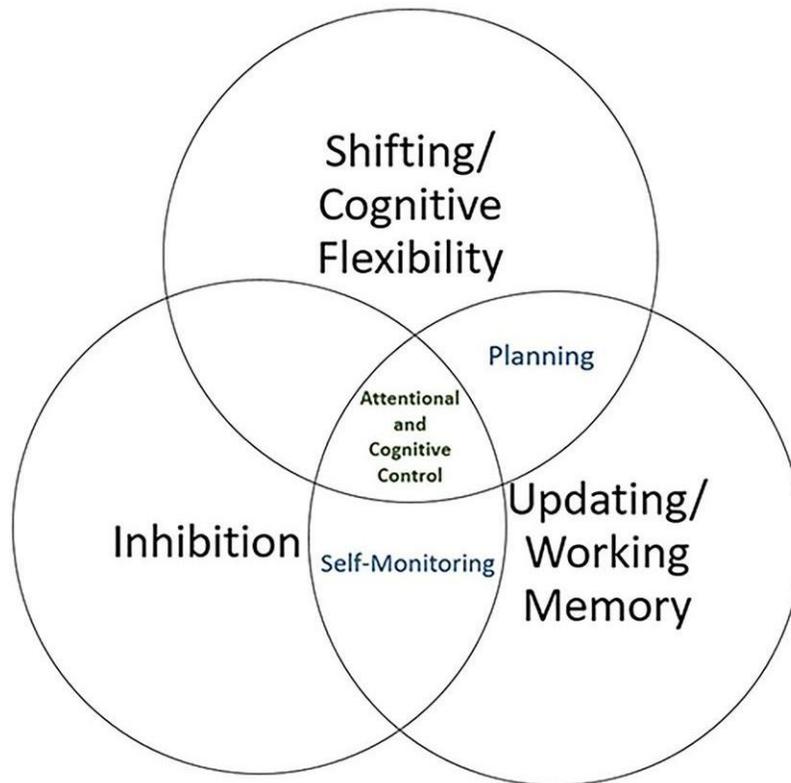


Figure 1: Components of executive function

Source: CLARK et al., 2021

Figure 1 shows the components of the executive functions. Scholars have not yet managed to come up with a unified definition, but they have agreed on three main pillars (ZELAZO et al., 2016; JÓZSA et al., 2018):

- Working memory
It helps us to track information and ideas and use them.
- Inhibition
These include self-control, inhibition of inappropriate behavior, selective attention, and cognitive control.
- Cognitive
This means being able to choose between the paths to a solution and even switch between strategies.

All the qualities mentioned above are essential to respond appropriately to a stimulus or situation on the field. Janacsek et al. (2012) found that from adolescence (age 12) onwards, model-based learning is dominant (explicit). Regarding its neural background, the prefrontal cortex and mediotemporal lobes are involved in education, along with the basal ganglia. Our previous research (MAKRA-BALOGH, 2018) examined and confirmed an inverse relationship between cognitive ability and physical activity. Still, it is essential to be precise

about the type of physical activity, as different training can have other effects. BDNF (Brain-Derived Neurotrophic Factor) was also mentioned. It contributes to the proper functioning of the nervous system and promotes brain plasticity. A decreased BDNF causes Alzheimer's disease, depression, and faster aging. This protein level can be increased. Mainly through lifestyle changes, sunbathing, an active social lifestyle, abstaining from harmful addictions, and, above all, good and regular exercise. So, we can conclude that PA stimulates BDNF, thus the well-being of the nervous system and cognitive abilities, the development of possible diseases, and its rapid deterioration. "(MAKRA-BALOGH, 2018)

There is a large body of research on the effects of physical activity on executive functions. However, the focus is mainly on a study group with some cognitive impairment. Golzari et al. (2019) found that a mind-body exercise program had a positive effect on executive function in 20 older people with cognitive impairment ($p < 0.05$). Another study (SHARON, 2016) investigated the effect of a 9-week sensorimotor exercise program on executive function in older adults with Parkinson's disease ($n=17$, mean age 71 ± 9) and found a positive effect. This is a vital area, as motor skills decline with age. (XU et al., 2015) Previous research on similar subjects with PD also confirms that physical activity, aerobic, combined, and cycling exercise programs can lead to improvements in the quality of endocrine function (FABIAN et al., 2015; DUCHESNE et al., 2015; NADEAU et al., 2017; TANAKA et al., 2009; KAMIJO et al., 2010)

As seen in the studies mentioned above, they mainly focused on older people. Another survey of older adults found that aerobic exercise improves the quality of executive functions and the neural efficiency of related brain areas (HSU et al., 2018)

RESEARCH QUESTIONS

HYPOTHESES

(Q1)

Are there any improvement regarding the reaction time in basketball players, after the completion of the core-proprioceptive training program?

[H1]

We assume that it will improve, both in terms of omitted rate and reaction time.

(Q2)

Are there any changes regarding the correctness of the responses using the VTS system?

[H2]

We assume that the number of correct responses will increase, and the number of incorrect responses will decrease (Table 1.).

Table 1: Research questions and hypotheses

Research questions	Hypotheses
(Q1) Are there any improvement regarding the reaction time in basketball players, after the completion of the core-proprioceptive training program,	[H1] We assume that it will improve, both in terms of omitted rate and reaction time.
(Q2) Are there any changes regarding the correctness of the responses using the VTS system?	[H2] We assume that the number of correct responses will increase and the number of incorrect responses will decrease.

Source: own source

METHODS

Our preliminary literature search has demonstrated that the study of the effects of physical activity and different training programs on executive functions is incomplete. Studies have been mainly conducted among people with some form of cognitive impairment and the elderly. For this reason, it was considered essential to include young people and elite athletes.

Our participants were the U13 girls' basketball players of the Debrecen Sportcentrum and the Debrecen Basketball Academy. They were continuously participating in advanced training. All members of the tested group volunteered to take part in the measurements and were nominated by the coach. The inclusion criteria were regular attendance at training sessions and injury-free status. The study involved twelve participants.

The players trained 4x1.5 hours per week, and in addition, they had to participate in a 40-minute core stabilization and proprioceptive training session. The entire training session lasted for nine weeks, twice a week, and was conducted by a physiotherapy student.

We started each session with a warm-up, which took about 15 minutes. This was to prepare the body for the increased workload, activate the muscles and central nervous system, and raise the heart rate. Moving from proximal to distal, we mobilized the joints. The core-

proprioceptive training, consisted of a 30–40-minute circuit with four stations. The exercise duration increased by 5 seconds per week. Depending on the number of participants, they were divided into groups of 2-3. The main goal was to increase the stabilizing function of the spine and to improve coordination skills. We used different tools to make the exercises more colorful and difficult. Our main tools were TRX, Bosu, Elastic bands, and Fit-ball. Body weight exercises were performed on unstable surfaces, so core muscles were stabilized. Increasing the strength and stability of the muscles around the lumbar spine contributes to the athlete's improved performance, and therefore it is important to develop lumbar motor control. At the beginning of each exercise, the correct posture, essential for executing the activities, had to be maintained. We always tried to correct incorrect postures, thus focusing on proper execution. We also used various sport-specific exercises, such as passing, ball passing, and dribbling while standing on an unstable surface, thus developing the basic skills necessary for basketball. At the end of the drills, we had a cool-down session, focusing on stretching the muscle groups used during the tournament. The main objective was to relax the body and restore the pulse, which was achieved through breathing exercises and stretching. Regular stretching helps the muscles to function correctly. Without it, the muscles become shortened, with limited range of motion and performance. Before and after the exercise session, the Vienna Test System (VTS), a psychological test system developed by Schuhfried, including the DT package, was used to measure executive functions. The Determination Test requires the discrimination of colors and acoustic cues, the memorization of their assignment rules and response buttons, and the correct response as quickly as possible. The program obtains the athlete's test's omitted, correct, incorrect, and median reaction time values.

STATISTICAL ANALYSIS

The data were evaluated using TIBCO Statistica. First, a normality test was performed, followed by a two-sample T-test or a nonparametric test according to the values obtained.

RESULTS

The average number of missed stimuli before the program was 20.5 ± 5.67 , which decreased to 13.17 ± 7.63 at the end of the program. This decrease is significant ($p=0.023$). This result shows that the training program positively affected the quality of perceptual-perceptual and thus cognitive skills, as well as executive functions (Figure 1).

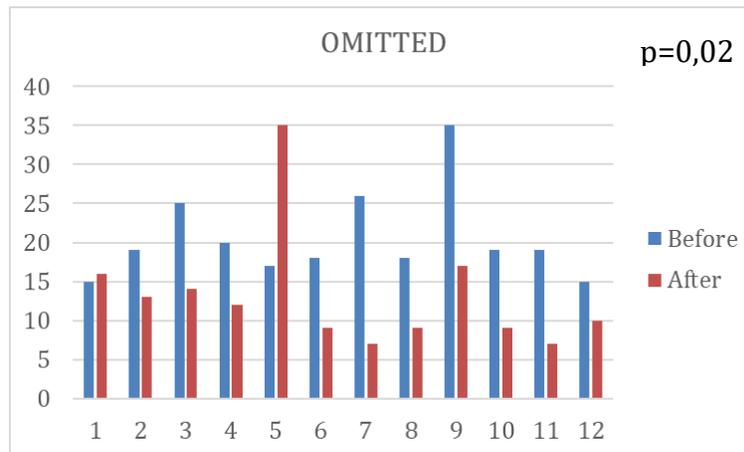


Figure 1: Number of omitted reactions

Source: own graph

There was a marked change in the number of incorrect responses ($p=0.683$), with 25.42 ± 19.98 before and 22.25 ± 12.9 after the measurement. The decrease in the number of incorrect answers with an increasing number of responses suggests that most decisions are correct. Thus, both working memory and cognitive flexibility improved (Figure 2)

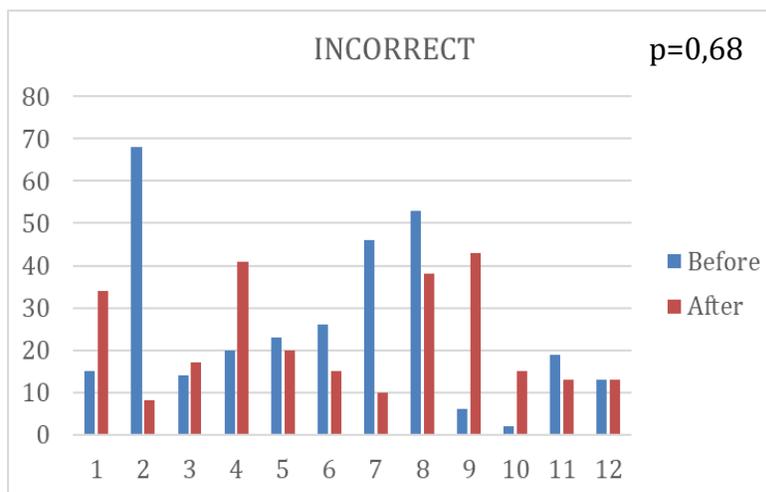


Figure 2: Number of incorrect responses; Source: own graph

The reaction times decreased from 0.79 ± 0.09 seconds to 0.73 ± 0.07 seconds ($p=0.386$). This sub-result is not significant, but it is a considerable improvement. The ability to produce more responses in the same amount of time and with fewer incorrect responses almost implies an improvement in response time, which can be seen at the trend level (Figure 3)



Figure 3: Reaction time

Source: own graph

There was a trend improvement in the number of correct answers ($p=0.076$), increasing from an average of 241.75 ± 37.81 to 268.5 ± 39.59 . This result also follows from the above (Figure 4)

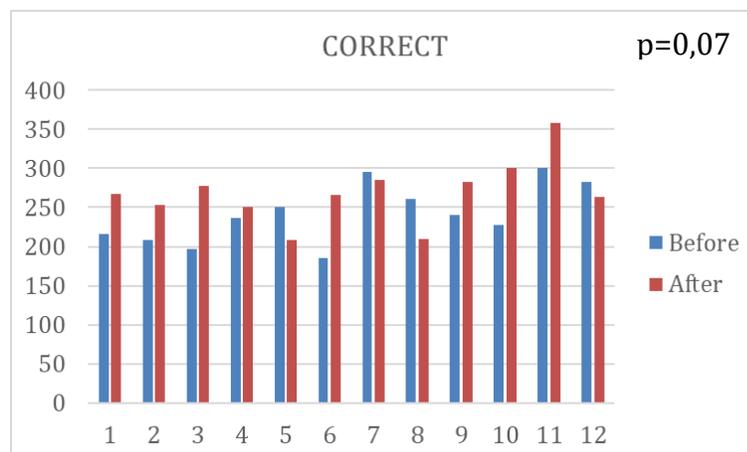


Figure 4: Number of correct responses

Source: own graph

Based on the results presented above, our hypotheses are as follows.

Our first hypothesis that the number of missed reactions and the reaction time will be improved among the parameters measured with VTS is confirmed by the above results.

Our second hypothesis is that the number of correct answers will increase, and the number of incorrect answers will decrease during the follow-up of the core-proprioceptive training. This hypothesis was also confirmed.

DISCUSSION

Overall, it can be concluded that our functional core training positively affected the quality of executive functions. It is essential to measure and improve these parameters properly, as mental preparedness will be the decisive factor in determining "who will be better." The quality of working memory, inhibition, and cognitive flexibility dramatically influences the performance of elite athletes in both training and training, in addition to the quality of everyday life.

Once a nine week targeted core-proprioceptive program has produced positive quantitative results in the above parameters, it may be motivated to incorporate this program systematically and consciously into all training work from the junior to the adult age group. This will also help to improve performance and prevent injuries.

We believe that by increasing the number of subjects, we can obtain even more robust results.

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