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Brain Gym and Core Stability Exercises are Superior in Improving Dynamic Balance in 8-9-Year-Old Children

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ABSTRACT

Introduction: The COVID-19 pandemic has led to low physical activity levels among children, resulting in a high risk of falls and injuries. Core stability exercises are standard practices to enhance dynamic balance. Brain Gym and balance boards are alternative activities that can be provided to children to improve dynamic balance. This study aims to demonstrate that combining Brain Gym and core stability exercises is more effective in enhancing dynamic balance in 8-9-year-old children than balance boards and core stability exercises.
Methods: This study employed an experimental design using a Randomized Pre-Test and Post-Test Control Group Design involving 32 participants divided into two groups.
Results: The Wilcoxon signed-rank test revealed a significant difference with a p-value of <0.01 in both Group I and Group II. The difference in means-tested by the Mann-Whitney U-test showed an essential difference between Group I and Group II with a p-value of 0.001 (p <0.05).
Conclusion: Brain Gym and core stability exercises are superior in improving dynamic balance in 8-9-year-old children compared to balance boards and core stability exercises.

Keywords: Brain Gym, balance board, core stability exercise, dynamic balance

INTRODUCTION

The COVID-19 pandemic has transformed various aspects of life. We must utilize digital technology to carry out multiple tasks and activities from home. Not only adults but also children have to engage in activities from home. Consequently, learning and play activities are predominantly conducted using smartphones and laptops. The COVID-19 pandemic has decreased children's physical activity levels and increased sedentary behaviour.[1] A longitudinal study in Shanghai, China, found that both children and adults reduced their physical activity by 435 minutes and spent an additional 28 hours on screen time per week since the widespread onset of COVID-19.[2] Children's age is characterized by immaturity in various aspects such as cognitive abilities, emotions, interaction with the environment, and motor skills. Therefore, children are at a higher risk of injury with the lack of physical activity.[3]

The lack of physical activity influences children's physical condition. Safe Kids Worldwide states that approximately 1.35 million emergency room visits occur annually due to sports-related injuries, with about 20 per cent occurring in children or adolescents.[4] The components of physical fitness consist of muscle endurance, strength, flexibility, general endurance, speed, coordination, agility, and balance. Dynamic balance is the primary component in maintaining the body's posture to stand erect and sustain body positions while moving. This involves the centre of gravity changes in the neuromuscular, musculoskeletal, and cognitive systems. It requires coordination between the nervous system, muscles, and spinal cord to achieve good dynamic balance in children.[5] Dynamic balance still needs to be optimal in elementary school-aged children. Hence, physical activity training is required to stimulate the components of dynamic balance.[6]

Children aged 8-9 years have suboptimal dynamic balance. At age 8, there is an initial phase of increasing dynamic balance abilities in both boys and girls. Optimizing dynamic balance requires physical activity training that stimulates the components of dynamic balance.[7] Core stability exercise is frequently used to reduce the risk of injury due to suboptimal body balance. This exercise aims to control the position and movement of the trunk to the pelvis to perform transitional movements and activities, thus maintaining body balance.[8] Another exercise that is effective in improving dynamic balance in children is playing on a balance board. Balance board games enhance proprioceptive function and train vestibular abilities, crucial in balance components.[9]

Both core stability exercises and balance board games can enhance dynamic balance by stimulating the motor and sensory systems. However, to optimize dynamic balance, especially in children, cognition is also a component of balance that must be considered. According to Piaget, the cognitive development of children consists of four stages: the sensorimotor stage (ages 0-2), the preoperational stage (ages 2-7), the concrete operational stage (ages 7-11/12), and the formal operational stage (ages 11/12 and above). Children's cognitive development indirectly influences their dynamic balance abilities. Dynamic balance is affected by cognitive functions involving internal representation and improving adaptive responses related to spatial and movement orientation.[4]

Brain Gym is one of the exercises that can be given to children to stimulate the components of dynamic balance, particularly in the sensory and cognitive systems. Brain Gym can improve concentration, attention, alertness, and the brain's ability to plan, respond, and make decisions during movement. Decision-making responses during movement influence central processing and anticipatory processes, affecting balance.[10] Brain Gym is a series of movement exercises involving various biomechanical aspects that uniquely help optimize human brain function. Brain Gym can improve blood flow and oxygenation to the brain, enhancing memory and concentration, boosting energy levels, and improving balance and coordination of movements.[3]

The improvement in dynamic balance occurs due to the enhancement of the vestibular, somatosensory, and visual systems from different pathways. Brain Gym, core stability exercises, and balance board games have their approaches to enhancing dynamic balance. Research on core stability exercises and balance board games is plentiful. However, combining Brain Gym and core stability exercises is a new combination offered by researchers who recognize the need for cognitive stimulation for dynamic balance in 8-9-year-olds.

Core stability exercises can improve dynamic balance by increasing the strength of the core muscles but may not stimulate cognition. Brain Gym can complement the shortcomings of core stability exercises by providing vestibular stimulation, which is also obtained from balance board games and cognitive stimulation. This combination creates a comprehensive and effective exercise regimen.

This study aims to demonstrate that: 1) The combination of Brain Gym and core stability exercises can improve dynamic balance in 8-9-year-old children, 2) The combination of balance board games and core stability exercises can improve dynamic balance in 8-9-year-old children, 3) The combination of Brain Gym and core stability exercises is superior to balance board games and core stability exercises for improving dynamic balance in 8-9-year-old children. This research is highly beneficial for raising awareness in the community about the importance of physical activity, especially for children, in the post-COVID-19 pandemic era.

METHOD

This study adopted an experimental design with a Randomized Pre-Test and Post-Test Control Group Design, conducted over a period of 1 month from May to June 2022 at Bina Insan Mandiri Sejahtera Elementary School in Badung, Bali. Sampling was conducted in the first week of May using simple random sampling to select 32 children from a population of 43, aged 8-9 years at the time of the study, with good nutritional status based on CDC charts, cooperative and able to understand verbal instructions, and in good general health without injuries. Children with postural abnormalities, post-trauma or fractures, deformities, or anatomical abnormalities were excluded. Dropout criteria were defined as missing more than two training sessions over the four weeks or failing to attend the evaluation after completing the 4-week research program, with a grace period of 3 days from the last day. The sample size was calculated using the Pocock formula, resulting in 32 samples. After obtaining the 32 samples, random allocation was performed by drawing lots to divide the samples into two treatment groups: Group I (Brain Gym and Core Stability Exercise) and Group II (Brain Gym and Balance Board). Follow-up was conducted in the second week of May, and a Pre-Test was administered. The Post-Test was performed after one month of intervention, specifically in the last week of June.

The dependent variable in this study was dynamic balance, with independent variables being core stability exercise, balance board, and brain gym. Age and nutritional status were controlled variables. Dynamic balance was measured using the Y Balance Test at the beginning and end of the study. Respondents' balance was assessed in three directions by standing on one leg at the center of a Y-shaped track, with the other foot hanging or non-weight-bearing, hands on hips, and reaching in each direction (anterior, posteromedial, and posterolateral). It was measured using the formula: [(mean anterior + mean posteromedial + mean posterolateral) / (leg length x 100)].[11] Measurements were taken one day before the first intervention and one day after the intervention concluded, over a period of 4 weeks, with three repetitions on the same leg. Descriptive statistics were used to describe the physical characteristics of the samples, including age, height, and weight, which were obtained before the initial test. Data normality was tested using the Shapiro-Wilk test, data homogeneity was tested using the Levene test, and hypothesis testing was conducted using the Wilcoxon signed-rank test for paired group differences and the Mann-Whitney U-test for differences between unpaired groups. Data were analyzed using SPSS version 22, copyrighted by IBM Corporation in 2013.

All participants' parents provided informed consent before the study, and the research obtained approval from the Research Ethics Commission of the Faculty of Medicine, Udayana University, with Ethical Clearance Number 1612/UN 14.2.2VII.14/LT/2022.

RESULTS

The Research Sample Scheme can be seen in Figure 1.

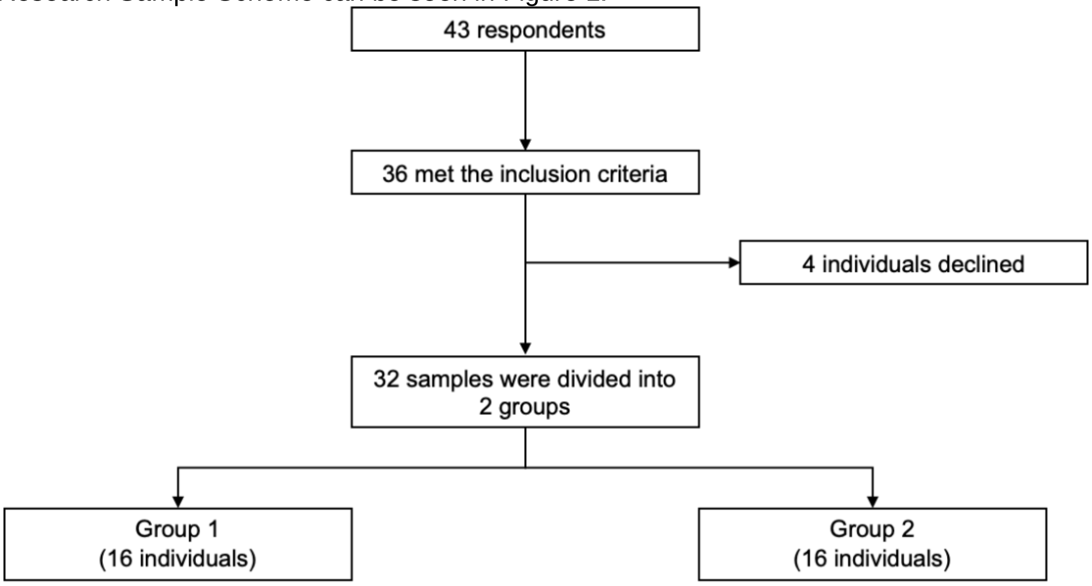

Figure 1. Research Sample Scheme

Figure 1 illustrates the sample recruitment process, where initially, 36 samples meeting the inclusion criteria were obtained. However, four individuals declined to participate as their parents did not allow them. Subsequently, the 32 samples were divided into two groups by lottery. Group I received Brain Gym and core stability exercise treatments, while Group II received balance board games and core stability exercise treatments. Parents of the selected samples received prior orientation regarding the research objectives and the effects of Brain Gym, balance board games, and core stability exercises on dynamic balance. Based on inclusion and exclusion criteria, parents of the selected samples were given an informed consent form to sign as evidence of their willingness to enroll their children as research participants. The Distribution of Sample Data Based on Gender can be seen in Table 1.

Table 1. Distribution of Sample Data Based on Gender

Gender	Frequency		Percentage (%)	
	Group I	Group II	Group I	Group II
Male	8	8	50	50
Female	8	8	50	50
Total	16	16	100	100

Table 1 shows that in treatment Group I, there are eight male subjects (50%) and eight female subjects (50%). In treatment Group II, the distribution indicates eight male subjects (50%) and eight female subjects (50%). The Distribution of Sample Data Based on Age and Nutritional Status can be seen in Table 2.

Table 2. Distribution of Sample Data Based on Age and Nutritional Status

Characteristics	Mean±Standard Deviation	
	Group I	Group II
Age (years)	8,44±0,512	8,38±0,500
Nutritional Status Score (%)	97,79±6,064	97,91±4,096

Table 2 indicates that the research subjects in treatment Group I (brain gym and core stability) have an average age of 8.44 years, while in treatment Group II (balance board and core stability), the average age is 8.38 years. Regarding nutritional status based on CDC guidelines, treatment Group I (brain gym and core stability) averages 97.79. In contrast, treatment Group II (balance board and core stability) averages 97.91. The Wilcoxon Signed Rank Test for Dynamic Balance Differences in Treatment Group I can be seen in Table 3.

Table 3. Wilcoxon Signed Rank Test for Dynamic Balance Differences in Treatment Group I

Variables	Wilcoxon Signed Rank Test				
	Mean±Standard Deviation	Median	Min.	Max.	p-value
Dynamic Balance Before Training	90.28±1.393	90.4	87.9	92.2	p<0.001
Dynamic Balance After Training	102.18±2.054	101.6	100	106.1	

Table 3 illustrates a significant difference in mean dynamic balance before and after treatment, with a p-value <0.05, indicating a substantial improvement in dynamic balance in treatment Group I. The Wilcoxon Signed Rank Test for Dynamic Balance Differences in Treatment Group II can be seen in Table 4.

Table 4. Wilcoxon Signed Rank Test for Dynamic Balance Differences in Treatment Group II

Variables	Wilcoxon Signed Rank Test				
	Mean±Standard Deviation	Median	Min.	Max.	p-value
Dynamic Balance Before Training	90.79±1.436	91.00	87.70	92.20	p<0.001
Dynamic Balance After Training	98.56±2.762	98.65	92.70	102.30	

Table 4 indicates a mean difference in dynamic balance before and after treatment with an average p-value <0.05, signifying a significant improvement in dynamic balance in treatment Group II. The Mann-Whitney Test for Difference in Dynamic Balance Improvement Scores between Treatment Group I and Treatment Group II can be seen in Table 5.

Table 5. Mann-Whitney Test for Difference in Dynamic Balance Improvement Scores between Treatment Group I and Treatment Group II

Variables	Wilcoxon Signed Rank Test				
	Mean±Standard Deviation	Median	Min.	Max.	p-value
Group I	11.9±4.972	12.30	10.40	14.50	p<0.001
Group II	7.77±5.136	8.20	6.00	10.30	

Table 5 presents the calculation results of the mean difference in dynamic balance improvement scores, yielding a p-value of 0.001 ($p < 0.05$) for the difference between pre-and post-training. This indicates a significant difference between the two training regimes. The mean improvement in dynamic balance scores in treatment Group I (brain gym and core stability exercise) is more significant than in Group II (balance board and core stability). Thus, it can be concluded that the training in Group I (brain gym and core stability exercise) results in a more significant improvement in dynamic balance scores than in Group II (balance board and core stability). The Percentage Increase in Balance Scores After Training can be seen in Table 6.

Table 6. Percentage Increase in Balance Scores After Training

Analysis Results	Group I	Group II
Balance Score Before Training	90.28	90.79
Balance Score After Training	102.18	98.56
Balance Score Difference	11.90	777
Percentage (%)	13%	8.5 %

Table 6 illustrates that the percentage increase in the mean dynamic balance scores in treatment Group I is more significant than in treatment Group II. Therefore, it can be concluded that combining a brain gym with core stability exercises is superior to combining a balance board and core stability in improving dynamic balance in children aged 8-9 years.

DISCUSSION

Sample Characteristics

The children in this study were aged 8-9 years, with 20 children aged eight years and 12 children aged nine years. In treatment Group I, ten children aged eight years and six children aged nine. In treatment Group II, there were also ten children aged eight years and six children aged nine years. The age range in this study was limited to 8-9 years based on the findings of research conducted by Hastuti (2018) regarding the influence of age on the dynamic development of children. It was reported that ages 8-9 years mark the beginning of dynamic balance development. At ages 8-9, boys and girls exhibit similar dynamic balance. This opinion served as the basis for determining the age limit in this study.[4]

Gender was not restricted or used as a basis for selecting research subjects in this study. This decision was based on previous research by Hastuti, which stated that children aged 8-9 years exhibit similar dynamic balance regardless of gender.[12] In this study, eight male and eight female children were in treatment Group I, which included the addition of a brain gym to core stability exercises. Similarly, in treatment Group II, which received a balance board and core stability exercise, there were also eight male and eight female children.

Improvement in Dynamic Balance in the Brain Gym and Core Stability Exercise Group

In the testing of treatment Group I using the Wilcoxon signed-rank test, a p-value of <0.001 was obtained, indicating a significant difference in the mean dynamic balance before and after treatment in treatment Group I, which received brain gym and core stability exercise among 8-9-year-old children. These findings are consistent with research conducted by Siamy in 2015. Brain gym provides new stimulation that strengthens the connections between nerves in the brain, making the brain more responsive and enhancing internal representative areas. Each brain gym movement serves as sensory input the sensory system receives, thus forming new neural connections and creating new synapses in the brain. All new movement experiences in the brain gym contribute to sensory learning, therefore possessing the potential to change the brain system through reorganization, known as neuroplasticity.[3]

Brain gym enhances proprioceptive input by activating the neuromuscular system through posture re-education. It involves exercises designed to activate the neuromuscular system with complex movements in various directions and slow speeds, thus eliciting mechanoreceptor stimuli. These complex mechanoreceptor stimuli allow subcortical nuclei to provide feedback to the central pattern generator (CPG) and facilitate learning in the neuromuscular system. Brain gym enhances the sensory ability to process responses to certain conditions.[13] Brain gyms can enhance dynamic balance due to complex and novel movement activities, thus broadening the utilization of brain areas, which in turn enhances the adaptive system's ability to affect balance responses, consistent with the findings of Larashati in 2018.

Brain gym enhances the utilization of broader brain areas, leading to improved sensorimotor integration. This results in the brain's ability to organize sensory information from both the environment and the body, thereby improving reaction speed when responding to balance-demanding movements. The lateral dimension coordinates the left and right brain hemispheres, crossing the body's midline and operating within the visual, auditory, vestibular, and kinesthetic systems. Therefore, repetitive movements improve the somatosensory, visual, and vestibular systems for balanced response. Good sensory input due to multisensory coordination facilitates crossing the body's midline, thus enhancing movement coordination.[10]

This study validates Dennison's theory that brain gyms complement core stability exercises in improving dynamic balance by enhancing the vestibular, somatosensory, and visual systems through different pathways. Brain gym enhances balance through complex and novel movement activities, allowing for the utilization of broader brain areas, thus improving the adaptive system that influences balance responses. On the other hand, core stability exercise improves balance by strengthening the core muscles, which act as stabilizers, leading to increased postural control, which is crucial for balance.

Dynamic Balance Improvement in the Balance Board and Core Stability Exercise Group

Based on the static balance data analysis before and after treatment in Group I using the Wilcoxon signed-rank test (paired samples), as shown in Table 4, the mean dynamic balance score before treatment was 90.79±1.436, and after treatment, it was 98.56±2.762, with a p-value of <0.001. These results indicate a significant effect of balance board games and core stability exercises on the dynamic balance of 8-9-year-old children at SD Bina Insan Mandiri Sejahtera. Engaging in balanced board games leads to increased proprioception in individuals. Proprioception plays a crucial role in improving dynamic balance. It stimulates the nervous system, prompting muscle responses to control the neuromuscular system.[4]

The study by Yalnaz in 2022 demonstrated that proprioceptive training using a balance board effectively improves dynamic balance in undergraduate students. This training is consistent with the findings that using a balance board enhances proprioceptive function in active joint stabilizers and stabilizes tone, increases motor unit recruitment, activates Golgi tendon organs, and improves coordination between intrafusal and extrafusal fibers with efferent nerves in the muscle spindle, thereby enhancing proprioceptive function and sensory input processed in the brain as central processing. Central processing determines the body's focal point and gravitational alignment, forming reasonable postural control and organizing sensory-motor responses required by the body. Subsequently, the brain transmits these impulses to the effectors so that the body can maintain good stability during movement. Another study involving basketball players aged 18-22 showed that proprioceptive training with a balance board significantly improves static and dynamic balance.[14]

The administration of core stability exercises to individuals experiencing balance issues, elderly individuals at risk of falling, and athletes have been proven to improve balance and reduce the risk of falls. The improvement in balance observed in the study closely aligns with the findings of Diah Elena et al. in 2022, where it was found that providing such training for four weeks could enhance both static and dynamic balance.[15]

The core region is crucial as it is the anatomical location where the center of gravity (COG) resides and where movements originate. Strengthening the core muscles improves the neuromuscular system and reduces displacement and shifts in the COG.[4] Contraction of the core stability muscles before the initiation of movement is the initial postural reaction of the neuromuscular system. Deliberate movements in the upper extremities are preceded by postural movements in the lower extremities (pelvic, hip, and trunk), contributing to the overall dynamic regulation of balance and inhibiting postural disturbances.[8]

The exercises can elicit specific reactions to control orientation in the spinal column. Global muscles cannot stabilize individual spinal segments except through load compression on the vertebrae. If one segment is unstable, load compression can cause pain as stress is exerted on the inert tissues at the end of that segment's range. Both global and core muscles have multiple layers, and stimulating these core muscle areas can influence the direction of movement response. These muscles provide dynamic support to a spinal segment and help maintain each segment stable, preventing inert tissues from experiencing stress due to restricted movement. Both muscle overload and global and core muscles play a role in stabilizing multiple spine segments. This indicates that mobility in the extremities can be efficiently achieved only with optimal postural stability (activation of core stability muscles).[15]

The Brain Gym and Core Stability Exercise Group Enhances Dynamic Balance More in 8-9-Year-Old Children.

The difference test aims to differentiate the difference in the average improvement of dynamic balance between treatment group I (brain gym and core stability exercise) and treatment group II (balance board and core stability exercise). The dynamic balance results were obtained through the Y balance test, repeated three times, and the best value from the three was taken.

Based on the analysis results using Mann Whitney, as shown in Table 5, a p-value of 0.001 was obtained. Treatment group I had a mean difference in dynamic balance improvement of 11.9±4.972 higher after treatment than treatment group II, which was 7.77±5.136. In this study, it can be concluded that treatment group I (brain gym and core stability exercise) improves dynamic balance more than treatment group II (balance board and core stability exercise).

Structured and planned physical training will influence balance components, including attention, a form of cognitive ability that can affect dynamic balance. Brain gym and core stability exercises are forms of physical training that improve neural levels affecting response speed, movement accuracy, and ability. Shi 2022, researched the acute effects of exercise on children's attention and movement response abilities, finding that physical training activates different brain areas, as observed through cortical transcranial magnetic stimulation manipulating subcortical cognitive functions during different movement commands. Physical training performed for 30 minutes has a more dominant effect on activating brain areas involved in movement attention than training performed for 10 minutes. In this study, brain gym and core stability exercises conducted for 30 minutes improved dynamic balance ability more than core stability exercises performed for 10 minutes, thus aligning with the research findings.[16]

Brain gym and core stability exercises improve dynamic balance more than balance board and core stability exercises, consistent with Diah Elena's 2022 study indicating that balance board and core stability exercises do not significantly affect cognitive improvement in movement, spatial tasks, attention assessed through Stimulus Onset Asynchrony (SOA), and inhibition of return (IOR).[15] Brain gym and core stability exercises enhance dynamic balance more than balance board and core stability exercises because brain gym enhances neurophysiological mechanisms in the brain more effectively than the balance board.

The study by Shi in 2022 suggests that physical training involving a broader range of brain areas improves the physiological mechanisms in the brain. Physiological improvements in the brain can be observed through increased blood flow and elevated levels of stress-reducing hormones, as well as increased growth hormones such as BDNF (brain-derived neurotrophic factor) in the hippocampus, frontal, and midbrain regions. Brain gym involves complex movements and engages the whole brain compared to core stability exercises, which primarily target strengthening the core muscles.[16]

Brain gym and core stability exercises are more effective in improving dynamic balance than balance board and core stability exercises, aligning with Shi's study in 2022. It was found that specific movements involving crossing the midline significantly enhanced the ability to respond to movement changes and sensory integration in maintaining balance compared to exercises that did not involve crossing the midline. In principle, brain gym incorporates more cross-midline movements than balance board exercises.[16]

Brain gym has a broader influence on brain functions, including the frontal, occipital, limbic, cerebral cortex, and brainstem. Brain activation facilitates rapid responses to situations requiring balance. The power of brain gym movements activates the entire brain's functions through complex connections with body movements.[10]

Core stability exercises induce dynamic balance through proprioceptive, tactile, and visual inputs, which require sensory integration in the cerebral cortex, cerebellum, and brainstem. After integration in the brain, these sensory inputs result in motor outputs that maintain dynamic balance. Organizing sensory information from the environment and the body ultimately affects reaction speed and balance maintenance.

Both training principles lead to synergistic improvements in dynamic balance at central and peripheral levels. Brain gym enhances dynamic balance centrally (internal representation, sensory integration, sensorimotor skills, anticipatory mechanisms), while core stability exercises improve peripheral aspects (muscles, proprioception, visuospatial skills, and somatosensory function).

This study represents the 8-9-year-old population regarding dynamic balance. However, the researchers acknowledge limitations in considering only the child's nutritional status and age without accounting for factors such as physical activity and socio-economic environment, which may also influence the study outcomes.

Conclusion

Based on this study, it can be concluded that conducting brain gym and core stability exercises three times a week for four weeks is more effective in improving dynamic balance than using a balance board and core stability exercises in children aged 8-9 years. The success of this research can be attributed to the appropriate selection of inclusion criteria and strict supervision by the staff during the study. Using consistent procedures for measuring dynamic balance in all study subjects also ensures the validity of the data. This study can represent the population of children aged 8-9 years in terms of dynamic balance. However, limitations in controlling factors such as home environment, play habits, physical activity, socioeconomic conditions, and psychological conditions of the subjects affect the research results.

Considering that brain gym, balance board, and core stability exercises were implemented for the first time at SD Bina Insan Mandiri Sejahtera, it is recommended to continue this research with different methods to evaluate the long-term effects of these exercises or compare various combinations of exercises. This will help refine our understanding of the benefits of these exercises and provide deeper insights for developing more effective exercise programs in the future.

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