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Comparison of the Impact of Body Percussion Exercises on Executive and Balance Performance in Intellectually Disabled and Healthy Girls of Ramhormoz City

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A B S T R A C T

Objective: The purpose of the present study was to compare the effects of body percussion exercises on the executive and balance performance of children with intellectual disabilities and their healthy counterparts.

Methods and Materials: The statistical population included healthy children and those with intellectual disabilities from Ramhormoz city, from which 20 healthy children (10 experimental, 10 control) and 20 children with intellectual disabilities (10 experimental, 10 control) aged 9 to 11 years were selected to participate in this research through pre-test and post-test evaluations using the Continuous Performance Test (sustained attention), Stroop Color and Word Test (response inhibition), Stork Stand (static balance), and Heel-Toe Walking (dynamic balance). The experimental groups (both healthy and with disabilities) received the selected body percussion intervention program in 45-minute group sessions twice a week for 8 weeks; however, the control groups (both healthy and with disabilities) engaged in usual school activities. Data analysis was performed using covariance analysis at the significance level of $p \leq 0.05$.

Results: The results showed that the effect of body percussion exercises on sustained attention ($p = 0.001$), response inhibition ($p = 0.001$), and static and dynamic balance ($p = 0.001$) was significant, and participants in the experimental groups performed better than those in the control groups ($p = 0.001$).

Conclusions: Based on the findings, it seems that body percussion exercises are a beneficial intervention for improving motor and cognitive skills in both healthy children and those with intellectual disabilities; therefore, it is recommended that these exercises be used in physical education programs in schools and rehabilitation centers.

Keywords: *Balance, Executive Function, Intellectually Disabled Children, Body Percussion.*

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1. Introduction

E One of the well-recognized theories that has attracted researchers' attention in recent years to find the relationship between the brain and behavior in children with intellectual disabilities is the executive function theory (1). Executive functions play a crucial role in the development and expansion of academic and social abilities in children and are especially important for their social and academic readiness for school entry (2). Research findings have shown that cognitive abilities of executive functions can predict and contribute to adaptive behaviors (3). These functions are among the necessary skills for individuals' mental and physical health, and issues in these areas can lead to behavioral and psychological problems and an inability to perform daily tasks (1). In fact, executive functions include a set of important capabilities such as decision-making, strategic planning, attention, self-initiation, impulse control, working memory, cognitive flexibility, response inhibition, and academic activities (4). Attention is one of the most important components of executive functions and is the first stage in information processing, meaning the ability to select a portion of received information from the environment for subsequent processing, on which focus and awareness are based (2). Sustained attention, a type of attention, refers to maintaining attention over time and is the most basic and initial level of attention. Since other types of attention depend on sustained attention, any issue in it can indicate problems in other types of attention (5). Response inhibition is another critical factor of executive functions, relating to the ability to stop thoughts, actions, and emotions. A lack of response inhibition in children leads to responding before understanding tasks. Children with issues in response inhibition are easily distracted by irrelevant stimuli. The ability to suppress actions and emotions are among the most important components of response inhibition (6). Response inhibition affects other cognitive functions, including memory and attention, and is influenced by them (5, 6).

Additionally, many individuals with intellectual disabilities and those who are healthy have issues with balance, postural stability, movement planning, and speed (7). Problems with balance and postural anomalies can reduce the ability to develop more complex skills (7). Balance control is essential for producing precise movements and everyday activities such as walking, climbing stairs, or standing in a bus (8). Disabilities and weaknesses in executive functions and balance lead to the withdrawal of children with intellectual disabilities from physical activity, highlighting the importance of designing appropriate programs for this group of society (9, 10). Findings from various studies have reported disorders in dynamic and static balance in populations with disorders. Sam and colleagues (2017) reported that balance in the group of children with disabilities is significantly lower than in healthy children (9). Despite the fact that disorders in balance and the occurrence of stereotypical behaviors alone do not pose any risk to the individual, because these issues are associated with significant disorders in acquiring social skills, and sleep-related problems (11), the necessity of determining effective methods and strategies to improve these problems is clearly felt. Over the past years, various therapeutic interventions have been used to reduce stereotypical behaviors and improve balance and cognitive status in individuals with disorders. One of the novel treatment methods is interventions related to body percussion exercises.

Body percussion exercises are among the sports interventions that, using the BAPNE method in physical education and sports sciences, serve as an excellent tool for improving many aspects related to motor coordination and many other areas (12). The BAPNE method, relying on disciplines such as biomechanics, anatomy, psychology, neuroscience, and ethnomusicology, enables the development of each of the multiple intelligences founded by Howard Gardner through body percussion training (13). In this context, Lotfi, Bigi, & Sadr (2018) demonstrated in a study that body percussion exercises have a significant effect on bilateral coordination, upper limb coordination, visual-motor control, speed, and upper limb skills in children with intellectual disabilities (14). Similarly, Siminghalam, Alibakhshi, & Vali Khan (2023) reported positive effects of body percussion exercises on balance and coordination in elderly individuals (10). Bo, Li, & Tao (2019) also concluded in a study that motor interventions lead to enhanced cognitive performance (15). Despite most studies showing the benefits of body percussion exercises, few studies have been conducted regarding the impact of this program on balance skills and executive functions in children with intellectual disabilities and those who are healthy. Furthermore, considering the research background, it seems there is a relationship between executive functions and motor skills. In other words, enhancing motor abilities affects executive functions; thus, due to the sedentary lifestyle of children with intellectual disabilities, engaging in sports and physical activity can significantly improve their problems, including motor skills, cognitive disorders, communication skills, and social (15). Currently, motor activity and cognitive function stimulation along with music are widely studied, and the results of studies underscore the importance of body percussion activities in the development of cognitive factors (16). Since cognitive and motor problems in children with intellectual disabilities lead to their withdrawal from activity and society, designing appropriate motor programs to assist this segment of the population is essential. In this vein, the aim of the present study is to compare the impact of body percussion exercises on the executive and balance performance of children with intellectual disabilities and those who are healthy.

2. Materials and Methods

2.1 Study Design and Participants

The quasi-experimental study design utilized was a pre-test post-test with control groups. The statistical population of the current study comprised all students enrolled in regular and special schools in Ramhormoz city, aged 9 to 11 years, in the academic year 2023-2024. From the target population, 20 children with intellectual disabilities and 20 typically developing children were selected as the sample using convenience sampling. Before the evaluation, the procedure was explained to the parents of the children, who then expressed their willingness to participate in the research by signing consent forms after being fully informed about the research stages and potential outcomes. The operational procedure of the current research was such that after selecting the sample, pre-tests related to executive functions including Continuous Performance Test (sustained attention), Stroop Color and Word Test (response inhibition), modified Stork Stand Test (static balance), and Heel-Toe Walking Test (dynamic balance) were administered. Subsequently, participants were randomly assigned into two experimental groups (healthy and with disabilities) and two control groups (healthy and with disabilities). Participants in the experimental groups engaged in group body percussion sessions twice a week for 45 minutes each over 8 weeks, while those in the control groups received no intervention. After the final training session, participants took part in the post-test, and the results were recorded.

2.2 Tools

Continuous Performance Test: This test was used to assess participants' sustained attention. It evaluates attention and impulsivity, requiring the maintenance of attention during a continuous task and inhibition of impulsive responses. Subjects need to focus their attention on a relatively simple set of visual stimuli and respond upon seeing a target stimulus. Variables measured in this test include 1- omission errors (not pressing the button against a target stimulus), 2- commission errors (pressing the button against a non-target stimulus), 3- reaction time (average reaction time of correct responses against the stimulus in milliseconds). The test comprises 150 stimuli, executed using software on a laptop, with 30 (20% of total stimuli) being target stimuli requiring a response (pressing a key). The interval between two stimuli presentations is 1000 milliseconds, and each stimulus is presented for 200 milliseconds. In studies by Hadian Fard et al. (2000), the reliability coefficients of different sections of the test, conducted on 43 elementary school boys with a 20-day interval, ranged between 0.59 and 0.93 (17).

Stroop Color and Word Test: Ridley Stroop introduced this test in 1935 to measure selective attention and cognitive flexibility. It's also an important tool for assessing response inhibition, widely translated and used by professionals worldwide. Various forms of this test have been developed for research purposes. The test presents 48 congruent color words (words whose color matches their meaning) and 48 incongruent color words (words whose color does not match their meaning) on a computer screen, with an 800-millisecond interval and a 2000-millisecond duration. The respondent must select the correct color on the keyboard, ignoring the word meaning. Scores for errors, correct responses, reaction time, and interference score (reaction time difference between incongruent and congruent words) are calculated separately for congruent and incongruent word groups for scoring and interpretation. Research on this test has shown it has suitable validity and reliability for assessing inhibition in children and adults (18).

Stork Stand Test: The modified Stork Stand Test is used to measure static balance with the dominant leg. Participants place their hands on their hips with the non-dominant foot positioned against the inside of the dominant leg. Participants stand as long as possible on the dominant foot. The test ends if hands move away from the hips or the non-dominant foot separates from the dominant leg's knee. Each participant has two attempts with a 15-second rest in between. The best performance is considered the participant's score. The test's validity and objectivity have been reported as 0.87 and 0.99, respectively (6).

Heel-Toe Walking Test: This test assesses the ability to walk in a straight line. Participants are asked to take 14 steps in a straight line, heel-to-toe. If a participant steps off the path before completing 14 steps (maximum score), the test is stopped, and the number of steps taken is recorded as the score. The test is repeated, and the highest score is considered the participant's record. The reliability of this test has been calculated by researchers as 91% (19).

2.3 Intervention

Body Percussion Exercises: Included clapping, snapping, chest thumping, thigh slapping, foot stomping, and hitting the opposite hand (10). The exercise protocol was derived from the book on body percussion and rhythmology by Shiva Tajparast (2018), along with content available on the internet. It is worth noting that the exercises were conducted under the supervision of the researcher (10). The exercises progressed from simple to complex and were tailored to the characteristics of children with intellectual disabilities.

2.4 Statistical analysis

For data analysis in different stages and groups, the Analysis of Covariance (ANCOVA) was used for for examining inter-group and intra-group differences, and the Bonferroni post-hoc test at a significance level of 0.005. Error rates were assessed with an alpha of 0.05 and a confidence level of 95%. All statistical operations were performed using SPSS software version 24.

3. Results

The age range of participants in this study was 9 to 11 years. Additionally, the normal distribution of data was accepted at a 95% confidence level using the Shapiro-Wilk test. Moreover, the results of the Levene's test were equal to (P=0.736), thus the assumption of equal variances was met.

Table 1. Mean and Standard Deviation of Executive Performance Components of Participants by Group and Test Stage

Component	Group	Pre-test	Post-test
Sustained Attention			
Omission Error (Count)	Experimental Disabled	14.20 ± 2.72	10.90 ± 1.39
False Alarm (Count)		24.60 ± 3.12	17.10 ± 1.05
Reaction Time (Time)		0.804 ± 0.54	0.615 ± 0.29
Omission Error (Count)	Control Disabled	14.70 ± 2.12	13.60 ± 1.42
False Alarm (Count)		25.20 ± 3.19	22.90 ± 1.12
Reaction Time (Time)		0.824 ± 0.32	0.789 ± 0.38
Omission Error (Count)	Experimental Healthy	9.60 ± 1.98	5.50 ± 1.77
False Alarm (Count)		13.90 ± 2.17	8.30 ± 0.682
Reaction Time (Time)		0.565 ± 0.24	0.417 ± 0.19
Omission Error (Count)	Control Healthy	9.50 ± 1.21	8.90 ± 0.640
False Alarm (Count)		13.30 ± 1.60	12.50 ± 2.45
Reaction Time (Time)		0.552 ± 0.21	0.549 ± 0.19
Response Inhibition			
Accuracy (Count)	Experimental Disabled	7.97 ± 2.76	13.90 ± 2.60
Speed (Time)		0.834 ± 0.43	0.612 ± 0.29
Accuracy (Count)	Control Disabled	10.00 ± 2.47	10.40 ± 2.37
Speed (Time)		0.835 ± 0.35	0.833 ± 0.25
Accuracy (Count)	Experimental Healthy	14.70 ± 1.42	20.70 ± 1.49
Speed (Time)		0.579 ± 0.18	0.425 ± 0.19
Accuracy (Count)	Control Healthy	14.00 ± 2.36	14.50 ± 2.45
Speed (Time)		0.550 ± 0.20	0.547 ± 0.24

Table 1 presents the means and standard deviations of sustained attention and response inhibition for participants with and without disabilities in the pre-test and post-test stages. According to the results from the table, it is clear that participants in the experimental groups (both with and without disabilities) performed better in the post-test stage compared to the control groups.

Table 2. Mean and Standard Deviation of Static and Dynamic Balance Scores of Groups by Test Stage

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)
Static Balance (Time)	Experimental Disabled	11.40 ± 1.07	33.20 ± 3.96
	Control Disabled	10.85 ± 3.24	11.50 ± 3.42
	Experimental Healthy	65.30 ± 5.12	83.40 ± 7.26
	Control Healthy	66.60 ± 4.11	67.80 ± 6.41
Dynamic Balance (Step Count)	Experimental Disabled	5.40 ± 0.82	9.10 ± 0.98
	Control Disabled	5.11 ± 1.05	5.50 ± 0.96
	Experimental Healthy	8.50 ± 1.37	13.00 ± 1.39
	Control Healthy	8.20 ± 1.32	8.30 ± 1.16

Table 2 shows the means and standard deviations of the scores for static and dynamic balance in the experimental and control groups in the pre-test and post-test stages. Based on the results from the table, participants in the experimental groups, both with and without disabilities, exhibited better performance in the post-test stage compared to the control groups.

Table 3. Results of the Covariance Analysis Test for Evaluating the Groups Across Test Stages

Variable	Source of Variation	DF	Sum of Squares	Mean Square	F	p-value	Eta Squared	Power
Omission Error	Group	3	432.32	144.10	39.21	<0.001	0.837	0.999
	Membership	35	872.74	24.936				
	Error	1	51.097	51.097				
False Alarm	Group	3	8037.83	2679.27	240.99	<0.001	0.855	0.999
	Membership	35	8.036	0.229				
	Error	1	97.717	97.717				
Reaction Time	Group	3	274.89	91.630	179.64	<0.001	0.860	0.999
	Membership	35	7014.12	200.403				
	Error	1	45.603	45.603				
Response Accuracy	Group	3	4862.75	1620.916	68.78	<0.001	0.711	0.999
	Membership	35	1094.859	31.281				
	Error	1	376.39	376.39				
Response Speed	Group	3	4383.687	1461.229	22.53	<0.001	0.720	0.999
	Membership	35	152.381	4.354				
	Error	1	97.717	97.717				
Static Balance	Group	3	8037.83	2679.27	10.29	<0.001	0.469	0.997
	Membership	35	281.27	8.036				
	Error	1	33.919	33.919				
Dynamic Balance	Group	3	432.32	144.10	5.731	0.022	0.141	0.644
	Membership	35	872.74	24.936				
	Error	1	51.097	51.097				

Table 3 presents the results of the covariance analysis used to evaluate the differences among groups across different stages of the test. The analysis shows significant effects across all variables tested, including omission error, false alarm, reaction time, response accuracy, response speed, static balance, and dynamic balance. The F-values and p-values indicate highly significant differences between groups ($p < 0.001$), suggesting that the body percussion exercises had a substantial impact on the participants' performance across these variables. Notably, the eta squared values suggest a large effect size for most variables, particularly for false alarm and reaction time, indicating that the interventions had a strong influence on improving attention and cognitive processing speed among the participants. This outcome is consistent with the hypothesis that body percussion exercises enhance cognitive and physical abilities, including executive functions and balance. The high power (.999) associated with these findings underscores the reliability of these results, suggesting that similar outcomes could be expected in repeated studies.

Table 4. Findings from the Bonferroni Test to Examine Group Differences

Variable	Group Comparison	Mean Difference	Standard Deviation	Significance Level

Omission Error	Experimental Disabled vs. Control Disabled	-2.37	0.513	<0.001
	Experimental Disabled vs. Experimental Healthy	-1.05	0.707	<0.001
	Experimental Healthy vs. Control Healthy	2.40	0.699	<0.001
False Alarm	Experimental Disabled vs. Control Disabled	-3.46	0.511	<0.001
	Experimental Disabled vs. Experimental Healthy	-1.31	0.513	<0.001
	Experimental Healthy vs. Control Healthy	-5.21	0.82	<0.001
Reaction Time	Experimental Disabled vs. Control Disabled	5.94	0.76	<0.001
	Experimental Disabled vs. Experimental Healthy	10.01	1.05	<0.001
	Experimental Healthy vs. Control Healthy	-5.23	0.744	<0.001
Response Accuracy	Experimental Disabled vs. Control Disabled	-8.66	0.14	<0.001
	Experimental Disabled vs. Experimental Healthy	-0.170	0.40	0.99
	Experimental Healthy vs. Control Healthy	0.120	0.17	<0.001
Response Speed	Experimental Disabled vs. Control Disabled	3.60	0.651	<0.001
	Experimental Disabled vs. Experimental Healthy	0.893	0.901	<0.001
	Experimental Healthy vs. Control Healthy	-5.063	0.657	<0.001
Static Balance	Experimental Disabled vs. Control Disabled	19.04	3.20	<0.001
	Experimental Disabled vs. Experimental Healthy	23.36	5.03	<0.001
	Experimental Healthy vs. Control Healthy	22.42	5.24	<0.001
Dynamic Balance	Experimental Disabled vs. Control Disabled	3.78	3.54	<0.001
	Experimental Disabled vs. Experimental Healthy	-1.08	4.62	0.082
	Experimental Healthy vs. Control Healthy	0.334	0.25	<0.001

Table 4, derived from the Bonferroni test, examines the position of differences between groups for various variables, including omission error, false alarm, reaction time, response accuracy, response speed, static balance, and dynamic balance. The findings reveal significant improvements in both cognitive and physical domains among participants engaged in body percussion exercises, as evidenced by significant mean differences between experimental and control groups ($p < 0.001$ for most comparisons). Specifically, improvements were noted in sustained attention and inhibitory control, as indicated by reductions in omission errors and false alarms, and enhancements in reaction times among the experimental groups compared to controls. Additionally, the exercises had a marked positive impact on both static and dynamic balance, showcasing the exercises' comprehensive benefits on participants' motor coordination and cognitive-motor integration. These results not only highlight the effectiveness of body percussion exercises in enhancing cognitive and motor functions but also underscore their potential as a valuable tool in the physical and cognitive development of children with and without disabilities. The significant improvements observed in the experimental groups compared to the controls underscore the utility of body percussion exercises in fostering better cognitive and physical health outcomes.

4. Discussion and Conclusion

The purpose of the present study was to compare the effects of body percussion exercises on the executive and balance performance of children with intellectual disabilities and their typically developing peers. The results of this study demonstrated that body percussion exercises significantly impact the executive and balance performance of both children with intellectual disabilities and typically developing children. Regarding executive performance components, the results indicated a positive effect of body percussion exercises on sustained attention and response inhibition. These findings align with the previous studies (20, 21), which showed that physical activity improves executive functions and cognitive performance. Moreover, Ziereis & Jansen (2015) demonstrated in their research that movement exercises improve the executive performance components of children with Attention Deficit/Hyperactivity Disorder (22). Ross, Case, & Leung (2016) found that physical activities enhance cognitive development and executive functions in children with physical-motor disabilities (23). Coetsee & Terblanche (2017) concluded that sports activity enhances cognitive and physical performance (20). These studies' results, indicating the impact of physical exercises on executive and cognitive performance, are consistent with the findings of this part of the study.

To explain these findings, it can be said that physical exercises play a foundational role in human cognitive activities. Essentially, it seems that individuals think fundamentally through their bodily movements, and through experiential movement, the activation of various brain parts allows for better situational recognition and performance due to motor experience. Moreover, the reticular activation system, including brain areas involved in executive functions and behavior segmentation, plays a crucial role. Various studies have shown that movement exercises and activities can improve the performance of the reticular activation system across different groups. Furthermore, rhythmic movement exercises are the easiest and fastest way to explore brain capabilities internally. These exercises can be highly enjoyable for children and enhance their cognitive performance by improving attention and concentration levels (24).

As mentioned in the findings section, the effect of body percussion exercises on sustained attention and response inhibition was significant, and participants in the experimental group performed better than those in the control group. These results are consistent with the previous (14, 25), which reported the benefits of body percussion exercises. Additionally, this part of the study aligns with the research by Bugos (2019), which demonstrated the impact of body percussion exercises on participants' working memory. A possible explanation for these results is that the body percussion method, based on the interaction of different elements, stimulates various cortical and subcortical areas across both brain hemispheres, affecting the motor cortex, cerebellum, and basal ganglia (26). Music effectively stimulates the right hemisphere, and through body beats, various cognitive aspects such as attention, memory, and information processing are strengthened. Specifically, observed levels of attention during the learning process of different movements lead to increased blood flow in the thalamic nuclei (thalamus), basal ganglia, and prefrontal cortex, thereby improving attention and learning (16, 26). Additionally, movement planning occurs in the frontal cortex, which is connected to other cortical areas, allowing access to planned information for movement, leading to an individual's awareness of their body and environment. Furthermore, executing body percussion exercises requires information processing in the central nervous system; therefore, skills requiring greater coordination and involving more body parts necessitate more optimized processing, which can lead to improved cognitive processes and consequently correct decision-making to create response inhibition in movements (16, 26). Overall, in the framework of body percussion in the BAPNE method, rhythm is the dynamic principle that guides motor psychological processes during body beating as an instrument. The sounds produced by this form of percussion instruments interact with all the aforementioned areas through the auditory system, thus providing feedback to the system. It seems this auditory-motor feedback mechanism, which leads auditory information to motor action, engages executive functions and their components, including sustained attention and response inhibition (25).

As stated in the findings, the results from the paired t-test showed that body percussion exercises significantly affect the static and dynamic balance of both typically developing children and those with disabilities. The examination of group progress in static and dynamic balance revealed that both experimental groups of typically developing and children with disabilities who participated in the body percussion program experienced significant progress. These results align with a previous study (25), indicating the positive impact of body percussion exercises on balance and coordination. Additionally, contrary to the findings of this part of the study, the studies by Eskandarnejad et al. (2016), Amirizadeh et al. (2018), reported that the movement program did not improve balance (19, 27). The discrepancy in these results could be attributed to the type of program, the number of sessions, and the age of the participants.

Balance involves neural impulses from peripheral sensory receptors to the cerebellum, integrated neural connections within the cerebellum and other related centers, and ultimately descending pyramidal output to lower motor neurons. Exercise, through repetition and practice, can facilitate transmission in these neural circuits. The findings of the current study can be explained by the increase in neural adaptability caused by exercise, such as the recruitment of efficient neural units, reorganization in the somatosensory cortex, enhanced efficiency and strength of synaptic connections, increased activation of the nervous system, reduction of inhibitory neural reflexes, and decreased resistance in neural pathways to impulse transmission (8). When examining the effect of physical activity on individuals' balance, we essentially observe an improvement in balance due to reliance on proprioceptive sensory information and a decrease in dependence on visual information for posture control and balance maintenance. Therefore, it can be concluded that body percussion exercises facilitate the transmission of vestibular or somatosensory information, or both, to higher neural centers for balance maintenance. Moreover, postural control involves a complex coordination between sensory and biomechanical information and muscular activity against external forces, where the loss of any of these factors can increase postural sway and reduce the ability to maintain control of a part or the entire body during movement and sports activity (28). In fact, somatosensory, visual, and vestibular systems, as well as muscular activity, play roles in maintaining postural control. If any of the sensory systems—visual, vestibular, or somatosensory—transmit incorrect information, or if the central nervous system is impaired, balance is disrupted. Given that a child's initial reactions are motor responses, teaching and learning motor skills in the early years of life take precedence over other skills. Utilizing physical or preferably sports activities can help improve children's motor activities. A possible explanation for the findings of this part of the study is that body percussion, combining music with body movements, creates relaxation, reduces muscle tone, strengthens rhythmic body movements or parts, increases effort, and improves psychological components related to movement, resulting in improved static and dynamic balance. Additionally, factors affecting postural stability include muscular weakness, decreased proprioception, and poor coordination. Since children with intellectual disabilities struggle with balance due to muscle laxity and weakness compared to their peers, body percussion exercises could be beneficial in improving static and dynamic balance in these children. Body percussion exercises, by creating appropriate physiological adaptations, can play a significant role in skill learning, motor unit recruitment, enhancement of motor cortex plasticity, and improved muscle utilization. These exercises are also closely associated with increased spinal cortical excitability. It seems the neural adaptations resulting from these exercises lead to improved balance because body percussion is an interaction between mind and movement and can be considered a combined exercise program where individuals need higher attention and neuro-muscular coordination compared to other exercises, thereby strengthening neuromuscular coordination and balance. Given the positive impact of body percussion exercises in this study, it is recommended that appropriate motor and cognitive programs be implemented during the educational years of both typically developing children and those with disabilities to significantly aid in the development of their mental and motor abilities.

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Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Authors equally contributed to this article.

Data Availability Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Ethical Considerations

Informed consent was obtained from all individual participants included in the study. This study was approved by the Ethics Committee of the Department of Sport Science of Payame Noor University (IR.PNU.REC.1402-282).

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