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Interactive Songs for Improving Postural Control in Nursery School Children

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ABSTRACT

Dalala Z, Mouchou-Moutzouridou E, Kapodistria L, Chatzopoulos D, Kyriakidis G, Lykesas G. Interactive Songs for Improving Postural Control in Nursery School Children. **JEPonline** 2024;27(1):38-48. The purpose of this study was to explore the effectiveness of a balance training program using interactive songs to enhance the balance of nursery school children. A total of 39 children (3.35 ± 0.22 years) were randomly assigned to either an Intervention Group (18 children) or a Control Group (21 children). The Intervention Group underwent a training program involving action songs (8 weeks, 2 times·wk^{-1}, total 16 sessions), while the Control Group continued with the standard curriculum. Before and after the intervention, both Groups underwent assessments involving the double-leg stance (sway path length of centre of pressure, ellipse area), the Timed Up and Go Test, walking on a line, and walking heel-to-toe on a line. The findings indicate that the Intervention Group exhibited improved performance in dynamic balance tasks (walking on a line and walking heel-to-toe on a line). However, there were no significant differences in static balance (sway path length and ellipse area). Additionally, the behavior of the children during the double-leg stance test on the force plate raised concerns about the suitability of this test for nursery school children. In conclusion, the balance training program using action songs appears to be an effective and engaging activity for enhancing postural control among nursery school children.

Key Words: Interactive Songs, Nursery School, Physical Education, Postural Control

INTRODUCTION

Maintaining balance is important for safely during the execution of everyday activities and sport performance, which is especially the case for nursery school children. The risk of injuries due to falls is higher compared to older children and adults because their postural control system is still in the process of development (24). Recent research indicates that the enhancement of balance control occurs not only as children mature, but also through their interactions with the environment (6). If a young child lacks the necessary stimuli for enhancing balance, it may result in a reduced ability to perform fundamental movement skills and effectively engage in daily activities (22,27).

Several studies investigated the effectiveness of balance training programs on postural control in healthy children, adolescents, and adults (13,30). One common feature of these programs is the incorporation of multiple repetitions of a task (e.g., one leg stance for 20 seconds), and they include multiple sets of repetitions that range from 3 to 5 (1,14,15,30). Furthermore, competitive games are often integrated into these programs to enhance engagement and motivation. Due to their intense training nature, these programs might yield positive results for athletes or older adults, yet they may not be appealing to young children. For instance, Granacher et al. (16) reported that a training program that was effective for healthy individuals across various age groups (young, middle-aged, and elderly participants) was ineffective for young children (6.7 ± 0.5 years old). This program consisted of a 10-minute warm-up, 45 minutes of balance activities (comprising 4 sets of 20 seconds for each exercise with 2-minute rest intervals between the exercises), and a 5-minute cool down (totaling 60 minutes). The researchers observed that maintaining focus for such a prolonged duration (1 hour) involving numerous repetitions, sets, and rests was challenging for children (16). While highly structured programs might suit adults and athletes, they may not align with the needs or attention span of young children.

Preschoolers typically have an attention span of less than 15 minutes, which can vary depending on their interest and the challenge level of the task (23). Balance exercises demand significant concentration, and preschool-aged children often experience cognitive overload when engaged in structured motor programs that exceed 30 minutes (17). Additionally, Kannass et al. (18) found that the average duration of young children's engagement in a single motor activity is approximately 3 minutes. Hence, the implementation of a balance program where each task lasts longer than 3 minutes is a challenge to sustain the necessary level of concentration needed by young children.

Interactive songs combine music and movement that prompt children to engage physically by following song directions and dramatizing lyrics through motion. These songs not only foster personal expression but also enhance children's motivation to participate in physical activities (5). Within the imaginative realm of interactive songs, children can freely experiment, make mistakes, and tackle new challenges without the pressure of performance anxiety. Hence, a well-chosen selection of interactive songs involving balance elements could be an appealing method for enhancing young children's postural control.

Previous studies (30) that have examined the impact of balance programs on children often utilized costly equipment, such as air cushions or Bosu balls, making their implementation challenging within nursery school physical education settings. Also, the traditional balance

training programs tailored for older children and adults involve repetitive exercises and competitive games that are not suitable for nursery school children. Young children require engaging and playful activities to maintain their interest and motivation. When a child finds an activity enjoyable, such as participating in interactive songs, they are more inclined to repeat associated balance activities that improves their postural control. The purpose of this study was to examine the effects of a balance program incorporating interactive songs on the postural control of nursery school children.

METHODS

Subjects

Based on G*Power (version 3.1), a minimum sample size of 34 participants was recommended (effect size f = .25, alpha = .05, power = .80) (12). Four kindergartens expressed an interest in participating in the research of which one was randomly selected. The current study included a sample of 39 nursery school children that consisted of 21 boys and 18 girls (3.35 ± .22 years old). The children were randomly divided into the Intervention Group (18 children, 9 boys and 9 girls, 3.41 ± 0.19 years old) and the Control Group (21 children, 12 boys and 9 girls, 3.30 ± 0.24 years old). The eligibility criteria for participation in the study included two components: (a) the absence of motor difficulties; and (b) the absence of neurological and/or orthopedic impairments. These criteria were assessed through a teacher questionnaire. Informed consent was obtained from the guardians of the children, with the understanding that they retained the right to withdraw their children from the study at any given point. The study was conducted in strict adherence to the ethical guidelines of the local University, and all procedures followed the latest version of the Declaration of Helsinki.

Procedures

The study lasted for 8 weeks, 2 times·wk^{-1} for a total of 16 times with each session lasting 15 to 20 minutes. The movement steps and poses of the choreography in the interactive songs were organized according to the 3 progression levels depicted in Table 1. The intensity of the activities was gradually increased: (a) by decreasing the base of support; (b) by incorporating dynamic arm and leg movements to perturb the center of mass; and (c) by varying the surfaces used (including hard surfaces and soft mats) (9).

Table 1. Progressive Balance Program.

Level 1 Reducing the Base of Support	Level 2 Displacement of the Center of Mass	Level 3 Surface
Double-leg, upright stance. Variations: wide stance, narrow stance, semitandem, tandem, (using hand support). One leg stance with hand support Toe walks, heel walks	Dynamic arm movements. “raise right hand”, “raise left hand”, “raise both hands and down”. Forward and backward arms sway, lateral sway (side to side). Body sways: forward/backward, sideways.	Hard surface Soft mat

Safety was a primary consideration in advancing within the program, with considerable emphasis placed on fostering the children's comprehension of safe practices (10,25). To enhance the children's motivation, they were encouraged to execute the activities in their individual styles, and instructions were conveyed using analogies (8,20).

The interactive songs in the program maintained a tempo that ranged from 120 to 130 beats·min^{-1} that aligns closely with the preferred tempo for preschool children (5,7). Various movement patterns were incorporated, such as step touch, step knee, leg curl, step kick (front, side), turn, toe tap, and heel touch (21). For example, the song "Hokey Pokey": "You put the right foot in (Toe tap front), you put your right foot out (Toe tap back) and shake it all about …". Special attention was given to avoiding both physical and psychological fatigue (2,22). The program included seven interactive songs (9):

- A Puppet said to Me…
- I'm a Stork.
- Hokey Pokey.
- Do the bear walk (https://www.youtube.com/watch?v=KG3AO6lJ4BQ).
- Balance On One Foot (https://www.youtube.com/watch?v=aQ2Vco_giiE).
- Balancing Song for kids (https://www.youtube.com/watch?v=VcIldqzt_-w&list=RDVcIldqzt_-w&start_radio=1).
- Hop a little jump (https://www.youtube.com/watch?v=TmXS7Rxx-Xo).

Throughout the 8-week study period, the Intervention Group received instruction from a physical education teacher possessing a preschool teacher certification. The Control Group received instruction from their regular teacher and participated in standard PE lessons focused on fundamental movement skills, encompassing locomotor movements and object control without specific balance exercises (19). All study procedures were conducted within the timeframe of 10:00 -12:00 hours.

Measures

The assessments were conducted both before and after the intervention in a quiet room at the nursery school center. Each child underwent testing individually, maintaining uniform testing conditions throughout. The administration of tests was carried out by Physical Education postgraduate students who were blinded to the group allocation.

Double-Leg Stance Test

The Double-Leg Stance Test was used to measure static balance. The Test was conducted on a portable forceplate (KINVENT, www.k-invent.com, sampling rate 75 Hz). The children were instructed to maintain a still double-leg upright stance position for 10 seconds with hands comfortably positioned at their sides with their gaze fixed on a cross placed on a wall at eye level 2 meters away. The children were evaluated barefoot. Data collection commenced immediately after the children assumed the specified position. The dependent variables were: (a) the sway path length of the Center of Pressure (CoP); and (b) the ellipse area (refers to the elliptical area created by the CoP data points). Two trials were performed with an approximate 30-second pause between each trial. The best performance of the two trials was selected for statistical analysis (29).

The reliability of the Double-Leg Stance Test was established using the test-retest method in a pilot study with 13 nursery school children (3 to 4 years old). The group was retested one week after the initial test and the intraclass reliability coefficient was satisfied (ICC = .70). The children in the reliability measurements were not included in the main study.

Timed Up and Go Test (TUG)

In the Timed Up and Go Test, the children were seated on a chair without armrests, their feet were resting on the floor with the knees flexed to approximately 90 degrees. Upon the cue “ready, go” the children stood up, walked along a straight line as quickly as possible (3 m), and turn back to the initial seated position on the chair. The time taken to complete the task was recorded (sec). A practice trial was followed by two trials, with a 1-minute rest period between the trials to reduce the effect of fatigue. The best of the two trials was used for data analysis. The TUG Test is a reliable and valid evaluation of balance and functional mobility in young children. It demonstrates high interrater reliability with intraclass correlation coefficient (ICC) values of 0.81 to 0.89 and high test-retest reliability with an ICC of 0.83 (4,29).

Walking Forward on a Line

The subtest walking forward on a line is one of the balance subtests in the Bruininks-Oseretsky Test of Motor Proficiency (3). The maximum score is 6 steps (on the line). The best score of 2 trials was recorded for data analysis.

The test's reliability was assessed using the test-retest method in a pilot study involving 13 nursery school children aged 3 to 4 years. A week after the initial test, the group underwent a retest, revealing a high intraclass reliability coefficient (ICC = .83) and interrater reliability 0.95. The children involved in the reliability measurements were excluded from the main study.

Walking Forward Heel-to-Toe on a Line

The subtest walking forward heel-to-toe on a line is one of the balance subtests in the Bruininks-Oseretsky Test of Motor Proficiency (3). The maximum score is 6 steps. The best score of 2 trials was recorded for statistical analysis.

The reliability of the test was determined by the test-retest method in a pilot study with 13 nursery school children (3 to 4 years old). The group was retested one week after the initial test and the intraclass reliability coefficient was very high (ICC = .86) and interrater reliability 0.94. The children participating in the reliability measurements were excluded from the main study.

Statistical Analyses

The data were analysed using a mixed ANOVA, incorporating the between-subject factor “group” (Intervention vs. Control), and the within-subject factor “time” (pre-testing vs. post-testing). The homogeneity of variances (Levene Test) was performed for all dependent variables. If the assumption of sphericity was violated, the Greenhouse-Geisser correction was applied. In instances of a significant interaction, subsequent univariate ANOVAs were conducted to identify significant differences. Furthermore, effect sizes for ANOVA are presented as partial eta square values. All statistical analyses were carried out employing SPSS (version 28). Statistical significance was set at an alpha level of $P \leq 0.05$.

RESULTS

Mean and standard deviation of the variables are presented in Table 2.

Table 2. Descriptive Data of the Variables in Pre-Test and Post-Test.

	Intervention Group		Control Group	
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**
Path Length (mm)	556.59 ± 114.16	491.86 ± 96.83	596.98 ± 114.60	555.66 ± 198.72
Ellipse Area (mm^2)	7886.46 ± 524.36	623.51 ± 528.57	770.95 ± 383.43	839.83 ± 687.3
Timed-Up and Go Test (sec)	12.39 ± 2.24	12.09 ± 2.28	13.05 ± 2.38	13.05 ± 2.47
Walking on a Line (steps)	3.11 ± 1.18	4.11 ± 1.41*	3.00 ± 0.89	3.05 ± 1.11
Walking Heel-to-Toe (steps)	2.28 ± 1.22	3.22 ± 1.30*	2.19 ± 1.07	2.33 ± 1.11

Abbreviations: *Significant difference between the 2 Groups ($P < 0.05$).

Path Length

Mixed ANOVA demonstrated no significant interaction effect between the Intervention Group vs. the Control Group and time of measurement (pre-test vs. post-test) ($F = .19$, $p = .66$, $\eta_p^2 = .005$). There were no statistically significant differences between the Groups neither at pretesting ($F = 1.20$, $p = .28$, $\eta_p^2 = .032$), nor at the end of the study ($F = 1.53$, $p = .22$, $\eta_p^2 = .04$).

Ellipse Area

There was no significant interaction between the Groups and time of measurement ($F = 1.27$, $p = .26$, $\eta_p^2 = .03$). There were no significant differences between the Groups neither at the beginning ($F = .01$, $p = .91$, $\eta_p^2 = .001$), nor at post measurement ($F = 1.18$, $p = .28$, $\eta_p^2 = .03$).

Timed Up and Go Test (TUG)

There was no significant interaction between the Groups and time of measurement ($F = .40$, $p = .52$, $\eta_p^2 = .011$). There were no significant differences between the Groups neither at the beginning ($F = .78$, $p = .38$, $\eta_p^2 = .021$), nor at the end of the study ($F = 1.56$, $p = .21$, $\eta_p^2 = .041$).

Walking Forward on a Line

There was a statistically significant interaction between the Groups and time of measurement (F = 15.52, p = .001, η_p^2 = .29). There was no significant difference between the Groups at pre-test (F = .11, p = .74, η_p^2 = .003). At the post-test, the Intervention Group performed significantly better in comparison to the Control Group (F = 6.90, p = .012, η_p^2 = .157).

Walking Forward Heel-to-Toe on a Line

There was a statistically significant interaction between the Groups and time of measurement (pre-test vs. post-test) (F = 11.80, p = .001, η_p^2 = .24). There was no significant difference between the Groups at pre-test (F = .05, p = .81, η_p^2 = .002). However, At the post-testing, the Intervention Group performed significantly better in comparison to the Control Group (F = 5.26, p = .027, η_p^2 = .125).

DISCUSSION

The purpose of this study was to investigate the effects of an interactive song-based balance training program on postural control of nursery school children. According to the results of the study, the Intervention Group revealed enhanced performance in the variables “Walking forward on a line” and “Walking forward heel-to-toe on a line” compared to the Control Group. However, there were no significant differences regarding double-leg stance (sway path length of CoP and ellipse area).

Given the absence of studies investigating the effects of balance training through interactive songs on nursery school children's balance, the findings of the current study will be compared to research involving specific balance equipment and/or older children. The results of the present study are in accordance with other studies (11,28,30). Specifically, Shim et al. (28) reported that engaging in 15 to 20 minutes of continuous pedal-less bicycle riding, conducted 3 times·wk^{-1} over a span of 4 weeks led to improvements in postural control among preschool children aged 3 to 5 years old. The advantage of the balance training program with interactive songs of the current study compared to Shim et al. (28) is that no equipment was required for the training program. The specialized balance equipment, such as bicycles or other unstable training devices (e.g., air cushions, ankle disks), employed in prior studies with older children not only involve high purchasing costs, but also necessitates ongoing maintenance expenses to ensure they remain in optimal condition.

While previous studies generally acknowledge the effectiveness of conventional balance training with specific equipment in enhancing postural control among adolescents and adults, there exist conflicting findings regarding its impact on pre-adolescent children (16,30). Granacher et al. (16) reported that engaging in balance training 3 times·wk^{-1} for 4 weeks following a typical balance training protocol with many sets and repetitions did not lead to enhanced balance parameters in elementary school children. The authors attributed these findings to maturational deficiencies within the postural control system of prepubertal children. They suggested that these children might lack essential neurophysiological prerequisites for adaptive processes after balance training.

In contrast, Wälchli et al. (30) reported improvements in balance among elementary school children after undergoing balance training involving unstable devices like Pedalo and

participating in competitive balance games. Comparable enhancements in balance were observed in 10-year-old children, as reported by Donath et al. (11) following slackline training and by Muehlbauer et al. (26) following inline skating sessions at 11 years old. It appears that the nature of the balance training program can significantly impact postural control outcomes. For this reason, it is suggested that future research involving young children should utilize balance training content that is appealing to them.

Another crucial aspect to consider in balance training programs for young children is safety. Previous research has indicated that balance training involving unstable devices like Pedalo or slackline training may effectively improve balance in elementary school children (11,26). However, it poses significant safety concerns when applied to nursery school children. Implementing similar programs using unstable devices in nursery school children necessitates, for safety reasons, a one-to-one supervision ratio that is unfeasible within a typical nursery school physical education setting.

Double-Leg Stance Test

Regarding the Double-Leg Stance Test, there were no significant improvements in the Intervention Group. The outcomes of the current study contradict those of Wälchli et al. (30) and Chatzihidiroglou et al. (5), but align with the findings of Chatzopoulos (6) and Tiktabanidi et al. (29). One potential reason for these conflicting results might be attributed to the diverse intervention equipment used. In the research by Wälchli et al. (30), the intervention involved older children (7 years old) and specific balance equipment (e.g., ankle disks or air cushions). It seems that the use of balance equipment significantly helps in improving static balance. However, for safety reasons in the present study, unstable equipment was not utilized. Moreover, the primary purpose of this study was to examine the feasibility and effectiveness of a balance training program incorporating interactive songs within standard physical education conditions. Therefore, specialized balance equipment like ankle disks or air cushions were not used.

Another factor that contributed to the varying outcomes among different studies might be the different measurements employed. While Chatzihidiroglou et al. (5) utilized the Flamingo Test (i.e., one leg standing on a balance beam), the present study implemented the double-leg stance assessment. Hence, the One-Leg Standing Test was not administered due to the children's limited ability to maintain balance on one leg for 10 seconds. Notably, using the double-leg stance may not be ideal for assessing potential improvements in nursery school children. During our measurements, we observed that the Double-Leg Stance Test was uninteresting for the children. They struggled to comprehend the task's purpose and had difficulty maintaining focus on a specific point on the wall for 10 seconds. Many instances required test repetition as the children frequently changed positions or moved. Consequently, for future studies involving young children, it is recommended to employ measurement methods that are engaging and appealing to the students.

Limitations in this Study

The main limitation of this research is associated with the children's limited concentration levels. Balancing activities necessitate a high degree of focus and attention, and it remains uncertain whether the children were able to perform at their optimal level due to potential challenges with maintaining attention during the activities.

CONCLUSIONS

Based on the findings in this study, implementing a balance training program with interactive songs leads to significant enhancements in postural control among nursery school children. This research could serve as a valuable resource for nursery school teachers, encouraging the incorporation of interactive songs to enhance balance within this age group. Given the importance of balance in children's motor development, it is highly recommended that comprehensive balance training programs should be integrated into early childhood curricula.

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