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Original Research Article

The Effect of Game on Cognitive Functions and Agility in a Football Cycle in Children Aged 11 to 12 Years

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Abstract

Motor and cognitive in children growth can be influenced by the practice of football. This study was enhanced with a 10-week game program at three sessions per week, which improved children's performance in motor and cognitive functions. We chose as variables for our study; agility as motor skill and mental flexibility, inhibition and visuospatial memory as cognitive functions. The participants (N = 33) were students in a football promotion center with an average age of 11.5. They were divided into two groups, 16 students from the experimental group who performed a play program and 17 students from the control group who had a regular program. The experimental post-test group showed significantly greater gains than the control group on agility measurements, visuospatial memory, mental flexibility and inhibition. In addition, our results were revealed only a correlation between mental flexibility and agility.

Keywords: football, game program, agility, cognitive functions.

INTRODUCTION

Development is a lifelong process and different aspects of development (physical, motor, cognitive, emotional, etc.) are correlated and interdependent in multiple ways. The complex interaction of our genes and our social, cultural and physical environment is what defines us. According to current theories, cognition, perception, motor behaviour and emotions are closely related [1].

In football each action includes a cognitive element. Players make decisions with the brain playing a role in analysing all the stimuli a player is exposed to and allowing players to make the right decisions. Football decisions are naturalistic and dynamic, players must make correct decisions when under pressure, with limited time, during various exercise periods and sometimes with limited resources and information [2, 3].

The required behaviour includes creative decision-making in which precision and speed are at the highest level. Such behaviour helps the football player to «read the game» and to achieve his expectations a priori; these cognitive abilities are called game intelligence in football [4]. In psychology, similar cognitive abilities are called executive functions [5, 6].

Open skill sports, such as football, are defined as those in which players must react in a changing environment in a dynamic, unpredictable and outdoor manner [7]. Players are constantly looking for the best options. The choices made by the players are based on the information they recognize in the context of the match that is the working memory which is the ability to retain and process new information already stored. A player must be able to anticipate and react quickly to the changing situations that occur during a football game, that is, the cognitive flexibility that is the ability to change perspective or attract attention. In addition, a player should be able to cancel a pass for a teammate in case his teammate is suddenly defended. Therefore, players need to be able to quickly suppress their motor responses and make a new decision c-a-d inhibitor control which is the ability to control attention, the behaviour, thoughts and/or emotions of the person concerned to overcome a strong internal predisposition or external distraction, and focus on more adaptive and relevant stimuli [8, 9].

It is widely recognized that complex motor tasks, involving coordination exercises, are more closely related to the cognitive functioning of children than simple motor tasks [10, 11]. Coordination abilities are traditionally recognized to stimulate cerebellum activation on working memory as well as on the speed and accuracy of attention tasks [12]. From this perspective, football has proven to be a physical activity that can improve motor and cognitive growth, respectively [13].

Football is supposed to stimulate coordination and cognitive functions simultaneously. Hitting a moving ball is a high-level action requiring forward control, perception skills and motor coordination [14]. Moreover, football is a physical activity adapted to the increase of perceptive organization, visuospatial memory as well as planning strategies, and not just technical elements [13]. Players are invited to respond quickly and accurately to the actions of their teammates and opponents during the game.

Moreover, according to Silva [15], playful situations (or games) allow the deployment of many mechanisms such as intelligence, observation, critical thinking, the faculty of analysis and synthesis. It will also allow the learner to invest his knowledge and have a better self-esteem. In addition, he will have to be active by acting as a partner with his team and by mobilizing his efforts to help his group win [16]. It is also possible that he takes pleasure in sharing and exchanging, so he will show a positive attitude.

One of the great challenges of playful play is that it makes it possible to circumvent resistance, to give envy, to set in motion, and whatever the nature of the ability to acquire [17]. According to Vauthier [16], the game has many virtues including motivating the learner, facilitating his concentration and his use of memory. When motivated, the learner can take the initiative to work either alone or with the peers of his choice. The game provides learners with opportunities to be motivated and thus foster their academic success.

In light of these theoretical considerations, this study aims to evaluate improvements in cognitive function and agility following a football intervention program enriched by games for 10 weeks and in children aged 11-12 years. We will also examine possible correlations between the cognitive functions tested and agility.

MATERIALS AND METHODS

Participants

This study was conducted through the voluntary participation of 33 students with an average age of 11.5, who were divided into two groups. (17 control group students, 16 experimental group students). All subjects gave their written (free and informed) consent after being informed in advance in detail of the experimental procedure and its constraints before participating and that they could drop out of the study at any time.

Procedure

Our experimental procedure would be based on a teaching/learning program: an intervention program lasting 10 weeks, at the rate of 3 sessions of 50 minutes per week. The sessions included individual and team activities. The intensity and difficulty of the exercises continued to increase to develop the motivation and creativity of young players. We have therefore designed games-based exercises and situations that will require executive functions and visuospatial memory through a diversification of stimuli (colours, numbers, alphabets, geometric shapes, etc.) and agility skills for the experimental group. The control group underwent a regular training program.

It should be noted that after one day of completion of the learning program, the three cognitive tests were retaken for both groups. The agility test was passed individually according to the protocol indicated by its author.

The cognitive function assessment tests

Mental Flexibility: Trail Making Test (TMT)

Refers to the ability to move from one cognitive task to another, from one behaviour to another according to requirements and to reflect on several possibilities at a given time to solve problems and is measured by Trail Making Test (TMT) [18]. For Part A of the task, subjects are instructed to link as quickly as possible 25 circles in ascending order (numbers are indicated inside the circles).

In Part B, they must link the 25 circles as quickly as possible by inserting a number, then a letter, then a number and a letter again, taking the numbers in ascending order and the letters in alphabetical order (1-A-2-B-3-C-4-D-…). The dependent variables measured are the completion times of each part (TMT A and TMT B). The difference between the two times (TMT B-A) is then calculated.

Inhibition: Stroop Test

It is the ability to suppress expression or preparation of information that would disrupt the successful completion of the desired objective and will be measured by Stroop Test version VICTORIA SCWT [19, 5] to assess inhibition. 24 stimuli in each of the three parts: Color map (map A): with squares in four colors, using a pseudo random order. Word Card (Card B): with the colour names printed in the corresponding colours. Word Color Card (Card C): with color names, but printed in different colors, for example, the word "green" printed in blue. It consists in denominating the color of words, some of which are themselves names of colors (which it is therefore to ignore). The task of the subject is to look at each sheet and scroll down the columns, read the words or name the ink colors as quickly as possible. Three scores (Time/Errors. Stroop can be used in children and adults (second to final year) and tests can be done in about five minutes.

Brief Visuospatial Memory Test (BVMT)
Visuospatial Memory Test

This test assesses immediate and long-term visual memory. Visual memory is governed primarily by temporal lobes. The participant is presented with a sheet containing six geometric figures for 10 seconds. As soon as the experimenter removes the sheet, the participant must redraw as accurately as possible and in the same places, the six figures presented (immediate memory). The same process is repeated two more times for a total of three tests (learning). A delayed reminder is made 30 minutes later to allow the participant to redraw the most geometric figures retained in memory, without being shown the sheet again. One point is awarded if the figure is well drawn and another if it is in the right place on the sheet. Immediate memory is therefore calculated on 12 points, learning on 36 and long-term memory also on 12 points [20].

The Agility Test

The test of agility [21] along a circuit with obstacles: from a starting line, the child had to run towards a central cone, turn right and reach the first obstacle 50 cm high, jump on it and immediately pass under the obstacle in the opposite direction, return to the central cone and repeat the procedure for the remaining three cardinal directions. The children were invited to complete this circuit as quickly as possible and without error. Typical mistakes were to reverse the obstacle, get the wrong direction, or not jump. When the child made a mistake, he was asked to repeat the task again. The score was expressed in seconds, measured by stopwatch. The final score combined accuracy and speed of performance.

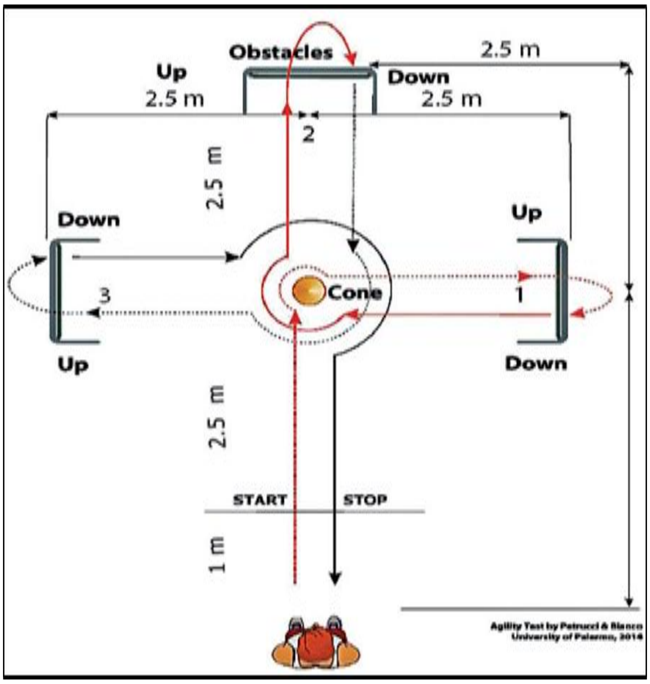

Fig-1: Agility test (derived and modified from Alesi et al. [11] and Alesi et al. [26]).

DATA ANALYSIS

The statistical tests were carried out using the STATISTICA software (StatSoft, France). The data were reported as a mean standard deviation. Once the normality hypothesis was confirmed by the Shapiro-Wilk W test, parametric tests were performed. For each of the analyses, when the ANOVA showed a significant effect, a post-hoc tukey test was applied to compare the experimental data two to two. All observed differences are considered statistically significant for a probability threshold below (p0.05).

RESULTS

Mental flexibility
Trail Making Test (TMT)

The results (mean standard deviations) of mental flexibility are presented in Figure 2. The statistical analysis showed a signficant interaction between the training effect and the group effect (F1.15 = 20.80; p=0.001; ηp2 = 0.58). Post-hoc analysis showed a significant improvement in post-training mental blight for the experimental group (p = 0.000), but without a significant varitaion for the control group (p = 0.38). . Indeed, improvements of 56.8% compared to 8.1% for the control group were noted.

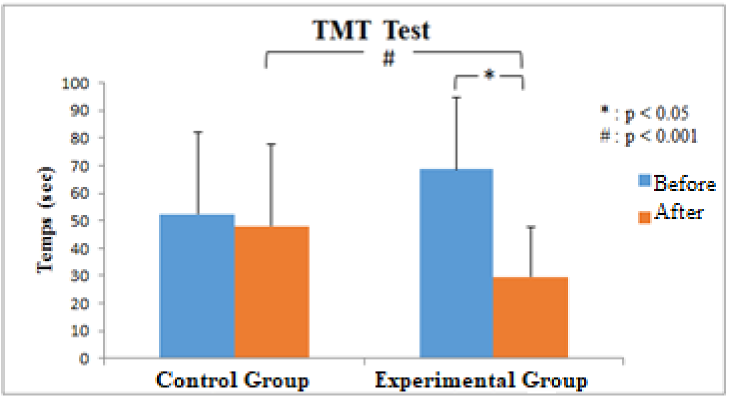

Fig-2: Effect of training on mental flexibility following a game-based program

Visuo-spatial memory

BRIEF Test

The results (mean standard deviations) of the visual-spatial memory are presented in Figure 3. The statistical analysis showed a signficant interaction between the training effect and the group effect ($F1.15 = 17.75$; $p=0.001$; $\eta p2 = 0.54$). Post-hoc analysis showed a significant improvement in visuo-spatial memory after the training period for the experimental group ($p = 0.000$), but without a significant varitaion for the control group ($p = 0.44$). Indeed, improvements of 29.2% compared to 4.3% for group 1 were noted.

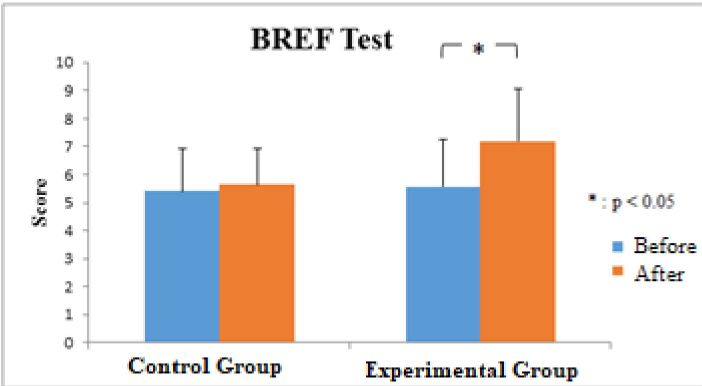

Fig-3: Effect of training on visual-spatial memory following a game-based program

The inhibition

The Test Stroop is presented in the following three boards (Board A, Board B and Board C).

Stroop Test

The results (mean standard deviations) are presented in Table 1. The statistical analysis showed a signficant interaction between the driving effect and the group effect ($F1.15 = 36.38$; $p=0.001$; $\eta p2 = 0.70$). Post-hoc analysis showed a significant improvement after the training period for the experimental group ($p = 0.000$), but without a significant varitaion for the control group ($p = 0.73$). Indeed, improvements of 21.1% were observed for the experimental group compared to 0.9% for the control group.

Table-1: Effect of training on inhibition following a game-based program (Card A)

Card A	Control Group		Experimental Group	
	Before	After	Before	After
Temps	15,6 ± 3,05	15,4± 3,03	16,7 ± 2,68	13,1 ± 1,97 $^{*\#}$
Erreur	0,58 ± 0,71	0,35 ± 0,49	0,62 ± 0,71	0 $^{*\#}$

***: p < 0.05 #: p < 0.001.**

The results (mean standard deviations) are presented in Table 2. The statistical analysis showed a signficant interaction between the driving effect and the group effect ($F1.15 = 10.15$; $p=0.001$; $\eta p2 = 0.40$). Post-hoc analysis showed a significant improvement after the training period for the experimental group ($p = 0.000$), but without a significant varitaion for the control group ($p = 0.64$). Indeed, improvements of 17.9% were observed for the experimental group compared to 1.8% for the control group.

Table-2: Effect of training on inhibition following a game-based program (Card B).

Card B	Control Group		Experimental Group	
	Before	**After**	**Before**	**After**
Temps	12,4 ± 3,16	12,2 ± 3,16	12,7 ± 3,51	10,4 ± 1,69 *#
Erreur	0,35 ± 0,78	0,47 ± 0,71	0,37 ± 0,88	0 *#

*: $p < 0.05$ #: $p < 0.001$.

The results (mean standard deviations) are presented in Table 3. The statistical analysis showed a signficant interaction between the driving effect and the group effect (F1.15 = 25.35; p=0.001; ηp2 = 0.57). Post-hoc analysis showed a significant improvement after the training period for the experimental group (p = 0.000), but without a significant varitaion for the control group (p = 0.69). Indeed, improvements of 20.1% were observed for the experimental group compared to 1.2% for the control group.

Table-3: Effect of training on inhibition following a game-based program (Card C)

Agility Test

Card C	Control Group		Experimental Group	
	Before	**After**	**Before**	**After**
Temps	33,9 ± 6,69	33,5 ± 6,65	35,8 ± 7,8	28,6 ± 8,8 *#
Erreur	3,16 ± 1,6	3 ± 1,2	3,6 ± 1,31	1,37 ± 1,3 *#

***: $p < 0.05$ #: $p < 0.001$.**

Agility Test

The results (mean standard deviations) of relative agility are presented in Figure 4. The statistical analysis showed a signficant interaction between the driving effect and the group effect (F1.15 = 21.59; p=0.001; ηp2 = 0.59). Post-hoc analysis showed a significant improvement in agility after the training period for the experimental and control groups (p = 0.000). Indeed, improvements of 11.1% compared to 3.8% for the control group were noted.

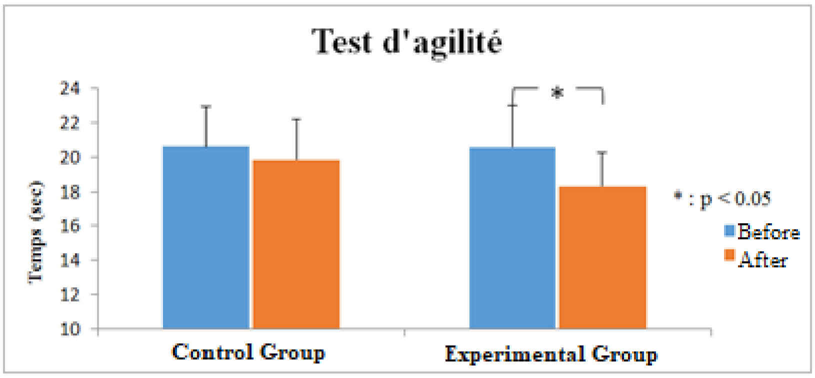

Fig-4: Effect of training on agility following a game-based program

Correlation

Statistical analysis showed a positive correlation between mental wiltness and agility performance after training (R= 0.51; p = 0.04) and no correlation for visual spatial memory (R= -0.21; p= 0.44) and for inhibition in all three maps (Chart A: R= -0, 21; p= 0,44/ Chart B: R= -0,15; p= 0,57/ Chart C: R= -0,31; p= 0,24).

DISCUSSION

The objective of our study is to examine the improvement of cognitive functions, and agility following a game-based intervention program in a football cycle with students from a promotion center aged 11 to 12 years. In addition, the study also aims to find a correlation between the functions tested and agility. This study explored the importance of executive functions (inhibition and mental flexibility) in predicting a student's motor and cognitive development. Indeed, the post-test experimental group showed significantly greater gains than the control group in measures of inhibition and mental flexibility. This is consistent with Torbjørn Vestberg [13], who found that general executive functions are important in football and can even predict success among football players. This sport would seem to be a natural context to stimulate the updating and construction of the space and the inherent information to keep. During a game, the players must deal, more or less at the same time, with the indications of the position and trajectory of the opponents and teammates as well as the location and direction of the movement of the ball. Football is categorized as an open skill sport, characterized by activities played in an outdoor environment rich in entertainers. Thus, this sport should be a powerful challenge to the ability to inhibit distraction and stay focused on helping his team score and prevents the other team from scoring [22]. Alesi [22] suggests that football is classified as a game of reflection and in this study; football seemed to improve inhibition abilities which is the ability to suppress the expression or preparation of information that would disrupt the successful completion of the desired goal. The post-test experimental group showed significantly higher results than the control group on inhibition capacity measurement. In football, the environment is constantly changing and movements must be continually adapted. During a game, each player must plan motor actions, using mental representations to regulate behavior. In addition, the actions must be continually updated and modified due to the actions of teammates, the movement of the ball, the opponents on the football field. During a football game, players must react quickly to teammates and opponents and suspend the execution of a pass, dribble or intentional shot if this is no longer possible due to changing situations on the field. These results are supported by previous studies that have shown similar results between professional and nonathlete volleyball players and highly qualified and low-skilled baseball players [23, 24]. In addition, comparable results were found on motor inhibition abilities among young elite football players (average age 11.9 years) [29].

Regarding mental flexibility, the players of the experimental group outperformed the players of the control group on the B-A difference, the study of Barbara C. H. Huijgen [29] demonstrate better cognitive flexibility skills among football players at a young age. In order to adapt quickly to new demands, rules or priorities based on changing situations on the field, a high perceptual capacity is not sufficient, players must excel in cognitive flexibility, This underlines the importance of “higher level” cognitive processes in football.

Interesting differences were also observed in the improvements in the visuospatial component for the experimental group compared to the control group which seemed to have benefited from the practice of football, as evidenced by the superior improvement of children in the work of Marianna Alesi [22]. This result could be explained by the nature of football activities, which stimulate the components of visual-spatial attention developing during childhood. To be able to search for and select targets from a spatial field, it requires not only selective or focal visual attention, and peripheral visual acuity to shift attention, but also more sophisticated metacognitive strategies [4]. Nevertheless, it seems that this ability can be improved through football training [25].

Another objective of the study was to assess whether children participating in football training three times a week would show an improvement in their agility skills compared to the other group. To do this, changes in agility and executive functioning were compared in one group that practices games-based exercises and the other group that has regular exercises. In the experimental group, significant results were obtained between the pre-test and post-test scores on the agility test. This improvement in agility is not surprising given that the football training program was based on tasks such as jumps, sprints and passing the ball at different distances. All of these exercises alter body movements in space and time and result in coordination skills such as eye-hand or leg-arm coordination, overcoming obstacles and balancing speed and dynamic balance. However, an earlier study demonstrated the effectiveness of this football training program in improving other motor skills such as running and explosive leg performance [27].

A final objective of our study was to assess the association between agility competence and executive functions. As expected, the experimental group showed significant associations to the control group. A significant correlation was found between agility and mental blight. Coordination skills are traditionally recognized to affect the speed and accuracy of attention tasks [12].

In particular, our results suggest that only two participations per week in the football activity by practicing games-based exercises improve the executive functions among players. Recent studies, in which a physical intervention was, conducted five times a week, reported positive effects of the intervention on inhibitory control, work memory and cognitive flexibility in children aged 7 to 9 years [29, 27].

CONCLUSION

The main strength of this study is the planning of a football exercise program as a “natural and enjoyable tool” to stimulate and increase cognitive resources.

Our results showed that football games improve executive functions such as mental flexibility, inhibition and visuospatial memory and agility, Furthermore, our results revealed that the situations played reinforce the correlation between mental flexibility and agility skills.

To conclude, we can say that the game, with an educational objective, is an essential element of learning: it is addressed to the greatest number in terms of its diversity, develops artistic and creative abilities, and participates in the construction of the self by its reference to the imaginary and by a strengthening of the capacity to develop. However, it cannot be an end in itself. The process of integrating the playful aspect, in the first sense of the term, must be accompanied by a “before” and an “after” to promote, in the student, a reflexive analysis of the strategies to be put in place and the skills required to solve tasks.

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