Research Paper

Retracted Article: The Effect of Paintball Game on Motor Performance, Neuropsychological and Social Skills Children With Attention-deficit/Hyperactivity Disorder

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ABSTRACT

Objective: Attention-deficit/hyperactivity disorder (ADHD) is one of the most common behavioral disorders in children. This study aims to investigate the effect of baseball training on motor and psychological performance and behavioral characteristics of children with attention-deficit/hyperactivity disorder (ADHD).

Methods: To experiment, the sample group was randomly assigned into two experimental and control groups. Fitness and motor test measures, behavioral measures, and neuropsychological tests are performed as a pre-test for both experimental and control groups. Then, the experimental group received baseball training for one month in 12 sessions with an average of 30 minutes, and the control group received no training. After the end of the course, the tests were re-administered on both experimental and control groups. The results of the study show that the mean of the two groups in pre-test is not significantly different; however, in the post-test, a big difference was found between the two experimental and control groups.

Results: Comparing the groups in post-test by subtracting the effect of the pre-test showed a significant difference between the groups (P>0.001), which indicated the effectiveness of exercises and sports activities in reducing behavioral disorders of the experimental group (P>0.001).

Conclusion: The results of this study suggested that the baseball game has a positive impact on all the investigated components. According to the results of the study, to design treatment programs for hyperactive/inattentive children, the use of baseball games in schools and educational centers can be considered. Accordingly, it is suggested that administrators, parents, and trainers in educational centers and educational environments provide sports, such as baseball games so that hyperactive children can benefit the most to strengthen and improve their behavior.

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Highlights

- Effectiveness of exercises and sports activities in reducing behavioral disorders
- Baseball game had a positive impact on all the components investigated
- Design treatment programs for hyperactive/inattentive children, in schools and educational centers.

Plain Language Summary

In this study, the role of parents and families in playing paintball games in open areas on increasing the motor and behavioral performance of children with hyperactivity disorder can be observed. Results of this study demonstrated that paintball training has a positive influence on the behavior and neuropsychological characteristics of children with hyperactivity disorder. Also, individuals involved in sports groups acquire psychological, social, behavioral and communication skills and prepare to appear in personal and social relationships, and in their part, make a constructive response to the behavior of others and reduce abnormal behaviors. In addition, when hyperactive children feel that their existence is valued and they are positively and unconditionally noticed, regardless of their weaknesses, they refrain from engaging in destructive and incompatible behaviors.

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1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common childhood behavioral disorders that has significant effects on the child, family, and society (Español-Martín et al., 2023). Studies related to investigating the prevalence rate of ADHD in Iran have mentioned different prevalence rates but reported an average of 8.72% (Hamidzadeh et al., 2021). Based on the conducted research, children suffering from this disorder show significant problems in terms of education and academic failure, such as low grades, increased rejection and repetition of academic grades, and expulsion from school (Horton, 2023). Most boys with hyperactivity behave unpredictably and do not care what others think or react to their behavior. This group of children shows aggressive behaviors, especially towards their peers, and most of them do not speak until the age of three or are taciturn in the early years of childhood (Fernández-Martín et al., 2023). Girls with hyperactivity are often careless, do not pay attention to the details and issues surrounding them, and in most cases, are weak in learning problem-solving and organization skills (Wender, 1998). Although ADHD causes are not completely known, recent evidence shows defects in dopaminergic pathways of the brain involved in the control of impulsivity and attention (Santos et al., 2022).

In previous studies, various treatment and correction methods have been used about this disorder, among which pharmacological and behavioral treatments can be mentioned (Öst et al., 2015). Treatment methods can affect attention, behavior control, academic performance, and social relations and improve the patient's condition (Taylor et al., 2023). Stimulant medicines, such as methylphenidate Ritalin or amphetamine are relatively effective in treatment. These medicines seem to increase the accessibility of dopamine in the central nervous system (Plumber et al., 2021); however, they do not cause a definite remedy. In addition, these methods have many limitations, including complications, such as hypertension and heart rate, and the non-generalizability of the treatment results to other situations (Shaheen et al., 2023). On the other hand, results of recent studies show that participating in sports exercises has the same effect as medication. This disorder is a crucial issue for psychologists, parents, and teachers, because the behavioral characteristics of affected children, such as the inability to control motor behavior, attention deficit, learning disability, aggression, academic problems, agitation, and movement restlessness, are considered a fundamental problem for parents, peers and school, too, and it also causes serious damage to the development of the child's mental talents, and social-emotional skills (Lyneham & Rapee, 2006). Sports training increases the number of neurotransmitters that increase the accessibility of dopamine in the central nervous system (Arazi et al., 2022). A study reported a very high correlation between doing sports activities and reducing anxiety and behavioral disorders in school children (Biddle & Asare, 2011). Coe et al. also report-

ed similar results and presented that performing various sports activities with different intensity levels improves children's behavioral performance (Coe et al., 2006). The studies of many researchers have proved the positive impact of physical activities on the treatment of anxiety, depression, and stress, and the improvement of individuals' mental state (Mahindru et al., 2023). Studies show that the level of these neurotransmitters increases after participating in sports training (Herrmann et al., 2023). Madigan et al. proposed that exercise therapy can be used as an effective method to reduce the symptoms of ADHD or to reduce the amount of medication used by students with this disorder (Daley, 2002). Also, in the study conducted by Pujalte et al., it was shown that participating in sports therapy programs increases the concentration of people with ADHD, which in turn improves their behavioral problems and social functions (Pujalte et al., 2023). The results of the studies conducted by Tosta et al. on rats with frontal lobe damage, modeling ADHD in humans, showed that without game-play, self-control and other executive functions do not develop properly. Physical play reduces excessive playfulness and impulsivity in rats with frontal lobe damage (Tosta et al., 2023).

Rasulzadeh et al. stated in research that the symptoms of attention deficit and hyperactivity-impulsivity, as the main symptoms of ADHD, were significantly reduced by playing paintball. Also, symptoms related to restlessness, coping, cognitive problems, anxiety and shame, social problems, and psychosomatic problems, as problems associated with this disorder, have been significantly reduced. However, the signs of perfectionism and emotional instability remain intact. It was also observed that the influence of the signs of attention deficit and hyperactivity-impulsivity from playing paintball was the same (Rasulzadeh, 2008). On the other hand, Jalali et al. stated that after the end of the intervention period and checking every eight weeks compared to the beginning of the treatment, the scores of both subscales of attention deficit and hyperactivity/impulsivity decreased under the influence of the exercise program, and with time, the scores decreased (Jalali et al., 2015). Today, given the tremendous advances in medical science and the scientific proof of the relationship between many behavioral abnormalities of children and adolescents with physical physiological disorders, it seems that the educational and training program in schools, especially boys' schools, needs a careful review by new scientific findings. Accordingly, one of the common behavioral disorders called "hyperactivity" in students, especially boys, is investigated to give these children the opportunity to be present in the future of the country and consider non-pharmacological treatments for these children. In a child treated with medicine, when the half-life of the medicine in the body ends, the symptoms return and the child will not have any other use of this treatment except for a series of temporary treatments that cause physical and mental illnesses. For the hyperactive child that we seek to treat using medicine therapy, most of the research has proven that this method of treatment is not correct and causes irreparable harm to the hyperactive child. The social opportunities provided by various types of exercise can act as a positive motivator for individuals with ADHD. Hyperactive children should participate in physical activities to release their extra energy and the best treatment method to control their emotions is to participate in sports activities.

Therefore, it seems to be very necessary to determine the effect of playing paintball on the behavioral and cognitive performance of children with hyperactivity because this disorder exists in some children and the studies conducted on the effectiveness of the game on reducing hyperactivity symptoms are very few. This calls for more work to clarify the different dimensions of the effectiveness of physical activity in improving the symptoms of hyperactivity. Therefore, this research was conducted to examine the effect of paintball games on motor performance, and neuropsychological and behavioral features of children with ADHD.

2. Materials and Methods

The research method is quasi-experimental. The statistical population of this research included 50 children aged 7 to 12 years in Tehran City, Iran in 2020. After determining the inclusion and exclusion criteria, 21 people with sufficient conditions to participate in the training sessions were selected as a sample.

Participants

The statistical population of the present study included 80 male students aged 7-12 years in Tehran City who visited counseling centers and psychological services in three-months and showed ADHD symptoms. The child symptom inventory-4 (CSI-4) questionnaire was distributed among students in coordination and with the help of the counselor and with the consent of their parents. Then 50 students who scored higher than the cut-off point in the disorder section were selected. Among those who did not use medications and according to the personal information questionnaire, had no history of illness, 30 students were selected in a purposeful method and were randomly assigned to two experimental (15) and control (15) groups. The samples are also checked in terms of parents' occupation, education, and economic status.

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Diagnosis

The symptoms of ADHD were compiled through the child symptom inventory-4 (CSI-4) based on diagnostic and statistical manual of mental disorders-fourth edition (DSM-IV) criteria (Allred et al., 2017). This questionnaire has two lists of parents and teachers, which has proven its effectiveness compared to other scales and methods and is a suitable alternative as an acceptable and time-saving psychiatric interview. The researcher has used teachers' version in this research. The sensitivity of the children's morbid symptoms questionnaire based on the cut-off score of 7, 5, and 4 for each of the ADHD is 0.75, 0.89, and 0.89, respectively, and its features are reported 91.92, and 0.0, 0.90, respectively. The reliability of this test was reported as 0.58, 0.73, 0.68, and 0.96 in the study (Mohamadesmaiel & Alipour, 2002).

Paintball training protocol

In this training program, a high-pressure carbon dioxide (CO_2) cylinder is used, driven by this engine at 205 miles per second. Your gun has four parts, the compressed air tank, which is near the handle, and depending on the manufacturer, the tank can be filled with hectopascal, nitro, compressed air, or carbon dioxide (CO_2), and the type of gas tank determines how fast or slow the whip is. Funnel--this is the large, funnel-like part that is placed on top of the gun and is where the ammunition explodes. The indicator/rifle barrel helps to move with the whip and barrel to make sure the cartridge is passing through the proper air when ejected. Device locker is just like a real weapon, the paintball gun has safety to make sure your weapon does not accidentally discharge. If you are looking to buy a beginner's rifle, do not look for high-powered, expensive weapons, instead, choose one that matches the gun you practice with and check it carefully before you buy. The paintballs look almost the same, and of course, additional customization is available (e.g. an air condenser tank, and a bigger funnel) (Keles et al., 2014).

Fitness assessment and movement testing, behavioral measures, neuropsychological measures

Ulrich's gross motor skills development test (Fallah et al., 2015), second edition, includes two sub-tests that measure developmental gross motor skills in the early stages of life. This test is designed to estimate gross motor performance in children aged 10–13 years. Its validity is 96%, reliability for each of the subtests is 87%, and gross motor gain is 91%. The test measures twelve gross motor skills that should be taught to children in pre-school and early years of elementary school. The two sub-tests of this test are as follows:

Gresham and Elliott standard questionnaire of social skills, student version

Gresham and Elliott designed the questionnaire on students' social skills (Gresham et al., 2011). It has been validated by Mottaghi et al. on students in Iran. This questionnaire consists of 27 questions and 4 components of self-control, empathy, self-expression, and cooperation, based on a 3-point Likert scale with questions, such as (I do good things for my parents, such as helping with housework without being asked) measuring students' social skills. In the study conducted by Islami et al., the content and form validity of this questionnaire have been assessed as appropriate. Cronbach's α coefficient calculated in the research (Abbasi Asfjir & Khatibi, 2016) for this questionnaire was estimated to be above 0.7 (Abbasi Asfjir & Khatibi, 2016)

Assessment of neurological disorders

Connors ADHD questionnaire includes 26 items in the form of a Likert scale that measures the level of these disorders in a person (Cordes & McLaughlin, 2004). ADHD is a neurodevelopmental disorder characterized by three main characteristics, attention deficit, hyperactivity, and impulsivity, and affects 3%-7% of children. Although in the past years, a misconception existed that this disorder improves from the post-adolescence years, today it is revealed that this disorder will continue into adulthood in more than 50% to 70% of cases. Other features of this disease are emotional instability, sudden and intense anger, intense emotional responses, confusion in doing things, instability in interpersonal relationships, job, and academic failure.

Data analysis

The research method is quasi-experimental. After completing the questionnaires by the parents, descriptive statistics (Mean±SD) were employed to analyze data and test the significance of the difference observed between the two experimental and control groups in the post-test, and control the pre-test scores, analysis of covariance (ANCOVA) and t-test were used. SPSS software, version 19 (Yamin & Kurniawan, 2009) was used for data analysis.

3. Results

Paintball game program

Heart rate and exercise duration were measured to monitor physical activity (paintball) levels. The average duration of training per session was 47 minutes, and

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mean heart rate was 154 beats per minute (77% of maximum heart rate). This indicates intensity in the moderate-to-vigorous category.

Fitness

According to Table 1, the mean of the two groups in the pre-test is not significantly different in the withdrawal (performance) variable; however, in the post-test, a large difference is observed between the two experimental and control groups. On the other hand, despite the increase in the mean of the experimental group in the post-test, not much difference was observed between the standard deviation of this group in the pre-test and post-test, which proves that the increase in scores in the post-test of this group includes all subjects.

Motor performance

According to (Table 2) ANCOVA results for motor skills show a group difference for two variables, the locomotion score, $F_{(1, 14)}$=8.885; P=0.006 (unicaudal test), and the total raw-motor-skills score, $F_{(1, 14)}$=8.276, P=0.007 (unicaudal test). Also, a tendency existed for a higher object-control score, $F_{(1, 14)}$=1.914, P=0.087 (unicaudal test).

Behavior

Table 3 presents that the difference between the two experimental and control groups in the pre-test is not significant (t [8]=2.530, P=0.035), but the comparison of the groups in post-test with the subtraction of the pre-test effect suggests a significant difference between the groups (t [8])=2.0, P=0.081, indicating the effectiveness of baseball exercises and activities on the behavior of the experimental group.

Neuropsychological measures

A significant difference was observed in the post-test for two neuropsychological variables. Children in the experimental group exhibited a higher level of information processing.

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Table 1. ANCOVA of anthropometrical and fitness variables

Variables	Physical Activity Group (n=10)		Control Group (n=8)		
	Mean±SD		Mean	$F_{(1, 18)}$	P[a]
	Post-test	Post-test	Pre-test		
Weight (kg)	33.2±1.3	34.6±1.4	33.9	0.557	0.233
Height (cm)	139.0±0.3	140.7±0.4	138.1	11.808	0.002
Body mass index (BMI)	17.5±0.6	17.3±0.6	17.9	0.033	0.429
Percentiles BMI	56.5±8.7	54.8±9.8	60.6	0.015	0.452
Push-up (max. number)	17.8±2.1	12.1±2.5	12.5	3.186	0.048
Sit-up (#/60 s)	42.7±3.3	36.9±3.8	37.3	1.233	0.142
Flexibility (cm)	24.4±0.6	24.8±0.8	22.2	0.135	0.359
Resting heart rate (b/min)	83.8±2.7	78.7±3.1	90.6	1.456	0.124
Bruce running time (min)	10.6±0.6	11.3±0.7	11.0	0.618	0.222
Bruce percentiles	61.2±11.4	54.2±13.6	63.8	0.154	0.350

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Heart rate and exercise duration were measured in order to monitor physical activity (paintball) level. The mean training duration per session was 47 min, and mean HR was 154 beats per minute (77% HR max). This that indicates intensity in the moderate-to-vigorous category.

aUnicaudal test.

Table 2. ANCOVA of neuropsychological variables

Variables		Physical Activity (n=10)		Control (n=11)		
		Mean±SD		Mean		
		Post-test	Post-test	Pre-test Grand Mean	$F_{(1, 18)}$	P[a]
Sky search	Time target pondered	10.0±0.6	8.8±0.4	8.1	2.908	0.05
	Attention pondered	7.7±0.5	9.6±0.6	7.9	0.203	0.329
	Score pondered	6.6±0.5	5.4±0.8	7.8	3.815	0.03
Sky search DT pondered		67.8±1.0	6.9±1.1	6.8	0.021	0.444
Walk/don't walk pondered		83.3±1.0	0.9±0.9	5.6	0.000	0.493

[a]Unicaudal test.

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4. Discussion

ADHD is a common behavioral disorder that affects about 8%-10% of children (Ng et al., 2017). The probability of diagnosing this disorder in boys is three times higher than in girls, but the reason for this difference has Cnot been determined yet. The results show that the paintball game program had a positive impact. Motor performance was better in the experimental group, which was shown by the increase in locomotion and total motor skill scores. Moreover, positive and significant behavioral scores are reported by parents for total problems, social problems, thought problems, and attention problems, and by teachers, for anxiety depression, and social problems in the physical activity group. The level of information processing assessed by visual research and auditory sustained attention tasks was also better for the experimental group. Baseline fitness parameters

Table 3. ANCOVA of behavioral variables reported by parents

Variables	Physical Activity (n=9)		Control (n=9)		
	Mean±SD		Mean		
	Post-test	Post-test	Pre-test Grand Mean	$F_{(1, 18)}$	P[a]
Anxiety-depression	71.4±21.6	82.8±17.5	84.2	0.550	0.235
Withdrawn-depression	79.9±3.1	87.2±3.4	81.8	2.808	0.059
Somatic complaints	66.1±6.0	72.1±6.6	72.9	0.503	0.229
Social problems	74.2±3.5	84.1±3.8	83.8	3.915	0.033
Thought problems	67.8±5.5	85.9±5.5	81.8	5.186	0.019
Attention problems	83.3±3.4	96.0±3.4	92.6	6.233	0.01
Rule-breaking behaviors	79.2±4.2	81.3±4.8	85.1	0.135	0.374
Aggressive behaviors	82.9±4.6	89.4±4.1	90.9	0.956	0.172
Internalized problems	75.9±6.6	76.0±6.7	84.0	0.000	0.497
Externalized problems	83.7±5.2	87.2±4.6	89.8	0.220	0.323
Total problems	78.8	91.3	90.8	3.681	0.038

[a]Unicaudal test.

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were similar, within the normal range in both groups, and did not differ after the paintball game program. The only exception was a higher number of pushups in the experimental group after the program. The higher scores of arm muscular strength, as assessed by the push-ups test, and motor skills were expected because the program included exercises targeting those variables. Specifically, motor skills exercises were included in the activities because significant difficulties have been reported in children with ADHD (Pan et al., 2019).

Results obtained from this research show that the mean of the two groups in the pre-test is not significantly different in terms of performance variables; however, in the post-test, a large difference is observed between the two experimental and control groups. These results are consistent with the study results of Ziereis and Jansen, in their research that investigated the effect of physical activities on the performance of hyperactive children, they concluded that exercise increases the performance factors of these children (Ziereis & Jansen, 2015). Similar results were reported in the studies conducted by Kamp, Sperlich, and Holmberg. Studies show that game therapy increases motor performance in children by increasing neurotransmitters (Kamp et al., 2014). Fedewa and Ahn and Keeley and Fox conducted a study titled "the effect of aerobics on children" and found that aerobic exercise had a positive impact on performance variables in hyperactive children, although subsequent research questioned its validity (Fedewa & Ahn, 2011; Keeley & Fox, 2009). Rickson's research, which examines the comparative effect of game-playing therapy and medicine therapy on hyperactive children, is aligned. In their research, they concluded that hyperactive children, when engaged in a game for some time, performed much stronger in social relations with their environment and had significantly fewer problems than the control group that only used medicine (Rickson, 2006). Fedewa and Ahn also achieved similar results in their study titled "the effect of exercise and physical readiness on hyperactive children" and by conducting a post-test, they found that the children showed better motor performance than before, and emphasized the effect of exercise on increasing motor performance in hyperactive children (Fedewa & Ahn, 2011). Research that seriously contradicts this result has not been reported; however, Pelham et al in a study titled "the effect of individual sports on behavioral symptoms of hyperactive children" reported that these children differed significantly in the withdrawal variable in the pre-test and post-test. This result may be because the intervention duration (individual exercise training) was short because these children were trained for five sessions, while in all subsequent studies, more than ten training sessions were used (Pelham et al., 2000). Diagnosing attention-deficit/hyperactivity/attention deficit in preschool age is critical because if not treated, hyperactivity turns into disorders, such as confrontational and conflicting behaviors, such as conducting disorder and increasing the child's readiness to accept psychological and social harm. One of these diseases is the result of using medicine to treat these children, which causes many physical and mental problems in them. Due to the side effects of these strong medicines, these children suffer a lot of pain in their joints and body after taking the medicine. As a result, effective methods should be used to treat them, the best of which is game playing and physical activity. These results are consistent with Ferreira et al.'s research. Ferreira et al in research entitled "the effect of a course of weight training on reducing the physical anxiety of hyperactive children" concluded that after a few sessions of working with light weights, these children reported a reduction in pain in their muscles (Ferreira et al., 2018). However, Padidela et al.'s research, which examined various treatment methods for children with ADHD, concluded that these children reported more fatigue (Padidela et al., 2021). In the related study, Padidela acknowledged that 20 activity sessions over 35 days may be the main cause of children's fatigue. Pan Chen Wei in a research titled "fundamental skills in children with autism and hyperactivity" reported that game playing is essential for the emotional and social development of children (Bakolaet al., 2019). Canu and Hilton also stated that a seven-month course of regular game-playing therapy reduces symptoms of social problems of ADHD (Canu & Hilton, 2022). Barrett's studies showed a positive relationship between play and the learning of students and that game playing can improve the social relationships of children with ADHD. Chen et al. also compared the effects of massage therapy and play therapy on children with ADHD and concluded that play therapy led to a sharp reduction in the social problems of these children from the parent's point of view (Chen et al., 2022). No research was found that contradicts the results of this hypothesis and all studies were consistent with the results of this study and the results confirmed this hypothesis.

5. Conclusion

Finally, in this study, the role of parents and families in playing paintball games in open areas can be observed to increase the motor and behavioral performance of children with hyperactivity disorder. The results of this study demonstrated that paintball training has a positive influence on the behavior, and neuropsychological character-

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istics of children with hyperactivity disorder. Also, individuals involved in sports groups acquire psychological, social, behavioral, and communication skills and prepare to appear in personal and social relationships, and turn, respond constructively to the behavior of others and reduce abnormal behaviors. In addition, when hyperactive children feel that their existence is valued and they are positively and unconditionally noticed, regardless of their weaknesses, they refrain from engaging in destructive and incompatible behaviors.

Limitations

Some methodological issues should be discussed. Due to the problems of involving children, participants in the experimental group were recruited from the same school, and children in the control group were from different areas. Furthermore, a difference was observed in the prescription of stimulant medicines between both groups. Those methodological issues were considered minimal because the groups were similar in terms of fitness, behavior, and neuropsychological variables before the program. In addition, the severity of symptoms is not the only variable that affects parents' decision to give medication to children, several other factors, such as side effects and the child's aversion to taking pills affect their decision to suspend or not take medication. Another limitation to the generalizability of these results is that both parents and teachers were aware of the treatment and likely had expectations for changes. Finally, the small sample used in the study and missing data in some cases limit the statistical power of the study. Therefore, the results should be considered preliminary and require replication. However, they can be useful to guide future research.

Thus, despite being positive, the results should be considered exploratory due to methodological issues. Nevertheless, they suggest that a paintball game program may be beneficial for children with ADHD. In addition to strength and motor skills, it has a positive effect on cognitive behavior and performance, such as attention in children with ADHD. To add support to these results, future research should include assessments of executive performance. In addition, secondary and additive effects of other treatments should be investigated.

Ethical Considerations

Compliance with ethical guidelines

We confirm that all experiments were performed by relevant guidelines and regulations. The authors confirm experiments on humans and the use of human tissue samples confirms that all experiments were performed by relevant guidelines and regulations. The studies involving human/animal participants were reviewed and approved by the Ethics Committee of the Central Tehran-Iran-Prairies Hospital. Also, all methods were carried out by relevant guidelines, and regulations, and the study procedures were explained, and informed consent was obtained from all participants and their parents before the start of the study.

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Authors' contributions

Project administration, resources, supervision, validation, visualization: Morteza Homayounnia Firouzjah, and Mojtaba Dehestani Ardekani; Conceptualization, data curation, investigation, methodology, and writing the article: All authors.

Conflict of interest

The authors declared no conflict of interest.

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