The effect of practicing skills with different coordination requirements on the executive functions of 9 to 10 year old girls

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Abstract

The aim of this study was to determine the effect of practicing skills with different coordination requirements (soccer, volleyball and golf) in terms of physical and intra-team interactions on children’s cognitive functions and compare them with each other.

Introduction

Childhood is the most important and sensitive period for cognitive and physical changes and its end is associated with the most biological, mental and social changes (1,2). Past research has shown that regular exercise, while improving physical function through increasing muscle mass and bone density, improves executive functions by increasing blood flow and oxygenation to the brain (3). Some studies have also shown that children with high levels of fitness and physical activity have larger volumes of hippocampus and cerebral ganglia, and these areas, in turn, are associated with executive functions (4,5).

In most studies, the effect of activities on executive functions from its physiological aspect, such as aerobic or anaerobic, intensity, duration and frequency have been investigated (7,6). In this regard, Chaddock (2011) showed that aerobic activity levels are directly related to children’s executive functions (8) and Davis (2015) reported in their review study that although children’s physical activity levels are related to improving their executive functions, factors such as the type of activity or the length of its sessions must also be considered (9). It seems that the type of activity is somehow related to the types of cognitive-social processes required, because examining the types of activities in terms of social cognitive needs and determining how social interactions intervene with other features has been proposed to further influence cognitive functions (6,8,10,11).

When examining activities in terms of social interactions, it can be seen that in team skills, the existence of dynamism and complexity of the environment, the strong interdependence of tasks and the need to coordinate individual actions according to team goals, increase coordination needs (12) and therefore affect cognitive processes and cognitive coordination between team members is likely to lead to cognitive changes (12,13). However, in individual sports, the success of the athlete depends on the individual’s own abilities, and unlike group sports, the criteria for performance are one-dimensional. In individual skills, athletes focus on themselves and in a calm environment, practice and strengthen their abilities and are less affected by the dynamics of the environment (14). Reimer (2006) stated that team sports require more coordination because of placing people under high work pressure or time constraints and preventing the team from interacting and communicating in the presence of the opposing team, and are likely to involve more cognitive activity. For example, in team sports such as soccer and handball, the pressure of the opposing team is direct and accompanied by physical contact (an indicator of interaction), but not in team volleyball (12).

Another approach in the field of sports activities and their impact on executive functions is to classify them in terms of the required cognitive complexity, level of social interaction and coordination needs, into two
mindful and mindless categories. For example, running or walking are categorized as mindless activities due to the lack of cognitive complexities in learning and performance (15) and some researchers believe that these activities can not cause significant cognitive changes (15). However, it has been reported that practicing skills with mental involvement (mindful activities) that have a high level of cognitive complexity and individual interactions can make more cognitive changes (15).

Previously, Chang (2012) reported positive effects by examining this mental conflict through studying the effect of coordinated activities and different intensities on children’s executive functions (16). Meng (2019) also showed that, to achieve their strategic goals, activities with interpersonal coordination requirements, such as team sports, affect executive functions more than individual sports without mental involvement (mindless) (17). However, evidence of the effect of mindless activities on the improvement of executive functions (18) has led to the need to study the impact of activities with different mental conflicts on executive functions, especially in terms of levels of social interaction and interpersonal coordination (4,6,15,18).

One of the factors influencing the cognitive and social complexities of the team environment is the number and type of communication between members, which leads to interpersonal coordination in sports teams. According to the social cognitive perspective, interpersonal coordination in teams occurs through the acquisition of shared knowledge between members. In the process of knowledge transfer, the information must first be retrieved from the sender’s memory and, according to the situation, the necessary changes must be made in it and new information must be encrypted. The encrypted message is sent through communication channels and then decrypted and interpreted by the recipients through cognitive processes (19). Bluma (2018) considers the acquisition of common knowledge before and during the game and its exchange between members through communication links to be dependent on the type of sport and the performance environment (4). In addition, Eccles (2007) believes that the number of players on sports teams and the obstacles created by members of the opposing team can be effective on the interaction of information and communication between team players and the increase in number of people and the types of interactions and direct physical contacts will increase the coordination requirements and level of social interaction of sports (13).

Different levels of social interaction and interpersonal coordination in sports lead to different cognitive loads. For example, soccer creates more mental conflict and cognitive burden in terms of social interaction than volleyball due to the larger number of members and direct contact with the opposing team (20).

Among the variables or cognitive factors, three main and intertwined skills of inhibitory control, working memory and cognitive flexibility have been considered in studies (21). Inhibitory control is our selective control over the surrounding stimuli or the selection of stimuli from the environment that we must respond to or ignore. In addition to storing information, working memory helps to perform several other operations in the mind at the same time and helps to use the information stored in the mind. Working memory is very important for reasoning and problem solving because maintaining information, examining information relationships with each other, separating and recombining elements requires working memory performance (22). Executive functions play an important role in the process of information transfer and communication between team members, as well as in the acquisition of shared knowledge that is necessary for the coordination of team processes between individuals (12) and it seems that participating in activities with different levels of coordination requirements and social interaction has different effects on the use and changes of cognitive factors (17,18,23,24,25,27).

Past studies have provided conflicting evidence on the impact of a variety of activities, including activities with different social cognitive complexities, on improving executive functions. For example, Pesce (2011, 2016) showed that activities with more cognitive requirements have a greater impact on children’s cognitive functions such as inhibitory control, working memory and attention (26,27). However, Meng et al. (2019), by studying the effect of volleyball and individual badminton on executive functions, showed that strategic team sports increase inhibitory control and attention while interactive badminton only improves memory performance (17). According to these researchers, each type of activity can have different effects on different executive functions based on its cognitive and social characteristics. While acknowledging the effects of
physical activity on children’s cognitive function, Davis (2015) points to the need to examine the impact of the inherent challenges of different types of activity on neurological mechanisms to determine whether these mechanisms are affected solely by movement or activities with inherent cognitive challenges improve cognitive functions (9). De Greeff (2018), in a review study, confirms that the effect of long-term activities with cognitive involvement is more effective than other activities on working memory and inhibitory control of children (23). Diamond (2016) also considered the impact of activities with different types of cognitive engagement more than other activities, but Takacs (2019) stated in a review study that activities with more social cognitive dimension do not have a greater impact on children’s executive and cognitive skills compared to other activities, and Hillman (2019) did not consider the effect of activities with cognitive involvement on children’s executive functions to be more than other activities (15,18,28).

In general, several studies, while emphasizing the need for further research on the role of activities with different coordination requirements in increasing cognitive performance, have suggested that the impact of various coordination activities in terms of levels of social interaction, especially on the two components of working memory and inhibitory control should be compared in children in order to identify the most effective training methods to improve executive functions and, consequently, to develop other mental abilities (4,17,22,27,28). Therefore, the aim of this study was to compare the effect of skills training with different coordination requirements on working memory and inhibitory control of 9 to 10 year old girls.

Study Methodology

Participants: In this study, a group of 34 children between the ages of 9-10 were selected from a girl’s primary school in Tehran. Criteria for inclusion in the study were: 1- Obtaining parental consent for children to participate in entrance, exit and total training courses 2- Checking the medical record and not having any physical or mental problems and not having serious injuries in the past year 3 - Not having obesity 4- No problems of attention 5- No talent and motor-sports, space and social intelligence deficiencies 6- Lack of professional training experience in any of the fields of volleyball, soccer and golf. Inclusion criteria were evaluated using a medical health record that identifies mentally and physically healthy children, calculates BMI through height and weight information that none of the children are obese, D2 attention test for Diagnosis of Attention Problems and Children’s Sports Talent Questionnaire, which is filled in by the physical education teacher at school and is in the children’s health record (children are included in the study who have obtained a minimum score of 100 out of a maximum score of 120). Control criteria: a) similarity of training intensity through heart rate control during training, b) division of people into three groups (soccer 12 people), volleyball (12 people), and golf (10 people) based on their interest in sports through watching videos of related sports. All children were familiar with the basic exercises of shooting, dribbling, passing, paw, forearm, simple volleyball service and golf club hitting.

Measuring tools

The BMI was assessed by measuring height and weight, and the inclusion criteria for the study included a maximum BMI of 22 (below excessive obesity). To assess attention, D2 attention test was used and the results were in accordance with the standardized forms of children aged 9-10 years in Tehran. Its standard score had to be higher than 35. Intelligence was assessed through the educational file and the results of the questionnaire for identifying sports intelligence, spatial intelligence and social intelligence, which according to the assessments of children were already included in their health records and only those who had at least 100 points from 120 could participate in the study. To evaluate the changes in working memory, in the first session and the last session, the working memory digit span test was used (29). The method of performing the memory test was that the child performed consecutive movements up and down a step with a height of twenty centimeters. Ten seconds after the start of the movement, numbers were played to him by voice and he had to repeat the numbers again after the announcement. The number of digits of the numbers provided by the voice was added by one from one attempt to another. The interval between the presentation of each digit from a set was one second. The test was continued until the child failed to repeat the number heard after two consecutive attempts. The correct number of repetitions of the number set by the child was recorded as a criterion for assessing memory.
The D2 selective attention test was used to evaluate the performance of inhibitory control. This test evaluates and compares the inhibitory control status of the subjects before and after the intervention period by evaluating the three components of information processing speed, accuracy and attention that can be calculated separately. This test consists of 14 rows of 47 signs each and the subject has twenty seconds to recognize and mark the desired signs in the row out of 47 signs. The same operation was repeated in the next twenty seconds for the next rows. The total number of correctly discovered signs and the subject’s errors were calculated and converted into standard scores for each individual by the standardized norms. Exercise intensity was assessed by a Polar coach 10 minutes after each activity so that the heart rate had to be between 60 and 80% of maximum heart rate. For the age group of 9 to 10 years, 60 to 80% of the maximum heart rate was 126 to 168 beats per minute. If more or less of this heart rate was displayed, participants were encouraged to do less activity or try harder.

Procedure

This research was conducted as a comparison design of three groups with pre-test-post-test measurement method. Subjects were randomly divided into three intervention groups: soccer, volleyball and golf, and in the second session, all of them underwent pre-tests to measure memory function and balance. Then, in the final session (two days after 20 sessions of intervention training) post-test was taken. The first session was dedicated to reviewing the inclusion criteria, justifying parents and children and obtaining consent to participate in the training course. After receiving the consent, the inclusion criteria were assessed by measuring BMI, medical records, Wechsler intelligence and attention tests. The second session and the final session were dedicated to memory test and inhibitory control test (D2) and in 20 intervention sessions, the following exercises were performed.

Training sessions were held three times a week for two months. The training duration of each session was 75 minutes, and each of the volleyball, soccer and golf training groups performed the main exercise independently for 40 minutes after 20 minutes of warm-up, then ended with 15 minutes of cooling. All children were familiar with the basics of shooting, dribbling, passing, clawing, forearm, simple volleyball service, and golf club hitting, but had not experienced continuous play and competition in any of the disciplines, and the training intensity was the same in all training groups and was measured by measuring the heart rate during games, so that every 10 minutes the heart rate was taken by a polar watch. If the heart rate was less than 60 percent or more than 80 percent of each participant’s maximum heart rate, by encouraging more activity or reducing activity by scoring, the heart rate drops to 60 to 80 percent of the maximum heart rate (126 to 168 beats per minute). Warm-up included dynamic stretching, jumping, and introductory exercises in each discipline (soccer: pass, shot; volleyball: claw, forearm, serve; golf: stick grip, balance exercises, impact). After warming up, the members of the soccer group played as two teams of 6 people, on a field measuring 15 × 25 meters, with a standard ball and the goal dimensions of 1.5 × 3 meters. The playing time in each half was fifteen minutes and there was a 10 minute break between the two halves. During breaks, each team was able to consult with team members about team goals, plans and tactics, and all children were familiar with playing soccer, but none had any professional playing experience or previous training experience. In each session of the volleyball training group, after warming up as 4 teams of three, they practiced in pairs on a mini volleyball court with dimensions of 4.5 × 9 meters with a net height of 1.60 meters and with a special mini volleyball ball. The game was played in 3 sets of 10 minutes with 5 minute break intervals. During breaks each team consulted with team members about goals, and team strategies. All the children were familiar with playing volleyball, but none of them had professional playing experience or long practice sessions.

In the golf training group, each child played independently but in interaction with other people. Meetings were held on the ground with variable dimensions of 20 × 40 covered with artificial grass and with standard wood and balls for children. In each session, after warming up, the person hit for 60 minutes in a row and moved in the form of walking and running along the ground.

Intensity of exercise during the game was controlled by measuring the heart rate. All exercise groups had a heart rate between 60 and 80% at every 10 minute measurement. Two days after the last training session
the post-test was carried out.

The present study was conducted experimentally with a pretest-posttest design. Due to the small sample size in each group and due to the abnormal distribution of data in each group, non-parametric analyzes were used. The effect of activity training on inhibitory control and memory was assessed with the Wilcoxon test, comparison of exercises was investigated by examining the difference between pretest-posttest data and one-way analysis of variance and LSD post hoc test at a significance level of 0.05.

Results

Table 1 presents the personal characteristics of the participants. The results of the Shapirovilk test in Table 2 show that the distribution of primary data among training groups was not normal.

Table 1. Personal characteristics of the participants

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Age</th>
<th>Height</th>
<th>Weight</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soccer</td>
<td>12</td>
<td>9</td>
<td>135±7</td>
<td>33±6</td>
<td>17±2</td>
</tr>
<tr>
<td>Volleyball</td>
<td>12</td>
<td>9</td>
<td>138±7</td>
<td>33±8</td>
<td>17±2</td>
</tr>
<tr>
<td>Golf</td>
<td>10</td>
<td>9</td>
<td>139±7</td>
<td>35±9</td>
<td>18±3</td>
</tr>
</tbody>
</table>

Also, the results of the Shapiro-Wilk test showed that the distribution of initial data among training groups was not normal (Table 2).

Table 2. Results of the normality of the distribution of research variables (Shapiro-Wilk test)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Asymp.sig.tailed</th>
<th>Processing speed</th>
<th>Accuracy</th>
<th>Attention span</th>
<th>Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body mass index</td>
<td>0.000</td>
<td>0.038</td>
<td>0.003</td>
<td>0.009</td>
<td>0.000</td>
</tr>
<tr>
<td>Processing speed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention span</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Distribution of data is not normal

Table 3. Comparison of pre-test and post-test data of groups in cognitive variables

<table>
<thead>
<tr>
<th>Group</th>
<th>Memory Pre-test</th>
<th>Processing speed Pre-test</th>
<th>Accuracy Pre-test</th>
<th>Attention span Pre-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soccer</td>
<td>8±1</td>
<td>35±6</td>
<td>39±2</td>
<td>40±3</td>
</tr>
<tr>
<td></td>
<td>12±2</td>
<td>46±9</td>
<td>39±2</td>
<td>45±4</td>
</tr>
<tr>
<td>P</td>
<td>0.0.0*</td>
<td>0.002*</td>
<td>0.0.0*</td>
<td>0.002*</td>
</tr>
<tr>
<td>Volleyball</td>
<td>7±1</td>
<td>36±5</td>
<td>38±2</td>
<td>40±3</td>
</tr>
<tr>
<td></td>
<td>10±2</td>
<td>46±7</td>
<td>38±1</td>
<td>45±3</td>
</tr>
<tr>
<td>P</td>
<td>0.002*</td>
<td>0.005*</td>
<td>0.00*</td>
<td>0.002*</td>
</tr>
<tr>
<td>Golf</td>
<td>7±1.03</td>
<td>33±5</td>
<td>40±3</td>
<td>39±3</td>
</tr>
<tr>
<td></td>
<td>9±1</td>
<td>43±5</td>
<td>37±3</td>
<td>44±2</td>
</tr>
<tr>
<td>P</td>
<td>0.031*</td>
<td>0.005*</td>
<td>0.041*</td>
<td>0.005*</td>
</tr>
</tbody>
</table>

In Table 3, the difference in performance between pre-test and post-test showed that training in all three training groups of soccer, volleyball and golf is effective in increasing memory, processing speed, accuracy and attention span.

Table 4. Intergroup comparison of training disciplines in each of the cognitive variables
D= mean difference of data between pre-test and post-test, R= Range of data changes

As can be seen in Table 4, there was a significant difference between the groups’ performance in memory tests (P = 0.000), processing speed (P = 0.000) and attention span (P = 0.000), but there was no significant difference in attention accuracy (P = 0.072).

Comparison of D (difference in average performance of individuals in pre-test and post-test) of training groups for each of the cognitive components (working memory, processing speed and attention span) in Table 4 shows that the soccer training group had the most changes in processing speed and power compared to the volleyball and golf training groups. Comparison of D in training groups for the cognitive component of memory shows that the changes in the soccer group were greater than in golf, but in the soccer and volleyball training groups the value of D is equal, and by comparing R (range of data changes) it can be deduced that memory function also changed more in the soccer training group than in the volleyball group.

Also, a comparison of D in volleyball and golf training groups for each of the cognitive components (working memory, processing speed, and attention span) in Table 4 shows that the volleyball training group had more changes in memory and processing speed than the golf training group. Examination of the cognitive component of the attention span of these two groups had a similar value of D and by comparing R (range of data changes) it can be concluded that the performance of attention span in the volleyball training group was higher than golf.

By comparing the cognitive changes resulting from training in each group, it is concluded that the training group of soccer compared to volleyball and volleyball compared to golf had a greater impact on increasing processing speed, attention and memory.

**Discussion**

In recent years, there has been much discussion about different types of exercise methods suitable for children, and some researchers have studied activities with different cognitive or mental involvement, including coordination exercises. Comparison of the results of the present study showed that long-term practice of skills with different coordination needs, both in terms of physical coordination needs and interpersonal coordination within the team had a different effect on children’s executive function and this is in agreement with previous studies that showed exercise with more coordination needs is more effective.

These results confirm the positive effect of practicing soccer, volleyball and golf activities on executive functions such as working memory, processing speed, accuracy and attention span, and more specifically showed that soccer and volleyball, respectively, increased working memory, processing speed and attention span compared to individual golf. Also, this study showed that the accuracy of attention in all three activities had a relatively uniform increase.

By designing productive exercises through the involvement of factors such as task complexity and social interactions, similar to this study, Pesce (2016) showed that exercises with more cognitive and social challenges, compared to other exercises increased children’s inhibitory control. They also found in another study that the higher the challenge point of cognitive engagement in various ways, including increased coordination requirements, the better executive functions such as attention function in children (26). In a similar study,
Crova (2013) examined the state of the brain through fMRI and concluded that cognitive activities (in open skills), with their inherent mental challenges and social interactions, improve children’s executive function, including inhibitory control of attention (30). This can help justify the effect of open skills and dynamic activities within them in this research. Also, Davis (2011) showed that activities with cognitive involvement such as soccer and basketball have affected the executive functions of children and have increased inhibitory control of their attention. As they point out, social interactions and motor activity improves children’s executive functions through nerve stimulation and neural integration. Therefore, it seems that the improvement in various aspects of the executive functions of this study is due to changes in the pattern of brain activation. These studies consider cognitive improvement to be the result of experiencing purposeful exercises with mental challenge and social interactions. In fact, when children face mental challenges arising from the needs of physical and interpersonal coordination in a sporting activity, they choose, control, and activate appropriate movements to learn and perform that activity properly, and therefore to manage perceptual and motor complexities they will require more executive functions. Adapting to the context and unexpected events of a sport also requires cognitive interpersonal interactions to master the perceptual-motor complexities of the situation (31,28).

However, a number of studies do not consider the effect of activities with cognitive challenges, including activities that require coordination, on improving executive functions to be more than aerobic activities. For example, Hillman (2019), referring to the role of aerobic exercise in increasing executive functions without the need for cognitive activity in them, justifies the increase in brain function by the effect of two mechanisms (18); First, increased blood flow, secretion of neurotrophic factors, and changes in catecholamines, which are more likely to occur during aerobic exercise, and the second mechanism, which helps justify the improvement of the executive functions of the present study and other similar researches, is through the cognitive needs within the activities, including coordination and purposeful activities (32).

According to Davis (2011) and Passos (2016), soccer and volleyball are open skill disciplines in a changing environment, which due to the need for high physical coordination, interpersonal interactions between members to learn and perform movements correctly and adapt and deal with variable conditions of activity require mental calculations and functions, including inhibitory control of attention and memory, and these activities are potential stimuli for brain changes and the creation of efficient brain networks (31,39). Also, Shimada (2018) considers individual golf as a very purposeful activity requiring high levels of physical coordination and great attention, and considers the practice of these characteristics as a factor in improving executive functions (35). In the present study, it can be said that by controlling the effect of activity intensity, the effect of the first mechanism is partially ignored and the improvement of executive functions through the second mechanism can be justified.

Some studies related to the effect of coordination activities on executive functions have focused on a single sport activity. The results of the present study are also consistent with these studies. For example, Chang (2012) demonstrated the effect of 8 weeks of soccer practice on improving children’s attention span and information processing speed. According to this researcher, soccer coordination exercises cause changes in the brain at both cortical and sub-cortical levels, especially the prefrontal cortex, which is related to executive functions. This increases the allocation of attention resources while increasing the speed of cognitive processing (16). In addition, Alesi (2016) showed the effect of 6 months of soccer training on increasing the memory capacity of 9-year-old children. Although the intervention duration of this study was three times that of the present study, in general, it seems that the complex activities of both studies, namely physical and interpersonal coordination exercises, improve executive functions more than simple exercises. According to this researcher, coordination tasks include large and delicate movements along with movement planning in which children must quickly combine existing and past information to make decisions in the shortest time and plan and execute a sequence of familiar and unfamiliar movements. It has also been mentioned that activities such as soccer increase children’s memory due to the need for selective focus and attention to deal with the distractions of the performance environment and the integration of past information with new information (33).
In their studies, Schuchen (2016) and Shimada (2018) attributed the effect of golf on increasing memory capacity to specific social and psychological aspects of this sport activity and the use of cognitive functions in learning its coordination (33,35). In their study on the effect of volleyball on executive functions, similar to the present study, Alves (2013) pointed to the improvement of attention function. According to them, the improvement of attention performance occurs more in activities with unpredictable environment such as team and ball sports (36). Therefore, in the present study, it seems that the mental conflict resulting from the complexity of the task and interpersonal communication in a dynamic environment has increased the performance of attention.

Meng (2019) when comparing the impact of volleyball and badminton sports activities on two aspects of executive functions showed that volleyball training increases the performance of attention and inhibitory control. However, he also noted that badminton, as an interactive solo discipline, has made more changes in processing speed, which is inconsistent with current results showing that volleyball (as a strategic team activity) is more effective at processing data speed than golf (17). Previously, Voss (2010), in a review study, divided sports into three categories: 1) Fixed sports such as running and swimming; 2) Interactive disciplines such as badminton, tennis, fencing, golf, the practice of which is related to coordination with a foreign object such as a racket; 3) Strategic disciplines such as volleyball, soccer, basketball, hockey, etc. According to them, training in these strategic activities requires simultaneous processing of a large amount of information from teammates, opponents, position of the field and the ball, which often includes a wide variety of conditions (37). Contrary to Voss (2010), in the present study, the strategic activities of volleyball and soccer showed a greater role in increasing information processing speed than golf. What is important when comparing activities is to pay attention to the role of social interactions in the development of children’s cognitive functions, because it has been reported that even strategic soccer and volleyball activities are different in terms of cognitive effects. This study showed that the more social interactions and interpersonal coordination required in a sport, the greater the mental challenges and consequently the cognitive effects. This has also been confirmed by Eccles (2007) (13). According to him, activities with more members (teammates and opponents) require more interpersonal coordination, and these create more cognitive and social challenges that are the result of communication links needed to achieve team goals are more effective on children’s cognitive functions (13). Paying attention to the inherent nature of training disciplines in applying the cognitive processes of the brain can help justify the discrepancies between the present findings and the studies of Voss and Meng (2019). This has already been reported in a study by Davis (2008) (38). Based on this, it seems necessary to provide more accurate definitions of team and individual sports activities, taking into account the needs of physical coordination, team and social interactions, as well as their impact on the activation of certain parts of the nervous system.

As a result, interpersonal coordination is formed through communication links between individuals to transfer information and acquire shared knowledge, and the prerequisite for success in team disciplines is the establishment of interpersonal coordination. Practitioners in disciplines that require more interpersonal interactions may be better able to enhance their executive functions. On the other hand, as the needs for physical coordination and social interaction increase, children’s executive functions are likely to be more affected and improved. This study had several limitations that are recommended to be considered in future studies. First, the inherent nature of sports activities or disciplines must be seen as an influential factor in cognitive change and must be controlled more carefully and objectively. For example, a simple suggestion is to compare more similar sports in terms of physical movements and skills. The second limitation of this research is related to the control of activity intensity, which needs to be done with more advanced tools and at more precise activity intervals in the future. Finally, it is recommended that such studies be performed with a larger number of samples from both age and gender groups.

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