

Research article

The Influence of Structured Multisport Activities at Different Weekly Frequencies on the Gross Motor Development of Preschool Children: Evidence for a Dose–Response Relationship

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Abstract

This study investigates the association between participation in structured multisport activities at different weekly frequencies and gross motor development in preschool children, aiming to provide practical evidence for promoting gross motor skills in early childhood. A total of 63 preschool children were classified into four groups according to their weekly participation frequency in structured multisport activities: the low-frequency group (L; up to 1 session/week, with intermittent participation; $n = 16$), the medium-frequency group (M; fixed participation in 1 session/week, with occasional participation in a second session; $n = 15$), the medium-high-frequency group (MH; fixed participation in 2 sessions/week, with occasional participation in a third session; $n = 18$), and the high-frequency group (H; fixed participation in ≥ 3 sessions/week; $n = 14$). All groups participated in a 12-week structured multisport activity program (60 minutes per session). Gross motor development was assessed before and after the intervention using the Test of Gross Motor Development-3 (TGMD-3). A 2 (Time: pre- vs. post-intervention) $\times$ 4 (Group: L/M/MH/H) mixed-design ANOVA was applied to evaluate changes in each gross motor development outcome within and between groups. After the 12-week intervention, (1) the total score of gross motor development showed a significant Time $\times$ Group interaction ($p < 0.01$, $\eta^2p = 0.280$). All groups improved ($p < 0.01$), and H, MH, and M showed greater improvements than L ($p < 0.05$). (2) The total score of locomotor movements showed a significant Time $\times$ Group interaction ($p < 0.01$, $\eta^2p = 0.205$). All groups improved ($p < 0.01$), and H and MH showed greater improvements than L ($p < 0.05$). For individual locomotor skills, horizontal jump showed a significant interaction ($p < 0.05$, $\eta^2p = 0.143$); all groups improved ($p < 0.01$), and H and MH showed greater improvements than L ($p < 0.05$). (3) The total score of object control movements showed a significant Time $\times$ Group interaction ($p < 0.01$, $\eta^2p = 0.183$). All groups improved ($p < 0.01$), and H and MH showed greater improvements than L ($p < 0.05$). For individual object control skills, two-hand strike of a stationary ball, one hand stationary dribble and two hand catch showed significant Time $\times$ Group interactions ($p < 0.05$, $\eta^2p = 0.124$, 0.128 , and 0.163 , respectively). For two-hand strike of a stationary ball and one hand stationary dribble, H and MH showed greater improvements than L ($p < 0.05$), whereas the significant interaction for two hand catch did not translate into significant Bonferroni-adjusted between-group differences at either pre-test or post-test. (4) The L group did not show significant improvements in gallop, skip, and one hand stationary dribble ($p > 0.05$), whereas the other groups improved in a wider range of movements ($p < 0.05$). After three months of intervention, preschool children participating in structured multisport activities showed improvements in overall gross motor development. Regular participation (once a week or more) was associated with improvement across all assessed gross motor skills. More frequent participation (at least twice per week) was associated with greater im-

provements in specific skills, including horizontal jump, two-hand strike of a stationary ball, and one hand stationary dribble. Although gross motor development generally tended to improve as participation frequency increased, no statistically significant additional advantage of the high-frequency group over the medium-high-frequency group was detected. These findings should be interpreted cautiously, given the absence of a non-intervention control group and the relatively limited sample size.

Key words: Preschool children, gross motor development, participation frequency, structured multisport activities.

Introduction

Motor competence is widely recognized as a fundamental component of early childhood development and an important foundation for children's participation in physical activity and continued engagement in movement experiences across the lifespan. During early childhood, gross motor skills, including locomotor and object control skills, constitute core dimensions of motor competence and provide the movement repertoire necessary for participation in increasingly complex physical activities. From a developmental perspective, motor competence and physical activity are dynamically related across childhood, with motor competence potentially supporting more positive trajectories of physical activity participation, perceived competence, and health-related physical fitness (Stodden et al., 2008). Building on this model, subsequent evidence has further highlighted the importance of motor competence for positive health-related developmental trajectories throughout childhood and adolescence (Robinson et al., 2015).

Early childhood, particularly the period from 3 to 6 years of age, represents a critical window for the acquisition and refinement of gross motor skills. Gross motor skill proficiency during this period contributes to children's later learning of sports and physical movements (Seefeldt, 1980), develops alongside ongoing neurological development and adaptation (Rosenzweig, 2000), and is associated with physical, social, and psychological development as well as the establishment of an active lifestyle (Lubans et al., 2010). Importantly, gross motor development should not be understood solely as a result of biological maturation. According to Newell's constraints model, motor development emerges from the interaction among individual, task, and environmental constraints (Newell, 1986). Within this framework, structured physical activity interventions

provide preschool children with appropriate movement tasks, supportive instructional environments, and repeated opportunities to explore, practice, and refine motor patterns. Previous studies have shown that such interventions can improve gross motor development in preschool children through diverse movement experiences, guided instruction, and repeated practice opportunities (Jahagirdar et al., 2017; Jones et al., 2011; Logan et al., 2012). Accordingly, the frequency of participation in structured multisport activities may be meaningful because it determines how regularly children receive these practice opportunities.

Exercise dose is commonly described in terms of frequency, intensity, duration, and type. Frequency, typically measured as the number of sessions per week, may influence activity outcomes. Research on school-aged children and adolescents has shown that higher participation frequency is generally associated with better outcomes in several domains, including mental health (Li et al., 2024), working memory and cognitive flexibility (Xu et al., 2022), physical fitness (Shi et al., 2022), and health-related quality of life (Calzada-Rodríguez et al., 2021; Finne et al., 2013). However, findings in some areas of youth health have been mixed. For example, the World Health Organization recommends that children and adolescents engage in at least three sessions of vigorous-intensity aerobic activity per week, alongside muscle- and bone-strengthening activities (Bull et al., 2020). Some studies indicate that high-frequency physical activity can improve bone density and bone mass in youth (Christoffersen et al., 2015), whereas other research suggests that relatively low-frequency but high-intensity, short-duration physical activity may be more effective for certain aspects of musculoskeletal health (Wu et al., 2021). These findings suggest that the effect of activity frequency may vary according to the outcome examined, rather than following a simple “more is better” pattern.

Most of these studies focused on school-aged children and adolescents. Findings from older populations cannot be directly generalized to preschool children because of developmental differences. Evidence regarding intervention frequency in early childhood remains limited. To date, few studies have explicitly examined the frequency-related dose-response pattern between structured activity participation and gross motor development in preschool children. Several public health guidelines recommend that young children accumulate a minimum amount of moderate-to-vigorous physical activity each day (Australian Government Department of Health and Aged Care, 2021; Tremblay et al., 2017); however, these recommendations mainly address intensity and total duration, whereas the frequency of structured activity sessions remains underexplored. Identifying whether different weekly participation frequencies are associated with differences in gross motor development is therefore relevant for the design of developmentally appropriate activity programs for young children.

For the purposes of this study, structured multisport activities are defined as structured, game-based sessions that provide preschool children with opportunities to practice a variety of gross motor skills. Such activities are a common form of organized physical activity for preschool

children. Prior research suggests that multidimensional programs incorporating diverse movement types may be beneficial for preschool children’s physical development (Wang et al., 2023). Therefore, the present study investigated the association between different weekly participation frequencies in structured multisport activities and gross motor development in preschool children. In this study, the dose-response relationship refers specifically to participation frequency, reflected by the number and regularity of weekly sessions attended during the intervention period. Given the limited existing evidence, the frequency groups were classified exploratorily according to the children’s actual participation patterns. Because this was an exploratory study, we did not assume a specific pattern of frequency-related effects. Based on previous evidence, we hypothesized that children participating at higher weekly frequencies would show greater improvements in gross motor development than those participating at a lower frequency.

Methods

Trial design

This study employed a quasi-experimental pretest-posttest design to compare changes in gross motor development among preschool children participating in structured multisport activities at different weekly frequencies. A total of 63 preschool children were recruited for this study. The participants were categorized into four groups according to their frequency of participation in structured multisport activities: the low-frequency group (L), the medium-frequency group (M), the medium-high-frequency group (MH), and the high-frequency group (H). Participants were not randomly assigned to these groups; rather, they were classified according to their actual weekly participation frequency during the intervention period. The intervention lasted 12 weeks. Baseline data were collected one week before the start of the intervention, and post-intervention data were collected within one week after completion of the program. The study was approved by the Ethics Committee of Beijing Sport University (Approval No. 2024192H) and was conducted in accordance with the Declaration of Helsinki and relevant guidelines and regulations.

Participants

A priori power analysis using G*Power (version 3.1; F tests, ANOVA: repeated measures, within-between interaction) for a mixed-design ANOVA (four groups $\times$ two time points; medium effect size $f = 0.25$, $\alpha = 0.05$, $1-\beta = 0.80$) indicated that a minimum total sample size of 48 participants was required. We ultimately enrolled 63 preschool children aged 3–6 years from an institution offering structured multisport activities, thereby exceeding the minimum required sample size.

Strict inclusion criteria were applied at enrollment to control potential confounders and enhance between-group comparability. Eligibility criteria required that participants were healthy, with no contraindications to exercise and no hearing or vision impairments or learning disabilities; attended non-sports-focused kindergartens where physical activity primarily consisted of unstructured free

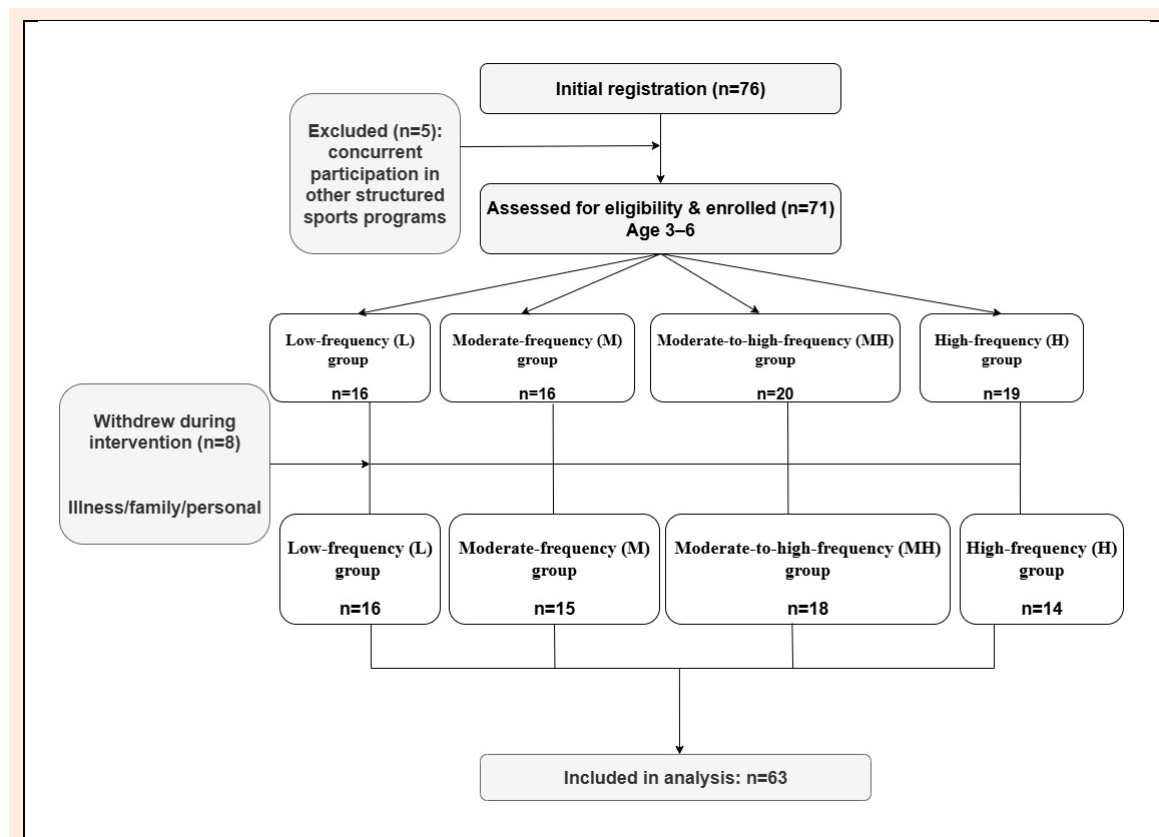


Figure 1. Participant flowchart.

play without specialized sports instruction; participated only in the program's structured multisport activity sessions during the study and refrained from any additional off-campus organized sports programs; and had not received systematic sports instruction prior to the intervention. Only participants who maintained the weekly participation frequency required for their respective group throughout the intervention period were included in the final analysis. The participant recruitment, retention, and exclusion process across the intervention period is illustrated in Figure 1. Informed consent was obtained from guardians, and permission for the study was granted by the participating institution.

Participants were classified into four groups according to their weekly frequency of participation in structured multisport activities: the low-frequency group (L; up to 1 session/week, with intermittent participation; $n = 16$), the medium-frequency group (M; fixed participation in 1 session/week, with occasional participation in a second session; $n = 15$), the medium-high-frequency group (MH; fixed participation in 2 sessions/week, with occasional participation in a third session; $n = 18$), and the high-frequency group (H; fixed participation in ≥ 3 sessions/week; $n = 14$).

For children attending two or more sessions/week, at least one day was required between consecutive sessions to ensure adequate recovery.

At baseline, height and weight were measured using an integrated height-and-weight measurement device, with one researcher guiding each child through the assessment and another recording the results. Table 1 presents the baseline age, height, and weight of the participants in each group. No significant between-group differences were found in these variables at baseline. All 63 participants were included in the final analysis.

Intervention

Children in each group participated, at the prescribed frequencies, in a 12-week program of structured multisport activity sessions (60 minutes per session). The program adopted a circuit-based format involving a variety of gross motor tasks, a format that has also been used in structured physical activity interventions for preschool children in China and internationally (Jones et al., 2011; Wang et al., 2023). This format was designed to reduce waiting time and provide children with more opportunities to practice gross motor skills during each session.

Table 1. Basic Information of preschool children participating in structured multisport activities at different weekly frequencies. Data are means $\pm$ SD.

Frequency	Age (years)	Height (cm)	Weight (kg)	n
H	4.4 $\pm$ 0.6	106.4 $\pm$ 5	17.7 $\pm$ 4.1	14
MH	4.1 $\pm$ 0.7	107.3 $\pm$ 6.2	18.0 $\pm$ 2.3	18
M	4.3 $\pm$ 1.1	106.7 $\pm$ 8.5	18.1 $\pm$ 3.1	15
L	4.2 $\pm$ 0.9	106.8 $\pm$ 8.3	17.3 $\pm$ 2.8	16

H: high-frequency group; MH: medium-high-frequency group; M: medium-frequency group; L: low-frequency group.

the participating institution offered multiple class time slots each week to accommodate the different groups; however, the session duration, structure, and planned activity content were kept consistent across groups. The program did not include a planned progression in activity load or task complexity over the 12-week intervention period; instead, a consistent session format was used so that the comparison focused on differences in participation frequency. Each session consisted of approximately 15 minutes of warm-up games, 40 minutes of basic practice, and 5 minutes of cool-down (see Table 2). The warm-up section used to running-jump games to prepare children for the main activities. The basic practice section adopted a circuit-style challenge format incorporating diverse movement tasks, including crawling, jumping, throwing, balance-beam walking, and S-shaped shuttle running. Activities were distributed across movement categories, with locomotor skills and object control skills each accounting for approximately 40% of the session content, and balance-related activities accounting for approximately 20%. This arrangement was designed to cover a broad range of gross motor skills and provide sufficient practice opportunities for both locomotor and object control skills. The cool-down section involved static stretching to facilitate recovery. To ensure intervention quality and consistency, each class was limited to 4 - 8 children and was delivered by one head coach and one assistant. All instructors held preschool physical education qualifications and received standardized preparation before the intervention to implement the curriculum according to the predefined syllabus. Throughout the intervention, researchers monitored attendance and session implementation. All groups followed the same curriculum, session duration, class structure, movement content, and teaching requirements. These procedures were used to maintain comparable activity demands across groups and to ensure that the comparison primarily focused

on weekly participation frequency.

Measurements

Gross motor development was assessed before and after the intervention using the Test of Gross Motor Development-3 (TGMD-3). The TGMD-3 is designed for children aged 3 - 10 years and comprises two domains: locomotor movements (6 items: run, hop, gallop, skip, horizontal jump, and slide) and object control movements (7 items: overhand throw, underhand throw, kick a stationary ball, two hand catch, two-hand strike of a stationary ball, one hand stationary dribble, and forehand strike of self-bounced ball). For each skill, a trained examiner provided a verbal description and a visual demonstration. Each child then performed two trials, and all performances were video-recorded. Trained raters subsequently scored each trial using the process-oriented criteria specified in the TGMD-3 manual, evaluating each behavioral component as present (1) or absent (0). Scores from both trials were summed for each skill. Item scores were summed to obtain the total scores for locomotor movements and object control movements; these were then summed to yield the overall gross motor score.

Before data collection, all raters received standardized scoring training. After training, the raters independently scored complete video recordings of all TGMD-3 test items performed by eight children aged 3 - 6 years to assess inter-rater agreement. Kendall's coefficients of concordance (Kendall's W) were all greater than 0.70, indicating good inter-rater reliability. To ensure scoring consistency, each participant was evaluated by the same rater across time points. As the children were identifiable during assessment, complete blinding to group allocation could not be ensured; standardized rater training and TGMD-3 scoring procedures were therefore applied to maintain scoring consistency.

Table 2. Content and structure of the structured multisport activity sessions.

Activity Sections	Activity Content and Duration
Preparation Part	Warm-up games (15 min), including: • Running • Jumping • Crawling These activities aim to activate the nerves and muscles in preparation for more intensive movement.
	Circuit-based challenge activities (40 min): • Three circular routes, each with 3 - 4 checkpoints • Practice includes: - Crawling - Jumping - Throwing - Kicking - Hitting - Dodging - Balance beam walking - S-shaped running - Other related movement tasks • Each route: 10 - 15 min
Closing Part	Static stretching and relaxation (5 min): • Help children relax muscles • Restore heart rate • Reduce excitement

Statistical analysis

Data were entered in Excel 2019 and analyzed using SPSS 26.0. Data screening indicated that there were no missing values or outliers. Examination of Q-Q plots indicated that the variables were approximately normally distributed, and Levene's test indicated that the assumption of homogeneity of variances was satisfied. To assess baseline equivalence across groups, one-way ANOVA was performed on the pre-test scores for each gross motor development outcome. A 2 (Time: pre-test vs. post-test) $\times$ 4 (Group: L / M / MH / H) mixed-design ANOVA was performed for each gross motor development outcome to examine differences associated with participation frequency. The total score of gross motor development was considered the primary outcome, whereas the domain scores and individual movement scores were treated as exploratory outcomes to provide a more detailed description of the observed changes. When a significant Time $\times$ Group interaction was identified, simple-effects comparisons were conducted to examine changes within each group and between-group differences at each time point. When a significant group main effect was identified without a significant interaction, post-hoc pairwise comparisons were conducted. The Bonferroni correction was applied to pairwise comparisons to control for Type I error. Effect sizes for baseline comparisons and for all main and interaction effects in the mixed-design ANOVA were reported as partial eta squared (η^2p). According to Cohen's guidelines, values of 0.01, 0.06, and 0.14 represent small, medium, and large effects, respectively (Cohen, 2013). Statistical significance was set at $p < 0.05$ (two-tailed).

Results

Baseline comparisons, pre- and post-test descriptive statistics, and ANOVA results

Table 3, Table 4 and Table 5 present the baseline comparisons, descriptive statistics, and mixed-design ANOVA results for gross motor development outcomes.

Baseline data comparison

As shown in Table 3, there were no statistically significant between-group differences in gross motor development outcomes at baseline ($p \geq 0.05$), indicating comparable baseline scores across the four groups.

Overall gross motor development

The total scores (gross motor) demonstrated a significant Time $\times$ Group interaction ($p < 0.01$, $\eta^2p = 0.280$). Within-group analyses showed significant pre- to post-test improvements in all groups ($p < 0.01$). Between-group analyses showed no differences at pre-test, whereas post-test scores diverged: H and MH $>$ L (both $p < 0.01$) and M $>$ L ($p < 0.05$) (Figure 2a, b).

Locomotor movements

The total score of locomotor movements showed a significant Time $\times$ Group interaction ($p < 0.01$, $\eta^2p = 0.205$). Within-group analyses indicated significant pre- to post-test improvements in all groups ($p < 0.01$) (Figure 3a). Between-group analyses showed no differences at pre-test, whereas post-test scores diverged: H $>$ L ($p < 0.01$) and MH $>$ L ($p < 0.05$) (Figure 3b).

The horizontal jump score showed a significant Time $\times$ Group interaction ($p < 0.05$, $\eta^2p = 0.143$). Within-group analyses indicated significant pre- to post-test improvements in all groups ($p < 0.01$) (Figure 3c). Between-group analyses showed no pre-test differences, whereas post-test scores diverged: H $>$ L ($p < 0.01$) and MH $>$ L ($p < 0.05$) (Figure 3d). A significant main effect of group was found for hop and run ($p < 0.05$), indicating overall between-group differences. For hop, group-level comparisons showed H and MH scored higher than L ($p < 0.05$; Figure 3e). For run, MH scored higher than L and M ($p < 0.05$; Figure 3f). Scores for gallop, slide, hop, run, and skip showed a significant main effect of time ($p < 0.01$). For gallop and skip, M, MH, and H improved significantly ($p < 0.01$), whereas L did not ($p > 0.05$) (Figure 3g, h). For hop, run, and slide, all groups improved significantly ($p < 0.01$) (Figure 3i-k).

Table 3. Comparison of baseline gross motor development scores across groups. Data are means $\pm$ SD.

Test items	L	M	MH	H	F	P	η^2p
Gallop	3.13 $\pm$ 2.45	3.67 $\pm$ 2.26	2.78 $\pm$ 2.46	3.21 $\pm$ 2.19	0.393	0.758	0.020
Slide	4.38 $\pm$ 2.58	4.00 $\pm$ 2.10	4.50 $\pm$ 1.86	4.07 $\pm$ 2.09	0.196	0.899	0.010
Skip	1.75 $\pm$ 1.91	1.87 $\pm$ 1.96	1.44 $\pm$ 1.92	1.50 $\pm$ 1.22	0.199	0.897	0.010
Hop	1.56 $\pm$ 1.63	1.87 $\pm$ 1.68	2.17 $\pm$ 1.29	2.43 $\pm$ 1.70	0.865	0.465	0.042
Run	4.56 $\pm$ 1.15	4.27 $\pm$ 1.10	5.22 $\pm$ 1.06	4.50 $\pm$ 1.29	2.162	0.102	0.099
Horizontal Jump	2.38 $\pm$ 1.93	3.33 $\pm$ 1.88	3.00 $\pm$ 1.28	2.86 $\pm$ 1.70	0.855	0.470	0.042
Total scores of Locomotor Movements	17.75 $\pm$ 8.00	19.00 $\pm$ 7.95	19.11 $\pm$ 6.28	19.00 $\pm$ 6.86	0.126	0.944	0.006
Forehand Strike of Self-bounced Ball	0.50 $\pm$ 0.73	0.73 $\pm$ 0.88	0.56 $\pm$ 0.86	0.93 $\pm$ 0.92	0.787	0.506	0.038
Kick a Stationary Ball	2.50 $\pm$ 1.26	2.73 $\pm$ 0.96	2.56 $\pm$ 1.15	2.71 $\pm$ 1.20	0.156	0.925	0.008
Underhand Throw	2.50 $\pm$ 1.86	2.53 $\pm$ 1.36	2.78 $\pm$ 1.35	3.21 $\pm$ 1.25	0.721	0.544	0.035
Overhand Throw	0.50 $\pm$ 0.89	0.87 $\pm$ 1.55	0.78 $\pm$ 0.81	1.50 $\pm$ 1.22	2.029	0.120	0.094
Two-hand Strike of a Stationary Ball	3.06 $\pm$ 1.39	2.87 $\pm$ 1.68	2.78 $\pm$ 1.83	3.00 $\pm$ 1.88	0.094	0.963	0.005
Two Hand Catch	2.25 $\pm$ 2.08	1.87 $\pm$ 1.77	1.67 $\pm$ 1.61	2.86 $\pm$ 1.75	1.281	0.289	0.061
One Hand Stationary Dribble	2.31 $\pm$ 1.74	2.60 $\pm$ 1.40	2.11 $\pm$ 1.13	2.50 $\pm$ 1.83	0.325	0.807	0.016
Total scores of Object Control Movements	13.63 $\pm$ 7.07	13.80 $\pm$ 6.73	13.22 $\pm$ 5.01	16.71 $\pm$ 6.12	0.970	0.413	0.047
Total scores	31.38 $\pm$ 12.72	32.80 $\pm$ 13.34	32.33 $\pm$ 10.27	35.71 $\pm$ 11.51	0.359	0.783	0.018

L: low-frequency group; M: medium-frequency group; MH: medium-high-frequency group; H: high-frequency group.

Table 4. Pre- and post-test gross motor development scores across frequency groups (mean $\pm$ SD).

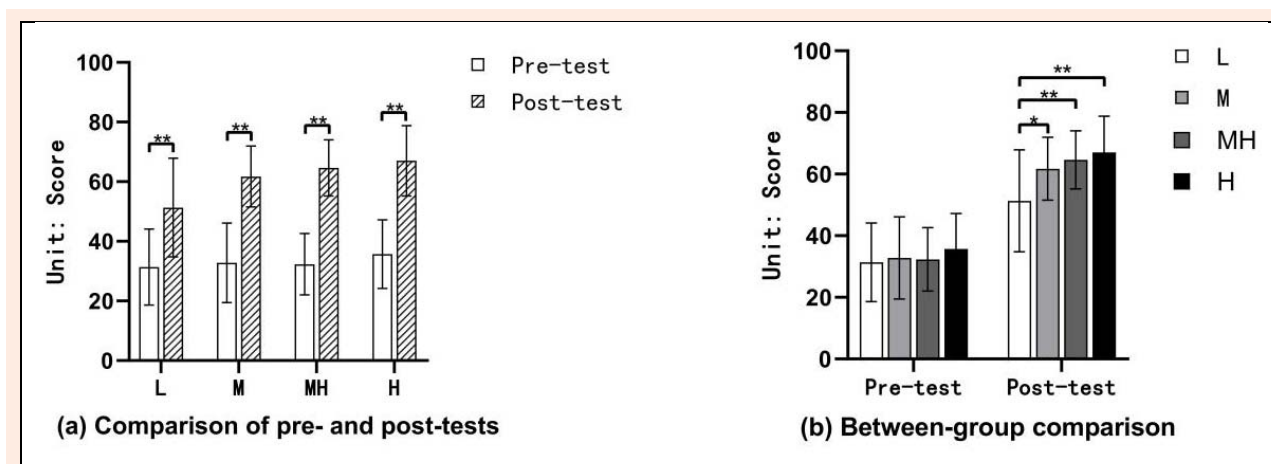
Test items	L		M		MH		H	
	pre-test	post-test	pre-test	post-test	pre-test	post-test	pre-test	post-test
Gallop	3.13 $\pm$ 2.45	4.19 $\pm$ 2.48	3.67 $\pm$ 2.26	6.33 $\pm$ 1.11	2.78 $\pm$ 2.46	5.50 $\pm$ 1.86	3.21 $\pm$ 2.19	6.29 $\pm$ 1.68
Slide	4.38 $\pm$ 2.58	6.56 $\pm$ 2.39	4.00 $\pm$ 2.10	7.20 $\pm$ 1.26	4.50 $\pm$ 1.86	7.44 $\pm$ 0.92	4.07 $\pm$ 2.09	7.07 $\pm$ 1.27
Skip	1.75 $\pm$ 1.91	2.19 $\pm$ 2.07	1.87 $\pm$ 1.96	3.13 $\pm$ 2.07	1.44 $\pm$ 1.92	3.11 $\pm$ 1.94	1.50 $\pm$ 1.22	3.00 $\pm$ 1.96
Hop	1.56 $\pm$ 1.63	2.81 $\pm$ 1.68	1.87 $\pm$ 1.68	3.80 $\pm$ 0.94	2.17 $\pm$ 1.29	4.39 $\pm$ 1.09	2.43 $\pm$ 1.70	3.93 $\pm$ 1.38
Run	4.56 $\pm$ 1.15	6.94 $\pm$ 1.29	4.27 $\pm$ 1.10	7.40 $\pm$ 1.18	5.22 $\pm$ 1.06	7.83 $\pm$ 0.38	4.50 $\pm$ 1.29	7.71 $\pm$ 0.73
Horizontal Jump	2.38 $\pm$ 1.93	4.31 $\pm$ 2.09	3.33 $\pm$ 1.88	5.40 $\pm$ 2.35	3.00 $\pm$ 1.28	6.11 $\pm$ 2.11	2.86 $\pm$ 1.70	6.79 $\pm$ 1.42
Total scores of Locomotor Movements	17.75 $\pm$ 8.00	27.00 $\pm$ 8.89	19.00 $\pm$ 7.95	33.27 $\pm$ 5.9	19.11 $\pm$ 6.28	34.39 $\pm$ 5.44	19 $\pm$ 6.86	35.14 $\pm$ 6.05
Forehand Strike of Self-bounced Ball	0.50 $\pm$ 0.73	1.88 $\pm$ 1.67	0.73 $\pm$ 0.88	2.87 $\pm$ 1.81	0.56 $\pm$ 0.86	2.72 $\pm$ 1.74	0.93 $\pm$ 0.92	3.07 $\pm$ 1.64
Kick a Stationary Ball	2.50 $\pm$ 1.26	3.88 $\pm$ 1.02	2.73 $\pm$ 0.96	3.93 $\pm$ 0.59	2.56 $\pm$ 1.15	3.94 $\pm$ 0.94	2.71 $\pm$ 1.20	4.29 $\pm$ 0.61
Underhand Throw	2.50 $\pm$ 1.86	4.25 $\pm$ 2.14	2.53 $\pm$ 1.36	5.13 $\pm$ 1.06	2.78 $\pm$ 1.35	5.5 $\pm$ 1.5	3.21 $\pm$ 1.25	5.86 $\pm$ 1.66
Overhand Throw	0.50 $\pm$ 0.89	2.38 $\pm$ 1.59	0.87 $\pm$ 1.55	2.27 $\pm$ 1.39	0.78 $\pm$ 0.81	2.78 $\pm$ 1.7	1.50 $\pm$ 1.22	3.00 $\pm$ 1.96
Two-hand Strike of A Stationary Ball	3.06 $\pm$ 1.39	4.69 $\pm$ 2.02	2.87 $\pm$ 1.68	5.67 $\pm$ 1.40	2.78 $\pm$ 1.83	6.11 $\pm$ 1.68	3.00 $\pm$ 1.88	6.50 $\pm$ 1.34
Two Hand Catch	2.25 $\pm$ 2.08	4.19 $\pm$ 1.56	1.87 $\pm$ 1.77	4.73 $\pm$ 0.96	1.67 $\pm$ 1.61	4.78 $\pm$ 0.65	2.86 $\pm$ 1.75	4.64 $\pm$ 0.84
One Hand Stationary Dribble	2.31 $\pm$ 1.74	3.06 $\pm$ 2.43	2.60 $\pm$ 1.40	3.87 $\pm$ 1.81	2.11 $\pm$ 1.13	4.44 $\pm$ 1.72	2.50 $\pm$ 1.83	4.93 $\pm$ 1.33
Total scores of Objects Control Movements	13.63 $\pm$ 7.07	24.31 $\pm$ 9.15	13.8 $\pm$ 6.73	28.47 $\pm$ 5.66	13.22 $\pm$ 5.01	30.22 $\pm$ 4.87	16.71 $\pm$ 6.12	31.86 $\pm$ 6.77
Total scores	31.38 $\pm$ 12.72	51.31 $\pm$ 16.55	32.80 $\pm$ 13.34	61.73 $\pm$ 10.22	32.33 $\pm$ 10.27	64.61 $\pm$ 9.43	35.71 $\pm$ 11.51	67.00 $\pm$ 11.82

L: low-frequency group; M: medium-frequency group; MH: medium-high-frequency group; H: high-frequency group.

Table 5. Main and interaction effects for gross motor development outcomes across participation-frequency groups

Test items	Time			Group			Time $\times$ Group		
	F	p	η^2p	F	p	η^2p	F	p	η^2p
Gallop	54.28	0.000	0.479	1.98	0.127	0.091	1.93	0.134	0.089
Slide	135.81	0.000	0.697	0.315	0.814	0.016	0.84	0.478	0.041
Skip	35.86	0.000	0.378	0.25	0.863	0.012	1.87	0.144	0.087
Hop	68.42	0.000	0.537	2.81	0.047	0.125	1.15	0.336	0.055
Run	321.19	0.000	0.845	2.891	0.043	0.128	1.62	0.194	0.076
Horizontal Jump	118.75	0.000	0.668	2.59	0.061	0.116	3.27	0.027	0.143
Total scores of Locomotor Movements	397.41	0.000	0.871	1.80	0.157	0.084	5.06	0.003	0.205
Forehand Strike of Self-bounced Ball	102.24	0.000	0.634	1.46	0.235	0.069	1.02	0.389	0.049
Kick a Stationary Ball	82.20	0.000	0.582	0.43	0.736	0.021	0.23	0.876	0.012
Underhand Throw	102.82	0.000	0.635	2.36	0.081	0.107	0.93	0.432	0.045
Overhand Throw	52.12	0.000	0.469	1.58	0.203	0.074	0.39	0.762	0.019
Two-hand Strike of a Stationary Ball	121.82	0.000	0.674	1.13	0.345	0.054	2.80	0.048	0.124
Two Hand Catch	202.95	0.000	0.775	0.55	0.653	0.027	3.84	0.014	0.163
One Hand Stationary Dribble	48.69	0.000	0.452	1.33	0.274	0.063	2.89	0.043	0.128
Total scores of Object Control Movements	486.72	0.000	0.892	2.00	0.125	0.092	4.41	0.007	0.183
Total scores	737.46	0.000	0.926	2.10	0.111	0.096	7.63	0.000	0.280

Effect sizes are reported as partial eta squared (η^2p). Boldface indicates statistically significant effects. For outcomes with a significant Time $\times$ Group interaction, the interaction effect and subsequent simple-effects comparisons were interpreted rather than the main effects alone.

**Figure 2.** Interaction effects for the overall gross motor score. L: low-frequency group; M: medium-frequency group; MH: medium-high-frequency group; H: high-frequency group. * indicates $p < 0.05$; ** indicates $p < 0.01$.

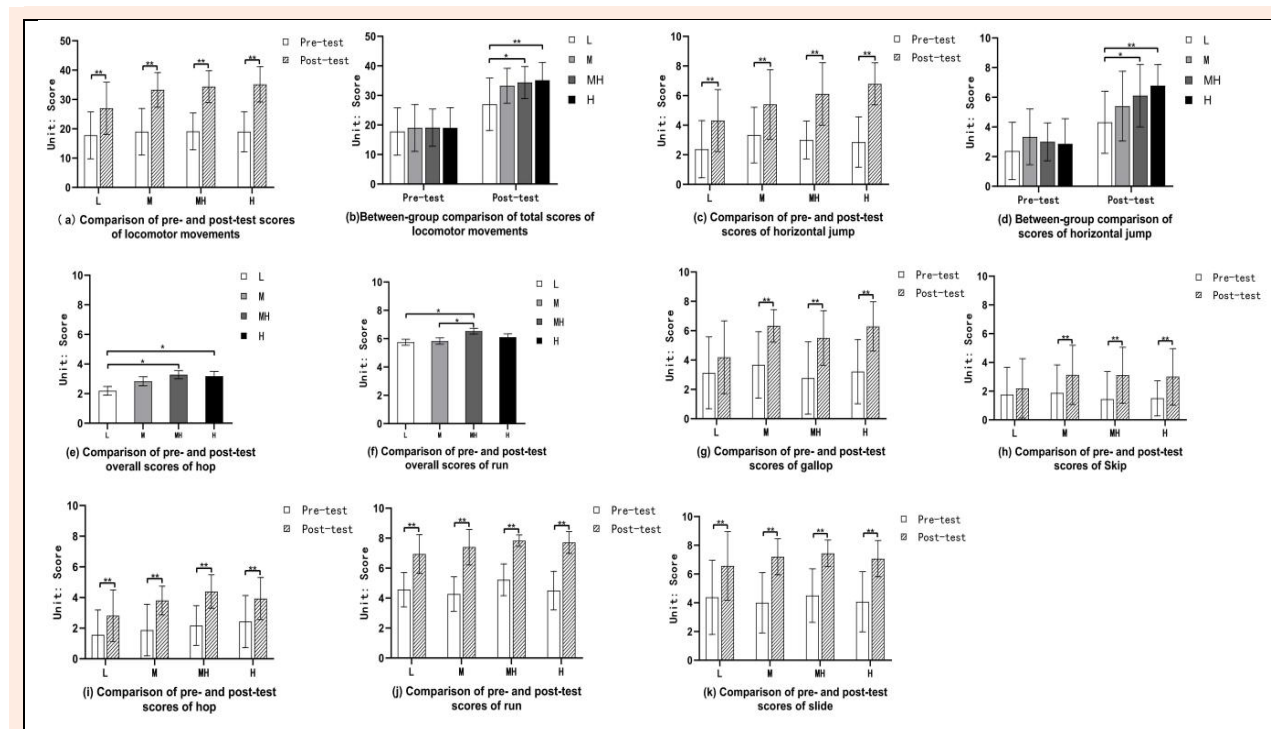


Figure 3. Effects of participation frequency in structured multisport activities on locomotor movements. L: low-frequency group; M: medium-frequency group; MH: medium-high-frequency group; H: high-frequency group. * indicates $p < 0.05$; ** indicates $p < 0.01$.

Object control movements

The total score of object control movements showed a significant Time $\times$ Group interaction ($p < 0.01$, $\eta^2p = 0.183$). Within-group analyses indicated significant pre- to post-test improvements in all groups ($p < 0.01$) (Figure 4a). Between-group analyses showed no differences at pre-test, whereas post-test scores diverged: $H > L$ ($p < 0.01$) and $MH > L$ ($p < 0.05$) (Figure 4b).

For two-hand strike of a stationary ball, a significant Time $\times$ Group interaction was observed ($p < 0.05$, $\eta^2p = 0.124$). Within-group analyses showed significant improvements in all groups ($p < 0.01$) (Figure 4c). Between-group analyses revealed no pre-test differences; post-test, $H > L$ ($p < 0.01$) and $MH > L$ ($p < 0.05$) (Figure 4d). For two hand catch, the Time $\times$ Group interaction was significant ($p < 0.05$, $\eta^2p = 0.163$). Within-group analyses indicated significant improvements across all groups ($p < 0.01$) (Figure 4e). However, the Bonferroni-adjusted between-group comparisons did not identify significant differences between specific groups at either pre-test or post-test (Figure 4f). Therefore, although the significant interaction suggests that changes over time varied across groups, this finding does not provide clear evidence of a frequency-related advantage for two hand catch and should be interpreted cautiously. For one hand stationary dribble, the Time $\times$ Group interaction was significant ($p < 0.05$, $\eta^2p = 0.128$). Within-group analyses showed significant improvements in H and MH (both $p < 0.01$) and in M ($p < 0.05$) (Figure 4g). Between-group analyses revealed no pre-test differences; post-test, $H > L$ ($p < 0.01$) and $MH > L$ ($p < 0.05$) (Figure 4h). The scores for forehand strike of self-bounced ball, kick a stationary ball, underhand throw, and overhand throw showed a significant main effect of time ($p < 0.01$), with all groups improving from pre- to post-test ($p < 0.01$) (Figure 4i-l).

Discussion

Participants in all four frequency groups showed improvements in overall gross motor development after the 12-week program. A basic premise of motor development is that children need opportunities to perform and practice movement tasks in an appropriate environment (Payne et al., 2008). Structured multisport activities provide such opportunities through a variety of movement tasks in a guided setting. Even intermittent participation may have introduced children to movement experiences that were not regularly available in their daily lives. However, because preschool children also develop rapidly through natural maturation and this study did not include a non-intervention control group, the pre- to post-test improvements should not be attributed to the program alone. Future studies including a non-intervention group would allow clearer evaluation of changes associated with structured multisport activities. In the exploratory analyses, the L group did not show significant improvement in skip, gallop, or one hand stationary dribble, whereas the groups participating more regularly showed improvement in a wider range of movements. These findings may be related to the demands of these skills. Skip and gallop require rhythmic coordination between the limbs, while one hand stationary dribble requires repeated hand-eye coordination and control of force. Such skills may require regular practice opportunities before clear improvements can be observed.

Compared with the L group, the groups participating at least twice per week showed greater improvements in horizontal jump, two-hand strike of a stationary ball, and one hand stationary dribble. Similar patterns were found for the overall gross motor, locomotor, and object control total scores. Previous studies have also suggested that more

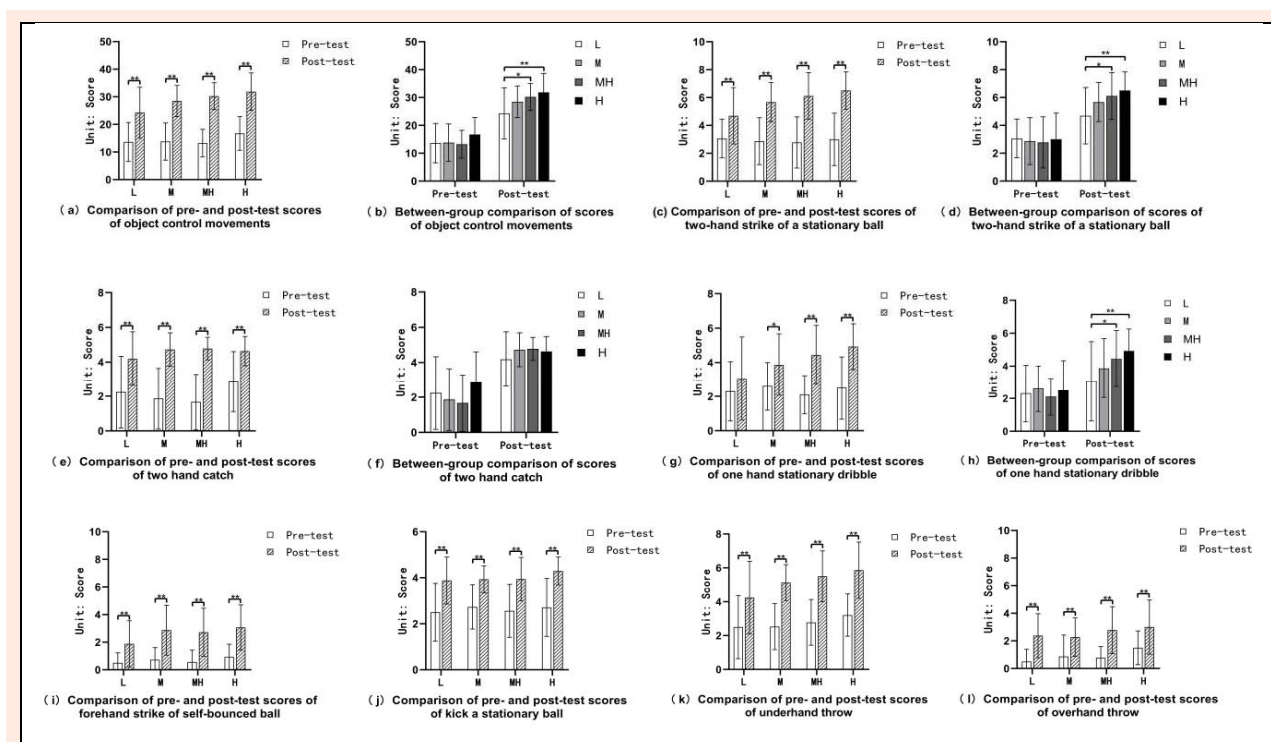


Figure 4. Effects of participation frequency in structured multisport activities on object control movements. L: low-frequency group; M: medium-frequency group; MH: medium-high-frequency group; H: high-frequency group. * indicates $p < 0.05$; ** indicates $p < 0.01$.

frequent opportunities for physical activity or movement practice may support motor skill development in children (Lopes et al., 2017; Valentini et al., 2016). Repeated practice may help children consolidate movement patterns, receive feedback, and make corrections over time (Moore et al., 1981; Shi and Feng, 2022). In the present study, more regular participation may therefore have provided more opportunities for children to practice and refine gross motor skills.

The findings can also be understood through Newell's constraints model, which proposes that motor development results from the interaction among the individual, the task, and the environment (Newell, 1986). In the present study, structured multisport activities provided children with a consistent practice environment and a range of movement tasks involving locomotor and object control skills. Differences in weekly participation frequency therefore represented differences in how regularly children interacted with these task and environmental conditions. More regular participation may have provided children with more opportunities to adapt their movements, coordinate their actions, and improve their performance in the tasks assessed. From this perspective, the observed differences among frequency groups may reflect not only repeated practice, but also differences in children's opportunities to engage with structured movement tasks over time.

Although the H group generally showed high post-test scores, no statistically significant differences were found between the MH and H groups in either total scores or individual movement outcomes. This indicates that the present study did not detect an additional advantage of the H participation pattern over the MH pattern. However, because the H group included children attending three or more sessions per week, the data do not allow conclusions

about whether gains plateau beyond three sessions per week. Further studies with clearly defined higher-frequency groups and larger samples are needed to examine this question.

Overall, this exploratory study examined how different weekly frequencies of participation in structured multisport activities were associated with gross motor development in preschool children. The primary outcome showed greater improvement in the more regularly participating groups than in the low-frequency group. Exploratory analyses further indicated frequency-related differences in several specific skills. These results suggest that regular participation may support gross motor development, while the detailed patterns across skill categories require further study.

For practice, the findings support providing preschool children with regular opportunities to participate in structured multisport activities that include diverse movement tasks. One session per week may still provide meaningful movement experiences, while more frequent participation may be associated with greater improvements in some skills. Because the study was exploratory and did not include a non-intervention control group, specific frequency recommendations should be examined further in future studies.

Limitations and future directions: First, participants were recruited from institutions offering structured multisport activities, and participant attrition resulted in a relatively small final sample. Future studies should recruit larger samples from different regions, institutions, and kindergartens to improve the generalizability of the findings. Second, although this study included only children attending non-sports-focused kindergartens, where physical activity primarily consisted of unstructured free play without

specialized sports instruction, children's actual physical activity during kindergarten hours could not be fully controlled or monitored. Differences in daily movement opportunities within kindergarten may therefore have influenced the observed between-group differences. Future studies could monitor children's whole-day physical activity to better examine the relationship between participation in structured multisport activities and gross motor development. Third, this study lacked a non-intervention control group. Therefore, the observed between-group differences and pre- to post-test improvements cannot be fully separated from changes related to natural maturation. Future studies should include a non-intervention control group to more clearly evaluate changes associated with the activity program. Fourth, sex information was unavailable in the final analytical dataset and could not be reconstructed retrospectively. As a result, this potentially important confounding variable could not be controlled or examined in the analyses, and unequal sex distributions across groups may have influenced the observed outcomes. Future studies should ensure the collection and retention of key demographic information to allow adjustment for potential confounding factors. Fifth, participants were classified according to their actual participation frequency rather than through random assignment. Although baseline comparisons indicated no significant differences among groups before the intervention, non-random grouping may still have introduced selection bias and influenced the observed results. Future studies should employ randomized allocation procedures whenever feasible to further strengthen internal validity. Sixth, complete blinding could not be guaranteed throughout the study process, which may have influenced the study findings. Future studies should adopt more rigorous blinding procedures where possible to further reduce potential sources of bias. Finally, this study examined only one type of structured preschool activity program: structured multisport activities organized in a circuit-based format involving a variety of gross motor tasks. The findings may not apply to other types of structured activity programs. Future studies should examine other program types, such as ball games and dance activities, and further explore whether participation frequency influences locomotor and object control skills differently.

Conclusion

After three months of intervention, preschool children participating in structured multisport activities showed improvements in overall gross motor development. Regular participation (once a week or more) was associated with improvement across all assessed gross motor skills. More frequent participation (at least twice per week) was associated with greater improvements in specific skills, including horizontal jump, two-hand strike of a stationary ball, and one hand stationary dribble. Although gross motor development generally tended to improve as participation frequency increased, no statistically significant additional advantage of the high-frequency group over the medium-high-frequency group was detected. These findings should be interpreted cautiously, given the absence of a non-intervention control group and the relatively limited sample size.

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Key points

- Regular participation in structured multisport activities (once a week or more) was associated with improvements in all assessed gross motor skills.
- Participation in at least two sessions per week was associated with greater improvements in specific skills, including horizontal jump, two-hand strike of a stationary ball, and one hand stationary dribble.
- No statistically significant additional advantage of the high-frequency group over the medium-high-frequency group was detected.

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