

The Effect of 8 Weeks of Play with a Researcher-Made Balance Device on Static and Dynamic Balance in Boys and Girls Aged 8 to 12 Years: Semi-Experimental Study

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Original Article

Abstract

Introduction: Maintaining balance may seem simple, but it is crucial for standing, walking, and daily activities. Play is a voluntary, unstructured, and aimless activity. The aim of this study is to investigate the impact of using a game machine created by the researcher to enhance static and dynamic balance in 8-12 year old boys and girls.

Materials and Methods: This study is semi-experimental, with a statistical sample of 40 children aged 8 to 12. They participated with consent from themselves and their parents. The subjects were divided into 4 groups (two intervention and two control). Before the research began, a pre-test was conducted for all four groups. The intervention groups played for 8 weeks, 3 sessions of 30 minutes each week. A post-test was then conducted for all groups. Data analysis utilized Shapiro-Wilk descriptive and inferential tests, ANCOVA.

Results: A significant difference in static and dynamic balance was observed between the intervention and control groups ($P=0.00$). The results demonstrated a positive effect of playing with the device in the intervention group, and no significant difference was found between boys and girls.

Conclusion: Playing with a balance device created by a researcher can enhance static and dynamic balance in children aged 8 to 12.

Keywords: Proprioception; Balance; Play

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Introduction

Play is not an organized, structured, or serious activity; rather, it is voluntary, free, natural, unstructured, and non-goal-directed. It represents an instinctive need that forms part of individual and social life (1). One defining characteristic of play is its positive influence on children's cognitive, psychological, and sensory development (2). Motor activity programs can incorporate movement-based and physical games (1). In developed societies, games are now used to correct

postural abnormalities in children (3).

Although maintaining balance may seem simple, it is a fundamental prerequisite for standing, walking, and performing activities of daily living (4). Balance is maintained through the integration of afferent sensory information from the visual, vestibular, and proprioceptive systems within the central nervous system, ultimately enabling control of the center of gravity within the base of support (5). The central nervous system must integrate and process inputs from

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the visual, sensory, and vestibular systems into efferent motor commands to initiate the motor responses needed to maintain balance. Body balance depends on several external and internal factors, including genetics, age, center of mass, base of support, emotional state, strength, coordination, flexibility, frequency of participation in motor activities, training status, and visual control (6). Balance control is commonly classified into two types: static balance, which involves maintaining a position with minimal movement, and dynamic balance, which involves maintaining a stable base of support during movement (7).

Motor system responses that maintain postural stability are referred to as automatic postural responses (8) and are controlled hierarchically within the central nervous system (9). These responses are organized at the subcortical level, primarily in the cerebellum. They occur subconsciously, precede voluntary movement, and cannot be modified through conscious effort (8). Postural stability results from the input, processing, and output of information within the peripheral and central nervous systems (10). The central nervous system must integrate and process inputs from the visual, sensory, and vestibular systems into efferent motor commands that activate the motor responses needed to maintain balance (6). Because postural stability requires cognitive resources to process somatosensory input, the central nervous system evaluates and processes this information to generate the motor output commands needed to maintain postural stability. This entire process operates continuously and automatically in a loop (10).

In recent years, play equipment has been used to improve components of physical and motor fitness. Balance is one such component that consistently influences quality of life (11), and balance control is integral to all activities of daily living (12). Corrective games represent a relatively new corrective approach. Their enjoyable nature and compatibility with children's physical and psychological characteristics may enhance motivation and interest in physical activity (11). Incorporating games into learning environments supports long-term learning, facilitates new connections, and promotes the effective use of prior knowledge. By fostering advanced problem-solving skills, games also enhance self-confidence and a sense of achievement (13). Play contributes to the development of various body systems and improves muscular endurance, strength, flexibility, and cardiorespiratory endurance. Several studies have demonstrated the effectiveness of these exercises in correcting postural abnormalities (11).

Research indicates that sedentary behavior

throughout the lifespan may even accelerate the biological aging of the nervous, muscular, and skeletal systems, collectively contributing to a high prevalence of dynapenia, sarcopenia, balance disorders, mobility limitations, and falls among older adults (14).

In light of the above, designing and developing play equipment that is enjoyable while addressing specific objectives, such as improving physical and mental fitness, is essential. The present study aimed to investigate the effects of a researcher-developed play device on static and dynamic balance in boys and girls aged 8–12 years.

Materials and Methods

Study Design and Participants: This study used a quasi-experimental design and was field-based and cross-sectional in implementation, with basic research as its purpose. The study population comprised children aged 8–12 years in Qazvin County. Researchers recruited participants through in-person meetings at schools, where they introduced the study. Convenience sampling was used to recruit 40 boys and girls who volunteered.

The sample size was determined using G*Power software. The analysis indicated that a minimum of 10 participants per group was required to achieve a statistical power of 0.80, assuming an effect size of 0.70 and a significance level of 0.05. Children were enrolled after their parents completed informed consent.

The inclusion criteria were no regular participation in sports activities, sufficient strength to operate the device, good physical and psychological health, and no use of tricyclic antidepressants. Unwillingness to continue participating in the study and musculoskeletal injury were considered exclusion criteria.

Ethical Considerations: The Ethics Committee of the Physical Education and Sport Sciences Research Institute approved all study procedures. All participants and their parents could indicate their agreement to participate. The study details, including its purpose and the correct procedures for performing the tests, were explained to the volunteers, and written informed consent was obtained from those willing to participate.

Study Procedures: The preliminary design of the researcher-developed balance device was prepared using AutoCAD software, version 24 (Autodesk Corporation, San Rafael, CA, USA). The design was then sent to the manufacturer to produce a prototype and identify potential problems. After constructing the prototype, a pilot study using pre- and post-test assessments was conducted with five participants to identify and address unforeseen design issues and

constraints that might prevent the device from meeting the study objectives.

To assess construct and content validity, the preliminary pilot results and details of the device's operation were submitted to three faculty experts specializing in sports injury and sports biomechanics. Following validation and design refinement, the final design was sent for fabrication. To play with the device, the user maintains balance on one leg while using the other foot to control one or more balls on the game board.

Initially, the children were divided into four groups: boys in the experimental group, boys in the control group, girls in the experimental group, and girls in the control group. Leg dominance was determined using a hopping test and supplemented by information reported by the children and their parents.

Static Balance Assessment: Static balance was assessed using the Balance Error Scoring System (BESS) on firm and compliant surfaces, evaluating both legs. The assessment comprised six conditions: double-leg stance, single-leg stance, and tandem stance on a firm surface, followed by the same three stances on a foam surface. Participants maintained each position for 20 seconds.

Scoring was based on the number of errors, with fewer errors indicating better performance. During each condition, the examiner recorded the participant's errors. Errors included lifting the hands off the hips (iliac crests), opening the eyes, stepping, stumbling or falling, and hip abduction or flexion exceeding 30° (5). The reported validity of this test ranges from 0.88 to 0.92 (7).

Dynamic Balance Assessment: Dynamic balance was assessed using the Y Balance Test in three directions—anterior, posterolateral, and posteromedial—with both legs evaluated. Because performance on this test is strongly associated with leg length (15), we measured true leg length before testing to normalize the data. Reported validity ranges from 0.67 to 0.87 (7).

Leg length was measured with a tape measure as the distance from the anterior superior iliac spine to the medial malleolus, with the participant lying supine on the floor (15), knees extended, and ankles positioned 15 cm apart (7).

Participants stood on one leg at the center of the Y-shaped testing area and attempted to reach with the opposite leg while maintaining balance on the supporting leg. Using the toes of the reaching foot, participants touched the farthest possible point in each designated direction without committing an error. The distance from the center to the point of contact was

recorded in centimeters as the reach distance.

To minimize learning effects, each participant completed six practice trials in each of the three directions, with a 15-second rest interval between trials. Following a five-minute rest, participants completed the formal test in the designated directions. If the supporting foot moved from the center or the participant lost balance, the trial was repeated (Figure 1).

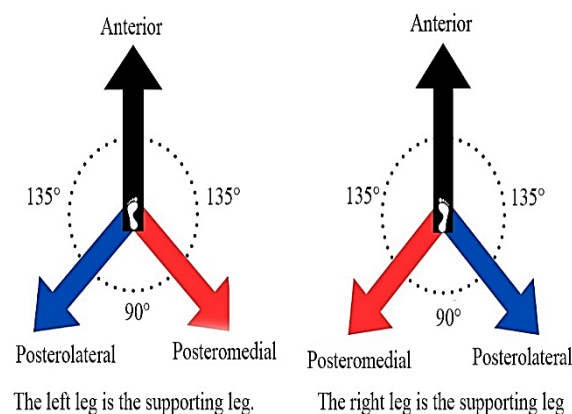


Figure 1. Y Balance Test for assessing dynamic balance

Normalized reach distance was calculated separately for each direction using the following equation (15):

Equation 1. Calculation of normalized reach distance in each direction

$$\text{Score} = \frac{\text{Access distance}}{\text{Limb Length}} \times 10$$

The experimental groups subsequently participated in an eight-week training program consisting of three 30-minute sessions per week using the researcher-developed balance device. The activities included a maze game (Figure 2a), a scoring-hole game (Figure 2b), and a colored-ball sorting game (Figure 2c). Children operated the device with their non-dominant foot while maintaining balance on their dominant leg. The control groups did not include any exercise training in their daily routines during the eight weeks. All groups were reassessed after completing the intervention.

Table 1 presents exercise details, and Figure 3 illustrates the exercise positions.

Statistical Analysis: Descriptive statistics, including means and standard deviations, summarized the characteristics of the study sample. For inferential analyses, the Shapiro–Wilk test was used to assess data normality.



C: Colored-ball sorting game

B: Scoring-hole game

A: Maze Game

Figure 2. Games incorporated into the device

We used analysis of covariance (ANCOVA) to evaluate and compare the effects of a play-based training program using the researcher-developed balance device

on participants' static and dynamic balance. The reported statistical power represents the probability of detecting a true effect as statistically significant.



B: Assisted Exercise

A: Seated Exercise

D: Independent Exercise

C: Guided Exercise

Figure 3. Types of exercises performed in the study's training program

Table 1. Training protocol used in the study

Exercise type	Week	Session 1	Session 2	Session 3
Seated exercise (Figure 3a)	1	After a 10-minute warm-up, participants played the maze game using the device for 20 minutes while seated in a chair.	After a 10-minute warm-up, participants played the maze game using the device for 20 minutes while seated in a chair.	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes while seated on a chair.
Seated exercise (Figure 3a)	2	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes while seated on a chair.	After a 10-minute warm-up, participants played the scoring-hole game using the device for 20 minutes while seated in a chair.	Following a 10-minute warm-up, participants performed the scoring-hole game using the device for 20 minutes while seated on a chair.
Assisted exercise (Figure 3b)	3	Following a 10-minute warm-up, participants performed the maze game using the device for 20 minutes with their backs supported against a wall.	Following a 10-minute warm-up, participants performed the maze game using the device for 20 minutes with their backs supported against a wall.	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes with their backs supported against a wall.
Assisted exercise (Figure 3b)	4	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes with their backs supported against a wall.	Following a 10-minute warm-up, participants performed the scoring-hole game using the device for 20 minutes with their backs supported against a wall.	Following a 10-minute warm-up, participants performed the scoring-hole game using the device for 20 minutes with their backs supported against a wall.
Guided exercise (Figure 3c)	5	Following a 10-minute warm-up, participants performed the maze game using the device for 20 minutes with one hand resting against a wall for support.	After a 10-minute warm-up, participants played the maze game using the device for 20 minutes, with one hand resting against a wall for support.	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes with one hand resting against a wall for support.
Guided exercise (Figure 3c)	6	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes with one hand resting against a wall for support.	After a 10-minute warm-up, participants played the scoring-hole game using the device for 20 minutes, with one hand resting against a wall for support.	After a 10-minute warm-up, participants played the scoring-hole game using the device for 20 minutes, with one hand resting against a wall for support.
Independent exercise (Figure 3d)	7	Following a 10-minute warm-up, participants performed the maze game using the device for 20 minutes without external support.	Following a 10-minute warm-up, participants performed the maze game using the device for 20 minutes without external support.	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes without external support.
Independent exercise (Figure 3d)	8	Following a 10-minute warm-up, participants performed the colored-ball sorting game using the device for 20 minutes without external support.	Following a 10-minute warm-up, participants performed the scoring-hole game using the device for 20 minutes without external support.	Following a 10-minute warm-up, participants performed the scoring-hole game using the device for 20 minutes without external support.

All data analyses were performed using SPSS software, version 23 (IBM Corporation, Armonk, NY, USA). Because no participant attrition occurred during the study, we did not perform an intention-to-treat (ITT) analysis.

Results

All participants completed every stage of the study; therefore, the attrition rate was zero. Table 2 presents the demographic characteristics of the 40 children included in the study.

The Shapiro–Wilk test indicated that the data were normally distributed ($p > 0.05$); therefore, we used parametric tests for subsequent analyses. Tables 3 and 4 present the results of the static and dynamic balance assessments for the experimental and control groups.

The ANCOVA results demonstrated statistically significant differences between the experimental and control groups after eight weeks of training with the researcher-developed balance device in the following static balance conditions: double-leg stance on a firm surface ($p \leq 0.0001$; $\eta^2 = 0.753$).

Table 2. Descriptive characteristics of participants by study group

Sex/category	Group/ comparison	n	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m ²)	Leg length (cm)	Dominant leg: left/right
Boys	Experimental	10	10.00 ± 1.56	134 ± 4.45	32.30 ± 5.41	17.84 ± 2.00	66.40 ± 3.43	3 7
	Control	10	9.30 ± 0.94	133 ± 4.97	33.10 ± 3.71	18.71 ± 2.06	66.80 ± 2.90	3 7
	Between-group p-value	-	0.245	0.609	0.705	0.356	0.729	1.00
Girls	Experimental	10	9.70 ± 1.49	133 ± 6.72	33.20 ± 5.02	18.44 ± 1.60	67.45 ± 4.11	2 8
	Control	10	9.20 ± 1.39	129 ± 4.81	31.20 ± 4.90	18.41 ± 2.19	65.20 ± 2.76	1 9
	Between-group p-value	-	0.450	0.155	0.379	0.975	0.171	0.557
Group means irrespective of sex	Experimental	20	0.666	0.908	0.705	0.473	0.544	0.628
	Control	20	0.854	0.174	0.343	0.761	0.196	0.290
Overall	Between-group p-value	-	0.166	0.144	0.691	0.501	0.412	0.714

Single-leg stance on the dominant leg on a firm surface ($p \leq 0.0001$; $\eta^2 = 0.809$); single-leg stance on the non-dominant leg on a firm surface ($p \leq 0.0001$; $\eta^2 = 0.657$); tandem stance on a firm surface with the dominant foot behind the non-dominant foot ($p \leq 0.0001$; $\eta^2 = 0.732$); tandem stance on a firm surface with the non-dominant foot behind the dominant foot ($p = 0.003$; $\eta^2 = 0.212$); double-leg stance on a compliant surface ($p \leq 0.0001$; $\eta^2 = 0.772$); single-leg stance on the dominant leg on a compliant surface ($p \leq 0.0001$; $\eta^2 = 0.606$); single-leg stance on the non-dominant leg on a compliant surface ($p = 0.002$; $\eta^2 = 0.232$); tandem stance on a compliant surface with the dominant foot

behind the non-dominant foot ($p \leq 0.0001$; $\eta^2 = 0.707$); tandem stance on a firm surface with the non-dominant foot behind the dominant foot ($p \leq 0.0001$; $\eta^2 = 0.412$).

The dynamic balance results also revealed statistically significant differences between the intervention and control groups in the anterior direction for the dominant leg ($p \leq 0.0001$; $\eta^2 = 0.902$) and non-dominant leg ($p \leq 0.0001$; $\eta^2 = 0.815$), the posteromedial direction for the dominant leg ($p \leq 0.0001$; $\eta^2 = 0.932$) and non-dominant leg ($p \leq 0.0001$; $\eta^2 = 0.795$), and the posterolateral direction for the dominant leg ($p \leq 0.0001$; $\eta^2 = 0.904$) and non-dominant leg ($p \leq 0.0001$; $\eta^2 = 0.756$).

Table 3. ANCOVA results comparing the experimental and control groups on the Balance Error Scoring System

Surface	Test condition	Group	Number of errors (mean ± SD)	Mean square	F	p-value	Effect size	Power
Firm	Double-leg stance	Experimental	1.20 ± 1.05	50.625	112.523	0.0001*	0.753	1
		Control	3.45 ± 1.05	—	—	—	—	—
	Single-leg stance: dominant leg	Experimental	2.90 ± 1.20	88.677	157.052	$\leq 0.0001^*$	0.809	1
		Control	6.05 ± 1.23	—	—	—	—	—
	Single-leg stance: non-dominant leg	Experimental	4.85 ± 1.26	19.600	70.876	$\leq 0.0001^*$	0.657	1
		Control	6.25 ± 1.11	—	—	—	—	—
	Tandem stance: dominant foot behind	Experimental	2.45 ± 1.05	56.687	100.811	$\leq 0.0001^*$	0.732	1
		Control	4.95 ± 1.23	—	—	—	—	—
	Tandem stance: non-dominant foot behind	Experimental	4.45 ± 1.19	5.832	9.928	$\leq 0.0001^{*2}$	0.212	0.866
		Control	5.05 ± 1.05	—	—	—	—	—
Compliant	Double-leg stance	Experimental	2.05 ± 1.09	54.141	125.602	$\leq 0.0001^*$	0.772	1
		Control	4.30 ± 1.03	—	—	—	—	—
	Single-leg stance: dominant leg	Experimental	4.60 ± 1.42	61.078	57.007	$\leq 0.0001^*$	0.606	1
		Control	7.25 ± 1.51	—	—	—	—	—
	Single-leg stance: non-dominant leg	Experimental	6.45 ± 1.27	4.268	11.193	0.002*	0.232	0.903
		Control	7.35 ± 1.30	—	—	—	—	—
	Tandem stance: dominant foot behind	Experimental	2.35 ± 1.26	93.540	89.474	$\leq 0.0001^*$	0.707	1
		Control	5.60 ± 1.39	—	—	—	—	—
	Tandem stance: non-dominant foot behind	Experimental	4.35 ± 1.30	15.767	25.930	$\leq 0.0001^*$	0.412	0.999
		Control	5.65 ± 1.13	—	—	—	—	—

SD: Standard deviation. Asterisks indicate statistically significant results.

Table 4. ANCOVA results comparing the experimental and control groups on the Y Balance Test

Test direction	Group	Distance (cm), mean $\pm$ SD	Mean square	F	p-value	Effect size	Power
Anterior: dominant leg	Experimental	75.35 $\pm$ 2.46	958.252	340.390	$\leq 0.0001^*$	0.902	1
	Control	64.88 $\pm$ 3.00	-	-	-	-	-
Anterior: non-dominant leg	Experimental	70.29 $\pm$ 3.46	496.225	162.817	$\leq 0.0001^*$	0.815	1
	Control	62.67 $\pm$ 2.56	-	-	-	-	-
Posteromedial: dominant leg	Experimental	76.19 $\pm$ 3.10	1362.826	504.109	$\leq 0.0001^*$	0.932	1
	Control	64.85 $\pm$ 2.98	-	-	-	-	-
Posteromedial: non-dominant leg	Experimental	71.65 $\pm$ 4.90	808.388	143.476	$\leq 0.0001^*$	0.795	1
	Control	64.08 $\pm$ 3.01	-	-	-	-	-
Posterolateral: dominant leg	Experimental	81.31 $\pm$ 2.58	2110.115	348.653	$\leq 0.0001^*$	0.904	1
	Control	66.82 $\pm$ 2.64	-	-	-	-	-
Posterolateral: non-dominant leg	Experimental	71.23 $\pm$ 4.47	546.681	114.556	$\leq 0.0001^*$	0.756	1
	Control	63.90 $\pm$ 2.82	-	-	-	-	-

SD: Standard deviation. Asterisks indicate statistically significant results. Statistical analyses were conducted at a 95% confidence level.

Given the statistical power of the tests, the findings suggest, with a high degree of confidence, that eight weeks of training with the researcher-developed balance device may improve static and dynamic balance in boys and girls aged 8–12 years.

As shown in Tables 5 and 6, the ANCOVA results showed no statistically significant differences between boys and girls in BESS or Y Balance Test scores across any test condition ($p > 0.05$). Thus, no statistically significant differences in static or dynamic balance were observed between boys and girls aged 8–12 years following eight weeks of training with the researcher-developed balance device. As shown in the tables, we observed no statistically significant differences

between boys and girls in any variable assessed before or after the intervention. Accordingly, we pooled data from boys and girls for the primary comparison between the experimental and control groups.

Discussion

This study investigated the effects of eight weeks of play with a researcher-developed device on static and dynamic balance in children aged 8–12 years. The findings indicated that playing with the device may positively influence and improve both static and dynamic balance in this age group. As the device was newly designed and developed for this study, no previous research had examined its effects.

Table 5. ANCOVA results comparing boys and girls on the Balance Error Scoring System (BESS)

Surface	Test condition	Group	Number of errors (mean $\pm$ SD)	Mean square	F	p- value	Effect size	Power
Firm	Double-leg stance	Boys	2.25 $\pm$ 1.37	0.058	0.032	0.860	0.001	0.053
		Girls	2.40 $\pm$ 1.72	—	—	—	—	—
	Single-leg stance: dominant leg	Boys	4.90 $\pm$ 2.19	0.009	0.003	0.957	0.000	0.050
		Girls	4.05 $\pm$ 1.73	—	—	—	—	—
	Single-leg stance: non-dominant leg	Boys	6.10 $\pm$ 1.37	0.240	0.301	0.587	0.008	0.083
		Girls	5.00 $\pm$ 1.16	—	—	—	—	—
	Tandem stance: dominant foot behind	Boys	3.95 $\pm$ 1.98	0.451	0.217	0.644	0.006	0.074
		Girls	3.45 $\pm$ 1.35	—	—	—	—	—
Compliant	Tandem stance: non-dominant foot behind	Boys	4.60 $\pm$ 1.27	0.004	0.005	0.943	0.000	0.051
		Girls	4.90 $\pm$ 1.02	—	—	—	—	—
	Double-leg stance	Boys	3.20 $\pm$ 1.23	0.304	0.161	0.691	0.004	0.068
		Girls	3.15 $\pm$ 1.84	—	—	—	—	—
	Single-leg stance: dominant leg	Boys	6.00 $\pm$ 2.40	0.1796	0.672	0.418	0.018	0.126
		Girls	5.85 $\pm$ 1.49	—	—	—	—	—
	Single-leg stance: non-dominant leg	Boys	7.15 $\pm$ 1.46	0.028	0.056	0.814	0.002	0.56
		Girls	6.65 $\pm$ 1.22	—	—	—	—	—
	Tandem stance: dominant foot behind	Boys	4.05 $\pm$ 2.43	0.367	0.103	0.750	0.003	0.061
		Girls	3.90 $\pm$ 1.77	—	—	—	—	—
	Tandem stance: non-dominant foot behind	Boys	5.05 $\pm$ 1.46	0.209	0.204	0.654	0.005	0.072
		Girls	4.95 $\pm$ 1.31	—	—	—	—	—

SD: standard deviation. Statistical analyses were conducted at a 95% confidence level.

Table 6. ANCOVA results comparing boys and girls on the Y Balance Test

Test direction	Group	Distance (cm), mean $\pm$ SD	Mean square	F	p-value	Effect size	Power
Anterior: dominant leg	Boys	70.82 $\pm$ 5.61	3.784	0.132	0.718	0.004	0.065
	Girls	69.41 $\pm$ 6.33	—	—	—	—	—
Anterior: non-dominant leg	Boys	66.43 $\pm$ 4.98	9.042	0.558	0.460	0.015	0.112
	Girls	66.53 $\pm$ 4.93	—	—	—	—	—
Posteromedial: dominant leg	Boys	70.38 $\pm$ 4.55	3.075	0.078	0.782	0.002	0.059
	Girls	70.65 $\pm$ 8.09	—	—	—	—	—
Posteromedial: non-dominant leg	Boys	67.63 $\pm$ 4.55	1.012	0.037	0.849	0.001	0.054
	Girls	68.10 $\pm$ 6.51	—	—	—	—	—
Posterolateral: dominant leg	Boys	75.16 $\pm$ 8.38	45.247	0.731	0.398	0.019	0.133
	Girls	72.97 $\pm$ 7.16	—	—	—	—	—
Posterolateral: non-dominant leg	Boys	66.88 $\pm$ 4.82	20.742	1.092	0.303	0.029	0.175
	Girls	68.25 $\pm$ 5.66	—	—	—	—	—

SD: Standard deviation. Statistical analyses were conducted at a 95% confidence level.

These findings are consistent with those of a study (16) investigating the effects of Körperkoordinationstest für Kinder (KTK) exercises on gross motor skills, particularly balance. That study demonstrated that play-based exercises improved children's balance and movement performance by providing an enjoyable experience. The present findings also align with those of a study (3) comparing the effects of corrective exercises and corrective games on upper crossed syndrome in female students. That study found that corrective games were more effective than corrective exercises because of their greater motivational and recreational benefits. Children appear to become fatigued more quickly during corrective exercises and may consequently be unable to complete them correctly. Therefore, corrective games are recommended as an alternative to corrective exercises for younger children.

Sensory input to the central nervous system, referred to as afferent information, serves several functions in generating motor responses. These include directly initiating reflex responses, determining the parameters of preprogrammed voluntary responses, and integrating feedback and feedforward mechanisms to generate automatic motor output that maintains balance during standing and walking (10). Three key regions providing proprioceptive input for postural maintenance are the plantar surface of the foot, the sacroiliac joint, and the cervical spine (8). When a child plays with the researcher-developed balance device, the plantar surface of one foot—one of these key regions—remains firmly in contact with the ground. Afferent input from the plantar surface contributes to postural awareness (10), and plantar cutaneous reflexes support posture and walking (17). Lower-limb afferents provide enough information to maintain an upright stance and are necessary to perceive postural sway. The second key region, the

sacroiliac joint, is challenged by perturbations generated as the child plays with the device. Lumbar proprioception is necessary for normal walking, while the sacroiliac joint contributes to force transfer between the lower limbs and the trunk.

Studies have shown that subcortical brain structures play a predominant role in human balance control (18). The information-processing mechanisms underlying motor control operate at several levels, including the spinal, subcortical, and cortical levels (10). At the spinal level, the primary function is regulating muscle reflexes (19). The subcortical level controls equilibrium, automatic postural reflexes, corrective reactions, and balance. The cortical level, which represents the highest level of neuromuscular control, initiates and controls complex voluntary movements (10). Clinical observations emphasize the cerebral cortex's crucial role in human balance and motor control, particularly the frontal lobe (18). Cortical motor control involves three key regions (8): the primary motor cortex, the premotor area, and the supplementary motor area. The primary motor cortex receives proprioceptive information, the premotor area organizes movement, and the supplementary motor area programs muscle groups to perform complex movements (10).

When children play with the researcher-developed balance device, they unconsciously use reflex responses to prevent falls, engaging information processing at the spinal level. Maintaining one foot firmly on the ground also engages subcortical processing, while manipulating the game with the other foot engages cortical processing. Accordingly, playing with the device may enhance the information-processing mechanisms underlying motor control, which may, in turn, directly improve the functioning of the musculoskeletal components responsible for movement.

The researcher-developed play device may also

improve balance by enhancing the function of the global muscular systems. These systems are primarily responsible for movement and comprise relatively superficial musculature extending from the pelvis to the rib cage, the lower limbs, or both. They include the deep longitudinal subsystem, which transfers forces from the lower to the upper body, and the posterior oblique subsystem, which transfers resultant forces arising from the transverse-plane orientation of the muscles to facilitate forward progression in the sagittal plane (20). Balance control systems must generate appropriate motor responses by counteracting destabilizing forces (5). The anterior oblique subsystem produces rotational and flexion movements and contributes to the stability of the lumbopelvic-hip complex. The lateral subsystem stabilizes the pelvis and hip during functional single-leg movements in the sagittal plane (20).

The principal feature of the play device used in this study is that children must maintain balance on one leg while using the other foot to perform the games. In addition to providing an enjoyable activity, this requirement may enhance proprioception and, consequently, improve balance.

Limitations

Because parents were unfamiliar with the play device, they had limited confidence in its effectiveness. Consequently, the pool of participants available for recruitment was very limited.

Recommendations

Further studies should investigate the effects of playing with this device in other age groups.

Conclusion

Playing with the researcher-developed balance device appears to improve static and dynamic balance in children aged 8–12 years. No statistically significant differences were observed between boys and girls.

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Authors' Contribution

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Equipment provision and recruitment of study participants: Siavash Rajabi.

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Conflict of Interest

The authors did not have a conflict of interest.

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