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Comparison of the Effect of Activities Based on Executive and Perceptual-Motor Functions on the Anxiety of 7-9-Year-Old Children: Quasi-Experimental Study

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Original Article

Abstract

Introduction: Performing sports exercises at any age can improve physical and mental health and boost self-confidence. Creating an environment for group and movement games can help enhance children's executive functions and attention. Thus, the present study was conducted to compare the impact of activities based on executive and perceptual-motor functions on the anxiety levels of 9-7-year-old children.

Materials and Methods: The statistical sample of the current research included 3 groups of 20 people, consisting of 10 girls and 10 boys, who were selected through available sampling. The Spence Children's Anxiety Scale (SCAS) was used to measure the children's anxiety levels. The first experimental group performed activities based on executive function in the form of abacus training and practice, and the second experimental group performed perceptual-motor activities in 16 sessions of 45 minutes for 8 weeks (2 sessions per week). The control group had no continuous, purposeful mental, perceptual-motor, or physical activities. At the end of the intervention, a posttest similar to the pretest was performed for all participants. The collected data were analyzed using analysis of covariance, the Bonferroni post hoc test, chi-square test, and Mann-Whitney test in SPSS software at an error level of $\alpha \leq 0.05$.

Results: The results showed that by controlling the effect of the anxiety score in the pretest, the average anxiety score in the executive functions group ($P < 0.001$) and the perceptual-motor functions group ($P = 0.006$) was significantly lower than the control group. However, the average anxiety scores of the two experimental groups were not significantly different ($P = 0.176$).

Conclusion: Since executive and perceptual-motor function activities effectively reduce children's anxiety, it is suggested that these exercises be included in sports and recreational programs for children with anxiety.

Keywords: Executive functions; Perceptual; Motor functions; Anxiety

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Introduction

Raising healthy children, physically and mentally, is one of the top priorities of societies worldwide. It is crucial to provide suitable conditions for their physical, emotional, and intellectual development as it helps guide and strengthen their potential forces toward constructive and transformative actions (1). To achieve this, it is essential to understand children's different physical and mental dimensions and provide appropriate material and spiritual support. Children's psychopathology divides childhood disorders into two categories (2) of internal problems, which are emotional behaviors such as crying, stress, anxiety, and withdrawal, and externalizing problems, which focus on aggressiveness and delinquent behaviors (3). Anxiety is a normal emotion that is warning us of danger and informing us of its imminent presence. However, if this emotion is excessive in intensity, duration, and frequency or is aroused by an unrealistic danger and causes a change in emotional functioning, it is considered a disorder (4).

Executive functions encompass all the complex

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cognitive processes required for performing targeted, difficult, or new tasks (5). These functions include inhibiting responses, planning sequential actions, and maintaining tasks' mental representation through working memory (6). Moreover, perceptual-motor functions refer to all movements that require perception, diagnosis, and decision-making. The range of perceptual-motor abilities varies from simple activities, such as walking, to complex activities, such as maintaining balance on a balance stick (7). Heredity and environment influence this ability and its growth in different proportions. Many experts in the field of perceptual-motor learning believe that motor learning is the origin of all learning, and cognitive processes occur only after appropriate development of the motor and perceptual system, and the integration between movement and perception (8). Perceptual-motor skills play an effective role in receiving, interpreting, and reacting to sensory stimuli, leading to progress in each of the perceptual and motor components. Different senses are integrated with each other in the form of perceptual-motor activities, providing the necessary ability to improve gross motor skills. Passing the sensory-motor and perceptual stages is necessary to enter the cognitive and educational stages. A child with suitable perceptual-motor skills will form a correct body image, develop self-confidence with success in activities, and increase their cognitive activities (9, 10).

The abacus is a tool that children can learn to use to perform mathematical calculations. After becoming familiar with its initial stages, they can imagine and perform the stages in their minds. Unlike traditional education in mathematics (11), which only uses the left hemisphere of the brain, the abacus allows children to use their imagination, and thus, also activate the right hemisphere. By moving the abacus virtually, utilizing the logic of the left hemisphere and combining it with the right hemisphere, children can develop and increase the function of both brain hemispheres. Additionally, video tutorials and other techniques can help students master this method faster (11).

Children between the ages of 7 and 9 are just beginning formal education, which can be challenging. They must spend extended periods away from their families, follow new schedules that may disrupt their play and rest hours, and are faced with new expectations from teachers and family members. Additionally, they may feel pressure to compete for the attention of their teachers and other adults outside of school. Building relationships with relatives and acquaintances or making new friends can also create anxiety for children. Studies have shown that improving executive function can effectively reduce anxiety and improve behavior in children (12-14). However, more detailed research is needed to establish a causal relationship between executive function and anxiety in children. Other studies have identified a connection between perceptual-motor activities, games, and anxiety reduction (17-15). However, it remains unclear which method is more effective. Therefore, this study compared the effects of activities based on improving executive and perceptual-motor function on the anxiety levels of 7-9-year-old children.

Materials and Methods

The current quasi-experimental study was conducted with a pretest-posttest design, 2 experimental groups, and 1 control group. Based on its duration, it is a cross-sectional study, and in terms of its purpose, it is an applied research.. The statistical population of the study included all children between the ages of 7 and 9 years in Isfahan, Iran. Using G*Power statistical software (G*Power 3.1.9.7 freeware, University of Düsseldorf, Düsseldorf, Germany) and considering a significance level of 5% ($\alpha = 0.05$), a power of 80% ($\beta = 0.2$), and a large effect size ($d = 0.5$), the sample size was determined to be 54 children who were divided into 3 groups of 18 (18) with 2 extra participants in each group to account for possible loss. The statistical sample included 10 girls and 10 boys in each group to control for possible gender effects. Moreover, 2 abacus training institutes were randomly selected from among those who expressed their willingness to participate. The participants of experimental group for the executive function were selected from participants in the abacus classes of Radman Institutions and Farhangsarai Bahar in Isfahan. The experimental group for perceptual-motor exercises and the control group were selected from among first-grade to third-grade boys and girls from several elementary schools in Isfahan.

The data for this study was collected in the field during the fall of 2022. The study utilized a demographic questionnaire and the Spence Children's Anxiety Scale (SCAS) (19). None of the participants had learning problems and they were selected based on anxiety symptoms, which were evaluated using the SCAS. The SCAS, developed in Australia, was used to assess anxiety in children between the ages of 7 and 15 years, based on the Diagnostic and Statistical Manual of Mental Disorders-Version IV (DSM-IV) in 1997. The SCAS has two versions, one for children with 45 questions and another for parents with 38 questions. The child's version is scored on a 4-point Likert scale ranging from never (0) to always (3). It consists of the 6 subscales of separation anxiety, social anxiety, practical obsession, panic market phobia, pervasive anxiety, and fear of physical harm. Out of the 45 phrases in this questionnaire, 39 are scored, while 6 are positive questions that are not included in the score calculation. The reliability of this scale has been reported to be 0.92 for general anxiety and 0.60 to 0.82 for other components. In Iran, the correlation level of this scale was reported to be 0.56 to 0.69 after 12 weeks and 0.45 to 0.60 after 6 months. The range of Cronbach's alpha of the SCAS was 0.70-0.80, except for subscale of fear of physical harm, which was 0.60 or lower, and for the overall score, which was 0.90 or higher (18). Another study (19) also reported the questionnaire's reliability between 0.62 and 0.89, using Cronbach's alpha method. The 6 questionnaire factors were confirmed by confirmatory factor analysis.

Before commencing the research, parents and their children were introduced to the study topic, details of the training program, and the method of performing the exercises during a briefing session. After this, the informed consent form was provided to the parents. Once the parents signed the forms, the children were included in the study and randomly assigned to one of the study groups: the first experimental group (activities based on executive function), the second experimental group (perceptual-motor activities), and the third group (the control group that did not receive any intervention). The participants were asked to refrain from engaging in any additional mental or motor activity during the research period and continue their usual daily routine.

Initially, the participants' anxiety levels were measured using the relevant instrument. Subsequently, the first experimental group underwent 2 sessions of 45 minutes per week (16 sessions in total) for 8 weeks, consisting of activities based on executive function in the form of abacus training. The abacus training was led by an experienced person with 4 years of experience working with the abacus (Table 1).

The second experimental group underwent 16 sessions of perceptual-motor activities similar to the conditions of the first experimental group by a researcher with 2 years of work experience (Table 2).

The control group did not engage in any continuous or purposeful perceptual-motor or physical activities. However, after conducting the research, the control group participated in two sessions of perceptual-motor and executive function (abacus) training course. At the end of the intervention, an anxiety posttest, similar to the pretest, was administered to all participants. During the research, children in all groups received the same standard verbal incentives and other rewards for answering. At the end of the study, the children and their parents who cooperated were thanked.

Table 1. Executive function activities (Abacus)

Session	Content of sessions
1	Familiarization with the abacus device and the use of fingers
2	Getting to know the numbers 0, 1, and 2 in the abacus
3	Teaching numbers 3, 4, and 5
4	Teaching numbers 6, 7, 8, and 9
5	Teaching simple two-digit addition and subtraction
6	Teaching addition and subtraction of small friends + Two digits
7	Training session of the small friend (-4)
8	Training of the small friend (-3)
9	Training of the small friend (-2)
10	Training of the small friend (-1)
11	Training of the small friend (-4) two digits
12	Training of the small friend (-3) two digits
13	Training of the small friend (-2) two digits
14	Training of the small friend (-1) two digits
15	Calculations with more rows - bug fixes
16	Final exam

Inferential statistics, analysis of covariance (ANCOVA), the Bonferroni post hoc test, chi-square test, and Mann-Whitney test, was used to compare the distribution of gender and age of children in the three groups. The tests were carried out at a significance level of 5% in SPSS software (version 26; IBM Corp., Armonk, NY, USA).

Results

In the present study, 60 children aged 7 to 9 years were examined in the form of 3 groups of 20 people (executive functions, perceptual motor activities, and control group). Half of the children in each group were girls, and half were boys. The dropout rate was 0 in all three groups. The demographic information of the studied sample is presented in table 3. The chi-square test results did not show any significant differences in the gender distribution of children between the three groups (P = 1.00). According to the Mann-Whitney test, there was no significant difference in the age distribution of children in the three groups (P = 0.913).

The results of measuring children's anxiety in three groups in the pretest and posttest are presented in table 4. According to the study plan, ANCOVA was used to analyze the data. The basic assumptions of this model including normality of data distribution, homogeneity of error variance, and homogeneity of the regression slope were checked and confirmed.

Table 2. Perceptual-motor activities

Session	Content of sessions
1	Introduction - greeting students - emotional connection with students - Amuzenjirbaf game
2	Sitting and walking in a direct and reverse way: Immediate implementation of the examiner's sudden commands after learning, the student's implementation of the commands in reverse
3	Targeting: throwing the ball in the ring, bowling,
4	Walking and running, playing through obstacles, creating shorter distances between obstacles, moving the ball through obstacles, and racing while crossing obstacles Balance games: walking with one leg, and putting a book on the child's head, and asking him/her to follow a path without the book falling
5	Direct and reverse memory games: correctly reciting the names provided by the examiner and then reciting them in reverse order
6	Reciting names in reverse order
7	The game of moving objects: The child looking at the room, and then, leaving the room, and moving the objects when the child is gone
8	Grouping children: putting several colored balls in a basket and several colored sheets on the floor, and the child placing the ball and sheet of the same color on each other
9	Placing two pans of water with a colored ball in front of two children's feet, taking out the ball with the foot without interfering with the hands
10	Placing two children on their backs and giving them access to several Lego models, and one child telling the other behind them how to build a specific Lego model using directions, and the second child trying to replicate the Lego model based on the advice given by the first child
11	Giving balls to two children at a distance to throw into baskets
12	Playing with smart cards
13	Showing two similar images and recognizing similar images and placing them on top of each other
14	The child looking carefully at the environment and memorizing the details, and then, finding the changes made in the environment
15	Asking the child to cross the maze we drew on the floor with chalk in different ways, for example, walking, crawling, or tiptoeing
16	Practicing all the training

The results of ANCOVA showed that the effect of the pretest on the posttest was significant at the 5% error level in the variables of fear of outdoor spaces, separation anxiety, fear of physical harm, social fear, practical obsession, general anxiety, and the total anxiety score ($P < 0.001$).

By controlling the pretest effect in the variables of fear of physical harm ($\eta^2 = 0.063$; $P = 0.161$), social fear ($\eta^2 = 0.031$; $P = 0.419$), and practical obsession ($\eta^2 = 0.040$; $P = 0.321$), no significant difference was observed in the posttest scores of children in the three groups. In the dimensions of fear of outdoor spaces ($\eta^2 = 0.151$; $P = 0.010$), separation anxiety ($\eta^2 = 0.190$; $P = 0.003$), general anxiety ($\eta^2 = 0.196$; $P = 0.002$), $P > 0.999$) and the total score of anxiety ($\eta^2 = 0.325$; $P < 0.001$), there was a significant difference in the mean posttest score of anxiety between the three groups of children. By controlling the effect of the pretest score, the mean score of phobia and fear of open spaces, separation anxiety, general anxiety, and the total anxiety score in the executive functions group was significantly higher than the control group. There was no significant difference between the two groups of executive and perceptual-motor functions. Moreover, the average score of separation anxiety in the perceptual-motor training group was significantly higher than the control group, but there was no significant difference between the perceptual-motor group and the control group in terms of the dimensions of panic and fear of open spaces, general anxiety, and the total anxiety score (Table 4).

Table 3. Frequency distribution of gender and age of children in the three studied groups

Variable	Executive function group	Perceptual motor group	Control group	P-value
Gender [n (%)]				> 0.999
Boys	10 (50)	10 (50)	10 (50)	
Girls	10 (50)	10 (50)	10 (50)	
Age (years) [n (%)]				0.913
7	6 (30)	8 (40)	5 (25)	
8	8 (40)	6 (30)	11 (55)	
9	6 (30)	6 (30)	4 (20)	
Total [n (%)]	20 (100)	20 (100)	20 (100)	-

Table 4. Frequency distribution of gender and age of children in the three studied groups

Variable (score)	Group	Executive function	Perceptual-motor	Control	P-value		
					Executive function group compared to control	Perceptual-motor group compared to the control	Perceptual-motor group compared to executive function
Fear of the outdoors	Pretest	6.55 ± 3.95	5.40 ± 4.49	4.95 ± 3.73	P = 0.003*	P = 0.172	P = 0.078
	Posttest	4.50 ± 3.20	4.85 ± 3.79	5.40 ± 2.76	η^2 = 0.151	η^2 = 0.033	η^2 = 0.076
	Intra-group comparison P-value	≤ 0.001*	0.389	0.389			
Separation anxiety	Pretest	6.60 ± 3.82	6.55 ± 3.91	6.55 ± 3.91	P ≤ 0.001*	P = 0.028*	P = 0.216
	Posttest	3.95 ± 3.19	6.05 ± 3.19	6.05 ± 3.19	η^2 = 0.186	η^2 = 0.083	η^2 = 0.041
	Intra-group comparison P-value	≤ 0.001*	0.010*	0.292			
Fear of physical harm	Pretest	6.36 ± 4.37	5.85 ± 2.89	5.75 ± 2.90	P = 0.559	P = 0.195	P = 0.750
	Posttest	5.30 ± 3.53	6.05 ± 3.15	5.20 ± 2.82	η^2 = 0.006	η^2 = 0.30	η^2 = 0.83
	Intra-group comparison P-value	0.043*	0.674	0.206			
Social fear	Pretest	4.95 ± 2.91	4.35 ± 3.10	3.30 ± 2.75	P = 0.296	P = 0.221	P = 0.801
	Posttest	4.45 ± 2.72	4.00 ± 2.29	4.25 ± 2.97	η^2 = 0.020	η^2 = 0.027	η^2 = 0.002
	Intra-group comparison P-value	0.340	0.603	0.054			
Practical obsession	Pretest	4.25 ± 2.15	3.60 ± 2.37	5.20 ± 2.97	P = 0.124	P = 0.471	P = 0.433
	Posttest	4.00 ± 2.22	4.20 ± 2.42	5.60 ± 3.07	η^2 = 0.040	η^2 = 0.009	η^2 = 0.017
	Intra-group comparison P-value	0.650	0.244	0.525			
General anxiety	Pretest	5.55 ± 2.48	6.30 ± 3.36	4.85 ± 3.36	P = 0.007*	P ≤ 0.001*	P = 0.350
	Posttest	4.15 ± 2.21	4.10 ± 2.40	5.50 ± 3.25	η^2 = 0.122	η^2 = 0.180	η^2 = 0.024
	Intra-group comparison P-value	0.003*	≤ 0.001*	0.333			
Total anxiety score	Pretest	34.25 ± 12.90	31.35 ± 15.53	30.60 ± 7.57	P ≤ 0.001*	P = 0.002*	P = 0.059
	Posttest	26.35 ± 10.64	27.40 ± 10.87	32.00 ± 8.20	η^2 = 0.320	η^2 = 0.158	η^2 = 0.088
	Intra-group comparison P-value	≤ 0.001*	0.034*	0.220			

*$P < 0.05$

Discussion

This research compared the effectiveness of activities based on executive and perceptual-motor functions on the anxiety levels of children aged 7-9 years. The results revealed that such exercises led to a significant reduction in general anxiety scores and those related to fear of open spaces and separation anxiety. The findings of this study were consistent with the previous researches on the subject (12, 18-24).

Studies have shown that cognitive processes such as attention, working memory, and emotional regulation play a crucial role in controlling anxiety levels in children (12-14). Studying the relationship between anxiety level and reaction time as well as accuracy in cognitive tasks is one of the ways to investigate how executive function affects anxiety in children. It has been found that anxiety negatively impacts performance on Inhibition but has no effect on performance on Update, unless the performance itself is stressful in nature (24). Children with anxiety may have weaknesses in executive functions such as attention, working memory, and organizational control (23). Improving executive and perceptual-motor functions can help reduce anxiety levels in healthy children (14) and those with attention deficit hyperactivity disorder (ADHD) (12). Anxiety is a common issue experienced by school-age children with learning problems, and high anxiety levels can negatively impact cognitive and academic performance (23)., which can seriously affect the child's self-confidence and future (14).

Physical exercises and executive functions are effective ways to inhibit anxiety response. These exercises are a type of movement-based cognitive rehabilitation that involves areas of the brain involved in skill execution, including the prefrontal cortex, posterior cortex, and middle temporal regions (15). All these areas are also activated in visual and motor exercises that involve the visual cortex and cerebellum (17). Participating in such physical activities can improve the functions of some brain regions and decrease anxiety levels due to the interconnection of these areas (17).

It has been observed that perceptual-motor exercises have resulted in a significant decrease in anxiety levels in children as compared to the control group. This finding is consistent with the results of the studies by Goodarzi et al., Mostafaie et al., and Runswick et al. (25-27). Anxiety can impact performance through an individual's coping mechanisms (28). Therefore, recognizing the positive (motivational) effects of anxiety can provide a starting point for reducing the adverse effects of anxiety. In other words, anxiety can be a valuable tool for individuals to maintain their performance in anxious conditions, owing to its positive impact on perceptual-motor performance (27). However, anxiety can also destroy the perceptual-motor function, leading to poor performance in situations requiring motor skills (15). Thus, it is vital to provide tools to help individuals maintain their performance in stressful situations (16).

The type of exercise appears to be related to physical anxiety, while the type of exercise does not make a significant difference in the anxiety coping model (28). For instance, individuals who participated in closed-skill exercises, such as swimming and gymnastics, showed higher anxiety scores than those who participated in open-skill exercises, such as ball throwing and soccer. Additionally, concerning worry, distraction, and coping with surrender, individuals with specific skills, such as marathon, performed better than those with general skills, such as flexibility and bodybuilding (28). Understanding the relationship between the type of exercise, anxiety level, and coping styles can be helpful in designing anxiety management plans and strategies. Designing and planning physical activity consistent with each person's perceptual-motor characteristics makes it possible to deal with anxiety and improve overall performance.

A significant difference was observed in the posttest anxiety scores of the groups in the dimensions of separation anxiety, fear of physical harm, social fear, and practical obsession compared to the pretest. These results are consistent with the findings of Mehmanpazir and Farrokhi (29). The age range of 7 to 9 years is a critical stage for children's skill development, and early planning can lead to better success. Successful planning involves paying attention to the most effective components and using their abilities to cultivate most dimensions of human existence (30). Perceptual-motor and executive function training can improve an individual's performance by increasing awareness and emotion regulation, thereby reducing anxiety levels (15). Perceptual-motor training improves executive functions such as attention, performance control, working memory, and behavior regulation, and by increasing concentration and relaxation and facilitating social communication, it can effectively manage and reduce child anxiety (16).

Compared to the control group, activities based on executive functions in the experimental group resulted in reduced anxiety levels in children in the components of panic and fear of open spaces, general anxiety, and the total anxiety score. Therefore, executive functions and perceptual-motor activities can be considered low-cost and low-risk interventions for the reduction of children's anxiety. Thus, this method is recommended for improving executive functions in children with anxiety.

Limitations

This research focused solely on primary school students of 7-9 years of age. Therefore, the findings cannot be generalized to students of other educational levels. To validate the results and increase their applicability to other educational levels, further and more extensive research is necessary in this field, including students of different age groups. Additionally, this study did not include a follow-up phase, and the duration of the beneficial effects of observation was not determined.

Recommendations

Future research could consider a more comprehensive age range to examine differences and patterns of change to ensure the results are generalizable and validated. Additionally, the study's duration could impact the exercises' effectiveness and anxiety reduction. More extended studies of exercises and their effects on children's anxiety could yield more accurate results. Simultaneously recording information from children's parents, teachers, and caregivers can provide valuable insights into children's experiences during the exercises and their impact on their anxiety. In general, it is recommended that future studies identify activities based on executive functions, and suitable games and entertainment for children based on perceptual-motor exercises. These methods should be introduced to schools, cultural centers, and families. Providing the necessary physical conditions and facilities, as well as spiritual support from teachers and coaches for using such games in schools, can be useful in the growth of the young generation. Moreover, it is recommended that the long-term effects of this type of intervention be examined in different age groups, including adolescence, youth, and adulthood, based on the proposed studies' results to increase students' long-term motivation to participate in sports activities. To reduce people's anxiety, perceptual-motor exercises should be continuously planned in school, university, and office programs.

Conclusion

In general, the findings of this research showed that activities based on executive functions can reduce children's anxiety. Therefore, it is suggested that educational centers and children's parents take advantage of abacus classes along with other formal training to improve children's executive functioning due to the availability, low cost, and low risk of these training classes. Furthermore, perceptual-motor exercises reduced general anxiety and the total anxiety score of children. Therefore, it is suggested that suitable games and entertainment for children based on perceptual-motor exercises be identified and made available to different schools and centers for further use and be introduced to families.

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Authors' Contribution

Study design and ideation: Fatemeh Momeni and Zohra Meshkati
Providing financial resources for the Study: Fatemeh Momeni
Scientific and executive support of the Study: Fatemeh Momeni and Zohra Meshkati
Providing equipment and statistical samples: Fatemeh Momeni
Data collection: Fatemeh Momeni
Analysis and interpretation of the results: Fatemeh Momeni and Zohra Meshkati
Specialized statistics services: Zohra Meshkat
Manuscript preparation: Fatemeh Momeni and Zohra Meshkati
Specialized scientific evaluation of the manuscript: Fatemeh Momeni and Zohra Meshkati
Confirmation of the final manuscript to be submitted to the journal: Zohra Meshkati and Fatemeh Momeni
Maintaining the integrity of the study process from the beginning until publication, and responding to the reviewers comments: Fatemeh Momeni and Zohra Meshkati

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Conflict of Interest

The authors have no conflicts of interest. Fatemeh Momeni was a master's student in motor behavior in 2019. Dr. Zohra Meshkati became a faculty member in 2012 and is currently an associate professor in the 19th grade.

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