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The Effectiveness of Percussion Exercises on Theory of Mind and Types of Attention in Attention Deficit Disorder

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ABSTRACT

Background: One of the main problems of children with attention deficit/hyperactivity disorder is attention deficit, and according to various studies, it is associated with cognitive and social deficits that are associated with a deficiency in theory of mind. Rhythmic body percussion exercises can stimulate their cognitive motor area. The aim of the present study was to determine the effectiveness of percussion exercises on theory of mind and types of attention in attention deficit disorder.

Method: The present study was a quasi-experimental study with a pre-test and post-test design with a control group. The statistical population of the study included all female students aged 7-9 in the first year of elementary school in Mashhad in the academic year 2023-2024, of which 30 were selected and divided into two experimental and control groups (n= 15) by simple random sampling. To collect data, the attention transfer and sustained tests as well as the theory of mind questionnaire were used. The experimental group received body percussion exercises for 12 sessions, 3 one-hour sessions per week. While the control group did not receive any intervention and continued their daily activities. Multivariate analysis of covariance was used to analyze the results.

Results: The results showed that body percussion exercises were able to lead to improvements in the attention span and sustained attention (P= 0.001) as well as the theory of mind of hyperactive elementary school children in the experimental group (F= 68.462, η^2= 0.934, p= 0.001), while no significant difference was observed in the control group.

Conclusion: The results showed that body percussion exercises were able to have a good effect on attention and theory of mind, so it is recommended that it be used as an easy, cheap, and accessible solution to improve attention and theory of mind in children with attention deficit disorder.

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Extended Abstract

Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders (5th Edition) (DSM 5), attention deficit/hyperactivity disorder (ADHD) is recognized as a neurodevelopmental disorder characterized by persistent patterns of inattention, hyperactivity, and impulsivity [1]. One of the most prominent disorders in ADHD is attention deficit disorder. Accordingly, attention can be classified into sustained and transient attention. Sustained attention refers to the ability of a person to maintain continuous attention and focus on stimuli or activities being observed, which is often accompanied by impulsivity [4]. On the other hand, attention deficit disorder in children is associated with cognitive and social deficits, and various studies show that children with attention deficit disorder face deficiencies in theory of mind [11]. Theory of mind in psychology refers to the ability to understand other people by attributing mental states to them (i.e., guessing what is going on in their minds) [12]. Among these, one of the cognitive-motor stimulation methods is Kobe body exercises, which are based on cognitive, emotional, and psychomotor stimulation [16]. Therefore, the researcher seeks to answer the question: Is percussion training effective on the theory of mind and types of attention in ADHD children?

Method

The present study was a quasi-experimental study with a pre-test and post-test design with a control group. The statistical population of the study included all female elementary school students aged 7-9 in Mashhad in the academic year 2023-2024. Among them, 30 students with ADHD (combined type: attention deficit hyperactivity/impulsivity) were selected based on inclusion and exclusion criteria and were divided into two experimental groups (15 people) and control (15 people) by simple randomization. The instruments were a consent form provided to the parents, a questionnaire on the student's personal characteristics, including name and surname, age, weight, and height. The Connors Teachers' Questionnaire [29], the fourth edition of the Wechsler Children's Intelligence Scale [30], the Sternman Theory of Mind Test [31], and the Matin Sadr et al.'s percussion motor exercise package [32],were used to collect data. The pre-test research samples included the theory of mind test by Sternman et al. (1999) [31], the sustained and shifting attention test under the supervision and guidance of the researcher. Then, in the experimental group, the participants received interventions related to percussion exercises for 12 weeks, 3 sessions per week for 45 to 60 minutes, and during this period, the control group performed their daily activities. After the completion of the interventions, the post-test including the items measured in the pre-test was repeated. Multivariate analysis of covariance was used to analyze the research data.

Results

Descriptive indices of demographic characteristics (age, weight, height, and intelligence) of participants by research group showed that the mean age of the intervention group was (8.07±0.799) and the control group was (8.93±0.799) years; the mean height of the intervention group was (123.60±4.154) and the control group was (125.07±5) centimeters; the mean weight of the intervention group was (28.2±503) and the control group was (26.93±2.963) kilograms; the mean intelligence of the intervention group was (102.93±9.28) and the control group was (102.07±7.09). Based on the results of the independent t-test, no significant difference was observed in the mean age (p= 0.705), height (p= 0.87), weight (p= 0.875), and intelligence (p= 0.921) of the participants in the two groups.

Table 1. Summary of the results of the analysis of covariance to determine the effectiveness of body percussion exercises on the theory of mind of ADHD students

Variable	Sum of Squares	df	Mean Square	F-value	Sig. (p)	Eta Squared (η^2)
ToM - Level 1	455.587	5	91.117	35.803	0.001	0.882
ToM - Level 2	143.515	5	28.703	52.249	0.001	0.916
ToM - Level 3	45.422	5	9.084	13.588	0.001	0.739
ToM - Total	1594.101	5	318.820	68.462	0.001	0.934

Therefore, subjects showed better performance in the post-test phase at level 1 (F= 803.35, η^2= 0.882), level 2 (F= 249.52, η^2= 0.916), level 3 (F= 588.13, η^2= 0.739) and complete (F= 462.68, η^2= 0.934).

Table 2. Summary of the results of the analysis of covariance to determine the effectiveness of body percussion exercises on sustained attention and shifting attention of ADHD students.

Variable	Sum of Squares	df	Mean Square	F-value	Sig. (p)	Partial η^2
Sustained Attention						
- Reaction Time (ms)	260,861.615	4	65,215.404	22.697	<0.001	0.784
- Omission Errors	6,677.409	4	1,669.352	42.353	<0.001	0.871
- Correct Items	9,580.707	4	2,395.177	172.021	<0.001	0.965
Shifting Attention						
- Omission Errors	1,618.649	4	404.662	121.568	<0.001	0.951
- Commission Errors	31.362	4	7.870	33.573	<0.001	0.843
- Total Time (min)	241.803	4	60.451	31.609	<0.001	0.835

Therefore, subjects showed better performance in the post-test phase in reaction time (F= 22.697, η^2= 0.784), omissions (F= 42.353, η^2= 0.871), correct items (F= 172.021, η^2= 0.965), omission error (F= 121.568, η^2= 0.951), commission error (F= 33.573, η^2= 0.843), and total time (F= 31.609, η^2= 0.835).

Conclusion

The results of the present study clearly showed that body percussion exercises have a significant effect on all three subscales of theory of mind and on all three subscales of sustained attention (omission error, commission error, and total time) and transitional attention (reaction time, omissions, and correct items) in ADHD children, and are consistent with the studies of Ahokaz et al.[25], Torabi and Hormozi[20], Weiss[18], Vailo and Welch[19], Nejati et al.[27], and Mehdinejad et al.[24]. However, some studies indicate that sports activities do not have a significant effect on the theory of mind of children with ADHD, and they suggested that more research is needed in this field [28]. By examining the study, it can be concluded that they used a general physical activity program, while in the present study, body percussion exercises were used, which were rhythmic and, in addition to physical activity, were also considered cognitive activity. Future research could examine the long-term effects of this combined intervention, which was also a limitation of the present study. Also, the use of neuropsychological methods and physiological markers such as brain imaging techniques could more precisely examine the neural mechanisms of these effects.

Ethical Considerations

Ethics Code: This article is based on the first author's master's thesis in the field of sports science at Semnan University. To comply with ethical standards, data were collected only after obtaining informed consent from the participants. Participants were assured that their personal information would be kept confidential and the results would be presented without any identifying details. In addition, ethical approval for this study was granted by the Ethics Committee of Semnan University of Medical Sciences with approval code IR.SEMUMS.REC.1403.068.

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Conflict of Interest: The authors declare no conflict of interest regarding the results of this study.

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Introduction

According to the Diagnostic and Statistical Manual of Mental Disorders (5th edition (DSM 5), attention deficit/hyperactivity disorder (ADHD) is recognized as a neurodevelopmental disorder characterized by persistent patterns of inattention, hyperactivity, and impulsivity (1). It's global prevalence is 3.5% and in Iran it is reported to be 3-6% (2). This disorder is one of the most common neurodevelopmental disorders among school-aged children, with 5-15% of its prevalence related to persistent learning difficulties in elementary school children, including reading and writing (3). If this disorder is not treated, it can lead to academic, social, and low self-esteem problems for the individual. Although the main causes of ADHD are still not fully understood, many believe that ADHD is a neuropsychiatric disorder that is associated with the frontal lobe, basal ganglia, and cerebellum (4). Neuroimaging studies show that the basal ganglia, prefrontal cortex, and cerebellar structures are damaged in individuals with ADHD (5).

One of the most prominent disorders in ADHD is attention deficit disorder. Accordingly, attention can be classified into sustained and transient attention. Sustained attention refers to the ability of an individual to maintain continuous attention and focus on stimuli or activities under observation, which is often accompanied by impulsivity (6). Children with ADHD have difficulty with various types of attention. This limitation in their attention capacity may arise from high levels of arousal and their attention to more stimuli at a time, making it difficult for them to find, control, and respond to stimuli. High and low levels of arousal in ADHD children likely limit and interfere with information processing and attentional capacity, and lower their performance. The most important attention problem in these children is sustained attention, which causes these children to be unable to focus their attention on the appropriate stimulus and to daydream while doing homework (7). In this regard, shifting attention, also called "switching attention," refers to a person's ability to quickly and effectively shift focus from one stimulus or activity to another. This type of attention allows a person to continuously shift their attention to different subjects and react quickly, such as when we shift our attention from one sound to another in a noisy environment (8).

The study of attention and its relationship to performance and learning is of theoretical and practical importance. From a practical perspective, attention plays a central role in all aspects of motor skill performance; its theoretical importance stems from the fact that it underlies the process of memory and learning and from a cognitive perspective, it is central to understanding how motor skills are acquired. Theories regarding the cause of attention deficit disorder are related to neural differences in the structure and function of the prefrontal cortex, because the frontal lobe is of an executive nature, involved in planning and organizing resources, and plays a critical role in mediating inhibitory behaviors such as controlling motor behavior and preventing attention from focusing on irrelevant stimuli (9). As a result, attention deficit disorder may manifest itself as distraction and being distracted from the task, lack of perseverance, difficulty staying focused, or being disorganized (10). On the other hand, attention deficit disorder in children is associated with cognitive and social deficits, and various studies have shown that children with attention deficit disorder have deficiencies in theory of mind (11). As Pineda (2018) examined the relationship between theory of mind and executive function in children with ADHD in a systematic review, and showed that theory of mind is most closely related to inhibitory control, working memory, cognitive flexibility, and attention. Theory of mind in psychology refers to the ability to understand other people by attributing mental states to them (i.e., guessing what is going on in their

minds) (12). In fact, theory of mind is a prerequisite for understanding the social environment; as a result, having a working theory of mind is essential for success in everyday human social interactions, because people use such a problem when analyzing, judging, and inferring the behavior of others (13).

So far, no unique method has been introduced to treat or improve the symptoms of hyperactivity. However, various therapeutic interventions have been conducted by psychoanalysts and evaluations have been made using behavioral, educational, and medical methods, such that drug therapy, cognitive-behavioral therapy, and combined therapy are used for its treatment (14). Due to the concern of parents and doctors about the side effects of drugs and the lack of research findings that show the long-term effect of drug therapy in the treatment of this disorder, cognitive-behavioral therapies have been considered (15). In a way that both involves cognitive function and is attractive and fun for children. On the other hand, a single-stage type of activity cannot alone improve cognitive function and attention in ADHD children; therefore, the type and nature of the exercise are important. Among them, one of the cognitive-motor stimulation methods is the Kobe body exercises, which are based on cognitive, emotional, and psychomotor stimulation. This method is carried out in accordance with the characteristics of biomechanics, anatomy, psychology, neuroscience and musicology of culture in the form of group activities based on the framework of Gardner's theory of multiple intelligences (linguistic, musical, logical-mathematical, spatial-visual, bodily-kinesthetic, naturalistic, intrapersonal and interpersonal) and is carried out in order to stimulate all lobes of the brain through rhythm and body percussion. The motto of this method is: "I learn with my body" and it is useful and applicable from childhood (6 months) to old age (99 years) (16). In these exercises, the body is used as a musical instrument and includes various techniques such as tapping, feet and heels, board tapping, bass drum, etc. In addition to providing an effective tool for teaching and practicing basic motor skills, rhythmic games can also affect cognitive processes, attention, perception, concentration, neuromuscular coordination, and the development of interpersonal relationships and social skills (17). Based on cognitive theories such as executive control theory, multisensory processing, and motor learning and conditioning theory, percussion exercises can help strengthen attention by improving executive control and motor processing. In this context, Narenjo et al. (2023) sought to investigate whether the neuromotor activities of dual-task percussion exercises can improve selective attention and concentration in fifth-grade elementary school students. The results indicated that selective attention was significantly and extensively better in the percussion group than in the control group. Some studies have also examined the effectiveness of rhythmic movements and music therapy on attention, motor skills, and executive function in children with autism, developmental coordination disorder, and intellectual disability, and have found similar and beneficial results for these exercises in children with the disorder (4, 18-23). In this context, some studies have also shown that rhythmic games, by increasing cognitive load (beyond exercise alone), have a positive effect on the theory of mind of children with developmental coordination disorder (18-20, 24-27). However, some studies have shown that exercise activities do not have a significant effect on the theory of mind of children with ADHD, and they have suggested that more research is needed in this area (28). Research in this area has expanded over the past two decades, but has been mostly studied in people with autism and mental retardation and in the adult population, and the effect of this cognitive ability on other disorders, especially in children, has been less studied. A review of

the research literature also shows that despite numerous studies on the role of various physical activities in terms of intensity and duration on cognitive functions, very little attention has been paid to the effect of cognitive motor activities. Although most studies of music therapy or musical exercises have shown that they can provide significant benefits for people with ADHD; however, the strength of these findings is limited due to inconsistencies between studies, such as changes in ADHD diagnosis, comorbidities, medication use, and gender. On the other hand, few studies have addressed new methods of physical exercises such as percussion, especially in the theory of mind of ADHD children. As a result, there is a growing need to provide new therapeutic methods or therapeutic assistance in ADHD children that can control themselves, apart from medication. Therefore, the researcher seeks to answer the question of whether percussion exercises are effective on the theory of mind and types of attention of ADHD children?

Method

Research Design: The present study was a quasi-experimental study with a pre-test and post-test design with a control group.

Participants: The statistical population of the study included all female elementary school students aged 7-9 in Mashhad in the academic year 2023-2024. Among them, 30 students with ADHD (combined type: attention deficit hyperactivity/impulsivity) were selected based on the inclusion and exclusion criteria and were divided into two experimental groups (15 people) and control groups (15 people) by simple randomization. The sample size was estimated to be 13 people in each group based on the formula for comparing two means and the results of similar studies (24, 20) and taking into account (α=0.05 and β=0.1) and 15 people were selected in each group in order to take into account the dropout. The sampling method was cluster randomization, so that from 20 public elementary schools for girls, 6 schools were selected by simple randomization, then by visiting those schools, 3 classes were selected by simple randomization from among the students of several first, second, and third grades, and from among the students of each class, 30 eligible students with hyperactivity disorder were selected based on the inclusion criteria for the study, which were: written consent of the child's parents to participate in the study, diagnosis Hyperactivity and attention deficit by a pediatric psychiatrist; no intellectual disability based on the fourth edition of the Wechsler Children's Intelligence Scale; no history of percussion or similar rhythmic training; no pervasive developmental disorder; no mental retardation; no orthopedic disorder; no heart problems and no significant vision and hearing problems as recorded in the child's file and interviews with parents and teachers; no other psychiatric and medical disorders, including the co-occurrence of this disorder with developmental coordination disorder; no use of medication due to its effect on motor skills (based on a structured clinical interview by a clinical psychologist, child psychiatrist, and the child's medical file); and the exclusion criteria were: participation in occupational therapy courses and simultaneous physical activities, 3 consecutive absences from practice sessions, and unwillingness to cooperate.

Instruments

The consent form provided to the parents, the student's personal characteristics questionnaire including name and surname, age, weight, height. To collect data, the Connors Teachers' Questionnaire (29), the fourth version of the Wechsler Children's Intelligence Scale (30), the Sternman Theory of Mind Test (31), and the Matin Sadr et al.'s Percussion Movement Exercises Package (32) were used.

1. Connors Teachers' Questionnaire (2002): This questionnaire has 38 questions that are administered by teachers to examine and assess children with ADHD. It has three

main subscales, which are: 1- Child behavior in the classroom (questions 1-21), 2- Group participation and cooperation (questions 22-29), and 3- Attitude toward authority figures (questions 30-38); The scoring method for each question includes a four-point Likert scale from not at all (0 points) to very much (3 points), the total score of each subscale indicates the score in that dimension. So that in the child's behavior in the classroom subscale (questions 1 to 21), including 21 questions, the scoring range for each question is 0 to 3, the minimum possible score is 0 and the maximum possible score is 63 = (21 × 3), the total score of this subscale includes the sum of the scores of questions 1 to 21; in the group participation and cooperation subscale (questions 22 to 29), including 8 questions, the scoring range for each question is 0 to 3, the minimum possible score is 0 and the maximum possible score is 24 = (8 × 3), the total score of this subscale includes the sum of the scores of questions 22 to 29; In the subscale of attitude towards authority figures (questions 30 to 38), consisting of 9 questions, the scoring range for each question is 0 to 3, the minimum possible score is 0 and the maximum possible score is 27 = (9 x 3), the total score of this subscale includes the sum of the scores of questions 30 to 38. Also, the total score of the three subscales is obtained. In the analysis of the obtained scores, if the total score is higher than 57, it indicates the presence of hyperactivity disorder, and the higher the score, the greater the severity. Connors et al. (2002) (29) reported the validity of this tool as CFI = 0.92, RMSEA = 0.05 and reliability as 0.90, and also reported the alpha coefficient of 0.93 for the entire scale using the Cronbach's alpha internal reliability method in the Persian-speaking community (33).

2. Fourth Edition of the Children's Intelligence Scale (Wechsler, 2003): The fourth edition of the Wechsler Children's Intelligence Scale was used to measure children's intelligence. This scale was designed and used by Wechsler (2003) and has fifteen subtests including 10 main tests and 5 surrogate tests. Five process scores are calculated as supplementary information in the fourth edition of this scale, which provides practical information for clinical exceptionality assessment specialists. It also has twenty level scores, four of which are obtained from the comprehension index, the working memory index, the perceptual reasoning index, the verbal content, the processing speed index, and the overall intelligence. In summary, the main scoring method includes; a) administering subtests (10 main tests and 5 surrogate tests); b) Converting raw scores into leveled scores (raw scores of each subtest are converted into scaled scores (scale 1 to 19, mean = 10, standard deviation = 3) based on a normative table appropriate to the child's age; c) Calculating the scores of the main indicators; each indicator is obtained from the average of the scaled scores of the relevant subtests and converted into a leveled score (scale 45 to 155, mean = 100, standard deviation = 15). d) Calculating the general IQ, which is calculated from the combination of the scores of the four main indicators (scale 40 to 160, mean = 100, standard deviation = 15); f) Process scores are calculated as supplementary information that helps to analyze the child's performance in more detail (for example, in memory or processing speed) and e) interpretation of the results includes comparing the scores of the indicators and identifying cognitive strengths and weaknesses and analyzing the differences between the indicators to detect learning or attention problems. Scores greater than 130 = excellent, 120-129 = excellent, 110-119 = above average, 90-109 = average, 80-89 = below average, 70-79 = borderline and below 70 = possible cognitive impairment. The validity and reliability of the original test were examined by Wallström et al. (2012) CFI = 0.97, RMSEA = 0.03 and the resulting reliability coefficient for all subscales except two subscales was 0.8 to 0.9 (34). The reliability

of the subscales of line completion and symbol recognition was 0.79. The Wechsler Intelligence Scale has a high correlation with other intelligence tests, which indicates the convergent validity of the test (34). This issue was also confirmed in Iran by Sadeghi et al. (2013), and the test-retest reliability coefficients of all subscales, except for the visual concepts subscale, were also adequate to excellent (35).

3. Theory of Mind Test by Sternman et al. (1999): This test is designed based on a developmental and multidimensional view of theory of mind. The present questionnaire has 38 questions and 3 subscales, which are: 1- Preliminary theory of mind, i.e., first-level theory of mind or recognition of emotions and pretense (20 questions), 2- Initial statement of a real theory of mind, i.e., second-level theory of mind or primary false belief and understanding of false belief (13 questions), 3- Advanced aspects of theory of mind, i.e., third-level theory of mind or secondary false belief or understanding of humor (5 questions). In addition, at the end of each question, it is specified which subscale this question belongs to. The time required to complete the entire test is between 15 and 20 minutes, and the scoring method is as follows: correct answers of the subject are given a score of 1 and incorrect answers are given a score of 0. A total score for theory of mind is obtained from the sum of the 3 subscales above, and the sum of the scores of the questions related to that subscale is the score of each subscale, and the total score for theory of mind is calculated from the sum of the scores of the three subscales (maximum score: 38). The higher this score is, the higher the child has achieved higher levels of theory of mind. The validity of this tool was determined by Qomrani et al. (2006) (36) as CFI = 0.91, RMSEA = 0.07, and Cronbach's alpha coefficient for the entire test and each of the subscales was 0.86, 0.72, 0.80, and 0.81, respectively. The overall reliability coefficient of the test was 0.98 (36).

4. Sustained Attention Test: The Sustained Attention Test was designed and standardized by Nejati (2015) (26) to measure and evaluate children's sustained attention. It consists of 14 rows of the letters C,B,T,P with vowels, and 4 sample letters are set at the top of the page. The participant is asked to find the letters similar to the sample letter at the top of the page and circle it. Measurement and scoring variables include; a) total time (the duration of the entire test in seconds and scoring (less time → better performance in processing speed); b) omission error (the number of target letters that were not circled) and scoring (each omission error = 1 negative score, indicating inattention or sustained inattention); c) Error of commission (number of non-target letters that were incorrectly underlined) and scoring (each error of commission = 1 negative score, indicating impulsivity or lack of response inhibition; and d) interpretation of the results includes favorable performance (less total time + lower error of omission and commission) and poor performance (high total time or many errors → possibility of problems in sustained attention, concentration, or response inhibition). The validity of this tool was estimated by Nejati (2015) as CFI = 0.93, RMSEA = 0.05, and in order to confirm the validity of this test, the test was repeated with an interval of 4 to 6 weeks and it was determined that the Pearson coefficients for error of omission, error of commission, and total time were 0.88, 0.61, and 0.47, respectively, indicating its significance (26).

5. Transfer Attention Test: Posner's paradigm test used to measure transfer attention. In this test, which is a software-based test, the subject responds to visual targets presented on the right or left side of the monitor by pressing specific buttons on the keyboard through a coordinated distance motor response. Before the targets are presented, a series of distance guides (valid = same side and invalid = opposite side) are displayed to the subject. This test must be

performed at a completely favorable place and time, and the conditions for performing the test must be met in terms of psychometrics. The goal is for the participant to use his maximum ability and achieve the best performance quickly. The attention indices calculated in this test include; a) Reaction time (the average time between the appearance of the stimulus and the subject's correct response in milliseconds, and a lower time indicates better performance), b) Percentage of omissions (the percentage that the subject should have responded but did not, and a lower percentage indicates better attention), c) Percentage of correct responses (the percentage that the participant responded correctly, and a higher percentage indicates greater accuracy), and Percentage of prediction errors (the percentage that the participant responded earlier than the circle was presented, and a lower percentage indicates better response control), where desirable performance includes; shorter reaction time, high percentage of correct responses, and low percentage of omission and prediction errors) and poor performance includes; long reaction time, high percentage of errors, and a large difference between valid and invalid conditions. This tool is measured and reported by a computer. Sadeghi Naeini et al. (2013) showed that it is a suitable tool for measuring attention transfer in children with a validity of CFI = 0.94, RMSEA = 0.04 and Cronbach's alpha coefficient α = 0.89 (35).

6. Sadr et al.'s percussion movement training package (2022):

1) Clapping with a cross sign ×
2) Stepping on the thigh with the palm of the hand with a circle sign O
3) Hitting the chest with a star sign #
4) Stomping the foot on the floor with a square sign □

Individual exercises (5 sessions): All four selected movements were worked on individually with the participants in a face-to-face manner.

Two-person exercises (7 sessions): Two people stand facing each other: (Cham-Cham game).

A: 1- Clapping 2- Right hands hit each other. 3- Clapping 4- Left hands strike each other (repeat).

B: 1- Clapping 2- Hands are held in a horizontal position and the person opposite hits the hands of his partner in reverse. 3- Clapping 4- Reverse position 2

Group exercises for four people (12 sessions) of the six exercises in question, the first three exercises were presented in six sessions and the next three exercises in the next six sessions:

A- They stand in a circle or semicircle or square and each person takes turns entering the geometric shape and performs a specific movement. For example: An imaginary quadrilateral was considered in the middle (according to Figure 1). First the right foot is placed on point 1 and then the left foot on point 2 and again the right foot to point 3 and then the left foot returns to point 4 and clapping is performed simultaneously with each movement of the legs.

Figure 1. Hypothetical quadrilateral for performing exercises

B- They stand in a desired arrangement (geometric or linear shape) and a movement is selected and they take turns and add a stroke to it. For example:

1- The first person claps once, the next person claps twice, the next person claps three times.

2- The first person claps, the next person claps then hits the chest, the next person claps, hits the chest, hits the thigh. All four selected strokes could be performed, but sometimes the students also hit other parts such as the arms or legs.

B- They stand in a desired arrangement (geometric or linear shape) and two movements are selected and the people repeat one of them. For example, the movements of clapping and hitting the thigh are selected. In this case, the first person: claps, the next person: taps his/her thigh, the next person claps again, and so on.
C- They stand in a line, and the leader stands in front of the line, and the people imitate the leader's movements.
D- They stand in a line, and the leader stands in front of the line, and the people leave the line one by one, and at the same time imitate the leader's movement. For example, the leader, along with the first and third people in the line, took a step to the right and clapped at the same time. The second and fourth people took a step to the opposite direction and clap at the same time.
E- They stand in two parallel lines facing each other, and each person has a partner facing them. When the leader announces the start, they move towards each other (the lines come closer together), and each person plays the game of Cham Cham with the partner facing them, and then they return to the starting position. This training protocol was extracted from the research work of Matin Sadr et al. (2022) (32).

Research implementation process: The present study was registered with the Ethics Committee of Semnan University of Medical Sciences with the ethics code IR.SEMUMS.REC.1403.068, then after obtaining the relevant permission from the Mashhad City Administration and receiving consent from the parents, the pre-test research samples, including the theory of mind test of Sternman et al. (1999) (31), the sustained and transferred attention test were taken under the supervision and guidance of the researcher. Then, in the experimental group, the participants received interventions related to percussion exercises for 12 weeks, 3 sessions per week for 45 to 60 minutes, and during this period, the control group performed their daily activities. After completing the interventions, the post-test, including the items measured in the pre-test, was repeated. The interventions used in the present study included percussion exercises or rhythmic body tapping exercises. Throughout the exercises, emphasis was placed on eye contact, initiating activity, taking turns, imitating visual symbols and verbal commands, and four selected movements were used for all sessions, which were marked with symbols. In order to analyze the research data, first, the central tendency and dispersion indices were used to describe the findings. The Shapiro-Wilk test was used to determine the normality of the data distribution, the Levine test was used to determine the equality of variances of the groups, the Muhly test was used to examine the assumption of equal covariances between the dependent variables, the M-box test was used to examine the homogeneity of the covariance matrix, and the multivariate analysis of covariance was used to examine the differences between the groups. Data analysis was performed using SPSS 20 and Excel (2016) software, and the significance level was ($P \geq 0.05$).

Results

Descriptive indices of demographic characteristics (age, weight, height, and intelligence) of participants by research groups showed that the mean age of the intervention group was (8.07±0.799) and the control group was (8.93±0.799) years; the mean height of the intervention group was (123.60±4.154) and the control group was (125.07±5) centimeters; the mean weight of the intervention group was (28.2±503) and the control group was (26.93±2.963) kilograms; the mean intelligence of the intervention group was (102.93±9.28) and the control group was (102.07±7.09). Based on the results of the independent t-test, no significant difference was observed in the mean age (p= 0.705), height (p= 0.87), weight (p= 0.875), and intelligence (p= 0.921) of the participants in the two groups. Also, the descriptive indices of the two intervention and control groups are reported in Table 1.

Table 1. Descriptive statistics of the Theory of Mind Test, Sustained Attention, and Shifting Attention, separated into the two experimental and control groups in the two pre- and post-test stages

Variable	Stage	Group	Standard deviation±mean	Minimum	Maximum
Level 1 (Theory of Mind)	Pretest	Control	7.07±1.280	5.79	9
		Intervention	7.67±2.059	5	12
	Posttest	Control	7.20±1.207	5	10
		Intervention	14.13±3.114	9	18
Level 2 (Theory of Mind)	Pretest	Control	5.27±1.623	3	9
		Intervention	5.07±0.884	4	7
	Posttest	Control	5.53±1.552	3	9
		Intervention	8.67±1.877	6	12
Level 3 (Theory of Mind)	Pretest	Control	1.40±0.910	0	3
		Intervention	1.67±1.447	0	5
	Posttest	Control	1.53±1.060	0	4
		Intervention	3.40±1.183	2	5
Complete (Theory of Mind)	Pretest	Control	13.73±2.963	10	19
		Intervention	14.00±4.342	4	20
	Posttest	Control	13.93±2.987	9	20
		Intervention	26.20±5.685	17	34
Omission Errors (Number Sustained Attention)	Pretest	Control	26.93±5.725	17	35
		Intervention	22.93±6.789	17	36
	Posttest	Control	27.07±5.535	18	35
		Intervention	16.80±5.870	10	30
Errors committed (number Sustained attention)	Pretest	Control	2.60±1.056	1	4
		Intervention	2.27±1.223	1	5
	Posttest	Control	2.47±0.743	1	4
		Intervention	0.73±0.704	3	2
Total time (minutes) (Sustained attention)	Pretest	Control	21.06±2.306	17	24
		Intervention	20.66±1.942	18	24
	Posttest	Control	20.90±2.253	17	24.5
		Intervention	16.94±2.689	13	20.5
Reaction time (milliseconds) (Transitional attention)	Pretest	Control	782.53±61.732	658	658
		Intervention	754.67±48.023	658	831
	Posttest	Control	774.73±78.880	605	605
		Intervention	615.33±62.690	500	700
Deleted items (number) (Transitional attention)	Pretest	Control	37.00±14.957	10	10
		Intervention	30.93±16.637	7	7
	Posttest	Control	36.80±14.615	11	11
		Intervention	13.60±6.738	3	3
Correct items (number) (Transitional attention)	Pretest	Control	150.20±13.018	130	130
		Intervention	150.80±12.542	134	134
	Posttest	Control	150.27±12.731	132	132
		Intervention	180.13±8.323	168	168

According to the results of the independent T-test, there is no significant difference between the research groups in the indicators under study. Therefore, the condition of no difference between groups in the pre-test is met for the use of parametric tests. Before using the statistical test, it is necessary to examine the assumptions of this test and after establishing the assumptions, the statistical test was performed. For this purpose, first, the assumptions of normality and the precondition of homogeneity of variance of the dependent variables of the research were examined using the Shapiro-Wilk and Levine test. Since the significance level of the Shapiro-Wilk and Levine tests was higher than 0.05, it can be understood that the assumptions of normality of the distribution of the dependent variables and equality of variance of the groups are valid for the final analysis. Also, the results of the Muhly test, which examines the assumption of equality of covariances between the dependent variables, showed that the significance level was higher than 0.05 and the assumption of data sphericity was confirmed. The M-box test of the observed covariance matrices between the intervention and control groups in the dependent variables were theory of mind

(Box= 0.412, M= 6.482, P); sustained attention (Box= 0.542, M= 5.681, P); and shifted attention (Box= 0.112, M= 18.512, P), which indicates that the significance level was greater than 0.05; as a result, the difference in the matrices is not significant and the equality of the covariance matrix between the groups is confirmed; therefore, the multivariate analysis of variance test can be used.

Table 2. MANCWA test results for theory of mind

Effect Type	Test Name	Value	F-Value	Degrees of Freedom	Significance Level	Eta Squared
Group	Pillai Effect	0.872	18.654	(3,22)	0.001*	0.872
	Wilkes Lambda	0.128	18.654	(3,22)	0.001*	0.872
	Hotelling Effect	0.816	18.654	(3,22)	0.001*	0.872
	Largest Root on	18.654	18.654	(3,22)	0.001*	0.872

As can be seen in Table 2, according to the test statistic of percussion exercises on theory of mind (η2=0.872, sig=0.001, F=654.18), since the MANOVA analysis test is statistically significant, each of the theory of mind subscales was evaluated (Table 3).

Table 3. Summary of the results of the analysis of covariance to determine the effectiveness of percussion exercises on the theory of mind of ADHD students

Variable	Sum of Squares	df	Mean Square	F-value	Sig. (p)	Eta Squared (η²)
ToM - Level 1	455.587	5	91.117	35.803	0.001	0.882
ToM - Level 2	143.515	5	28.703	52.249	0.001	0.916
ToM - Level 3	45.422	5	9.084	13.588	0.001	0.739
ToM – Total	1594.101	5	318.820	68.462	0.001	0.934

Table 3 shows the results of the analysis of covariance to determine the effect of percussion exercises on the theory of mind of children with attention deficit/ hyperactivity disorder. According to the results of the table, individuals showed better performance in the post-test phase at level 1 (F= 35.803, 2η= 0.882), level 2 (F= 249.52, 2η= 0.916), level 3 (F= 13.588, 2η= 0.739) and complete (F= 462.68, 2η= 0.934). Based on the results of the parametric eta square in the theory of mind components, it was shown that 88% of the difference observed in level 1, 91% in level 2, 73% in level 3 and 93% in complete theory of mind in the post-test phase between the two groups was due to the effect of the percussion exercises intervention. On the other hand, the extent of the Pillai effect, Wickles' lambda, Hotelling effect and largest root at the first level (F= 0.001, p= 803.35, 2η= 0.882), at the second level (F= 0.001, p= 249.52, 2η=0.916), at the third level (F= 0.001, p= 588.13, 2η= 0.739) and at the fourth level (F= 0.005, p= 452.9, 2η= 0.658) indicates a strong and significant effect of the model.

Table 4. Summary of the results of the analysis of covariance to determine the effectiveness of body percussion exercises on sustained attention and shifting attention of ADHD students

Variable		Sum of Squares	df	Mean Square	F-value	Sig. (p)	Partial η²
Sustained Attention	Reaction Time (ms)	260,861.615	4	65,215.404	22.697	<0.001	0.784
	Omission Errors	6,677.409	4	1,669.352	42.353	<0.001	0.871
	Correct Items	9,580.707	4	2,395.177	172.021	<0.001	0.965
Shifting Attention	Omission Errors	1,618.649	4	404.662	121.568	<0.001	0.951
	Commission Errors	31.362	4	7.870	33.573	<0.001	0.843
	Total Time (min)	241.803	4	60.451	31.609	<0.001	0.835

Table 4 shows the results of the analysis of covariance to determine the effect of percussion exercises on sustained and shifting attention in children with attention deficit/hyperactivity disorder. According to the results of the table, subjects showed better performance in the post-test phase in reaction time (F= 22.697, 2η= 0.784), omissions (F= 42.353, 2η= 0.871), correct items (F= 172.021, 2η= 0.965), omission

errors (F= 121.568, 2η= 0.951), commission errors (F= 33.573, 2η= 0.843) and total time (F= 31.609, 2η= 0.835). Based on the results of the parametric eta square in the components of sustained attention, it was shown that 78% of the observed difference in reaction time, 87% in omissions, 96% in correct cases, and in the components of transitional attention, 95% of omission errors, 84% of commission errors, and 83% of total time in the post-test phase between the two groups was due to the effect of the body percussion exercises intervention. On the other hand, the extent of the Pillai effect, Wickels lambda, Hotelling effect, and the largest root in sustained attention (F= 0.001, p= 0.054.163, 2η= 0.955) and transitional attention (F= 0.001, p= 0.056.55, 2η= 0.879) indicates a strong and significant effect of the model on the variables of sustained and transitional attention.

Discussion

The aim of the present study was to investigate the effect of body percussion exercises on theory of mind, sustained and transfer attention of elementary school students with ADHD.

The results of the present study clearly showed that body percussion exercises have a significant effect on all three theory of mind subscales including the first, second and third levels as well as the total theory of mind of ADHD children and are consistent with the studies of Ahokaz et al. (25), Torabi and Hormozi (20), Weiss (18), Vailo and Welch (19), Nejati et al. (27), Mehdinejad et al. (24). However, some studies indicate that sports activities do not have a significant effect on the theory of mind of children with ADHD and suggested that more research is needed in this field (28). By examining the study conducted, it can be concluded that they used a general physical activity program, while in the present study, body percussion exercises were used, which were rhythmic and, in addition to physical activity, are also considered cognitive activity. As a result, the difference in the nature of the type of exercise can explain the difference in the present findings. Since these exercises require coordination between different movements and body parts, they can therefore be effective on factors such as attention, concentration, motor coordination, and cognitive performance of children; as shown by Mehdinejad et al. (2021) (24) and Ahokaz et al. (2025) (25), body percussion exercises require high attention and concentration, and children must be able to coordinate different movements and sounds, which helps improve their attention and concentration. Therefore, improving these cognitive aspects can in turn lead to improving abilities related to theory of mind. It seems that performing rhythmic (melodic) and game-like activities can affect the functioning of mirror neurons in children with ADHD and facilitate their cognitive activities. Since theory of mind refers to the ability to understand and predict the thoughts, feelings, and intentions of others; As a result, from a more general perspective, it can be said that body percussion exercises help children to better focus on cognitive aspects and strengthen their theory of mind-related abilities. Among the effective mechanisms that can be mentioned is the improvement of the functioning of the brain's neural networks that are responsible for attention and concentration. This improvement in neural function can lead to the strengthening of cognitive abilities, including theory of mind. Body percussion exercises can also increase the levels of neurotransmitters such as dopamine and serotonin, which can help improve mood, reduce stress and anxiety, and cognitive abilities in children (25). However, the most important explanation in this regard is the increase in cognitive load that body percussion exercises impose on children. Of course, these results are in line with some of the existing research literature, but more research is needed to confirm and generalize these findings. Future research could help to better understand this issue by examining the mechanisms underlying these effects, as well

as comparing the effects of different exercises on the theory of mind of children with ADHD.

In line with the effectiveness of percussion exercises on attention, it was found that these exercises have a significant effect on all three subscales of sustained attention (error of omission, error of commission and total time) and transitional attention (reaction time, omissions and correct cases) in ADHD children, and the present findings were consistent with the results of studies by Naranjo et al. (37), Mazella et al. (23), and Torabi et al. (20). Many researchers have sought to influence attention and cognitive performance through various exercise methods and interventions in ADHD children. As Naranjo et al. (37) showed in their study, attention was significantly and extensively better in the percussion exercise group than in the control group. Since, according to studies, ADHD children have difficulty in cognitive control and filtering irrelevant information and show ineffective neurocognitive mechanisms during active suppression (38), as a result, these children have little ability to suppress distractors that are associated with symptoms of inattention. Studies on spectral analysis have shown that ADHD children have inadequate coordination and cognitive control in a visual search task compared to normal children (39). In addition, recent studies have shown that in these children, neural activity is reduced in a wide range of brain areas involved in cognitive control, including temporal, parietal, and cingulate cortex (40). Therefore, the results of all these studies suggest that ADHD children may be exposed to memory-consistent distractions and show reduced memory-based attention due to less efficient cognitive control mechanisms. According to the executive control theory, attention is known as a function of executive control systems in the brain, and since percussion exercises require precise coordination of body movements and the production of rhythmic sounds, they can help improve executive control and attentional abilities (41). Also, according to the motor learning theory, percussion exercises can help strengthen attentional skills by enhancing motor learning and coordination due to the need for motor coordination and rhythm learning (5). In this regard, based on the conditioning theory, children learn through percussion exercises how to regulate their behaviors based on rewards and reinforcers. This process can help strengthen attention and focus on desired behaviors (42). It should be noted that ADHD children have impaired multisensory integration; therefore, according to the multisensory processing theory, percussion exercises usually include multisensory interactions, including auditory and motor. These interactions can help improve attention processing, because the brain is naturally designed to process information from different sources simultaneously (43). In summary, considering the definition and nature of shifting attention or switching attention, which includes the ability to change focus from one subject to another without losing efficiency, and sustained attention refers to the ability to continuously focus on a task or activity for a long period of time; In conclusion, in explaining the present findings, it can be said that body percussion exercises require continuous attention and concentration to perform movements and sounds in a coordinated manner and are performed in situations where there is a need to quickly adapt to environmental changes or make urgent decisions; therefore, these activities can help children improve their ability to maintain, change, or transfer their attention. Also, regular physical activities can have positive effects on children's overall cognitive performance, as percussion exercises were performed regularly in the present study. In fact, studies show that there is a strong relationship between play activity and cognitive development. The simultaneous use of music and rhythm (in the form of rhythmic games) leads to an increase in neural branches (44). In rhythmic

movement games, the child is required to follow predetermined game patterns, and if repeated and practiced, space is provided for improving memory measures, especially working memory. Research has demonstrated the effectiveness of physical activity and rhythmic exercises on memory and learning, and cognitive training has been shown to increase neural activity and connectivity during the resting state of the brain, and cognitively loaded physical activities have been shown to enhance cognitive ability (beyond exercise alone) (45). The present study therefore supports the findings of research that have shown that regular physical activity can help improve memory, attention, and executive function in children with ADHD (5) and supports the meta-analysis of Leo and Zhang (46) that music interventions and music exercises have significant potential as a complementary treatment for children with ADHD, offering new ways to address the psychosocial and cognitive aspects of the condition, and are effective in improving executive function, timing, arousal regulation, modulation of the default mode network, neural bubble, emotional management, and facilitating social bonding.

The findings of the present study showed that body percussion exercises can produce significant improvements in theory of mind and attention (transitional and sustained) in primary school children with ADHD. While these results are promising, it is important to acknowledge the limitations of the study and the need for further research to explain and expand on these findings. The present study was conducted with a limited number of ADHD children, which may affect the generalizability of the results. Therefore, it is suggested that future studies be conducted with larger sample sizes and in diverse geographical areas. Also, the duration of percussion exercises may not be sufficient to produce sustained changes in theory of mind and attention; therefore, future studies can investigate the long-term effects of this combined intervention, which was also considered a limitation of the present study. The assessment of variables was also mainly based on questionnaires and behavioral tests; therefore, the use of neurocognitive methods and physiological markers such as brain imaging techniques can more accurately examine the neural mechanisms of these effects. In addition, the present study compared percussion exercises with an inactive control group; while comparison with other intervention groups such as drug therapy or cognitive training could clarify the relative effectiveness of this method. Overall, although the findings of this study indicate a positive effect of percussion exercises on the theory of mind and attention of ADHD children, there are methodological limitations and the need for additional research to generalize the results. Therefore, it is suggested that future researchers address these limitations and help develop practical programs to improve the quality of life of ADHD children.

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