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Environment for Preschool Children to Learn Fundamental Motor Skills: The Role of Teaching Venue and Class Size

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Received: 17 August 2020; Accepted: 20 November 2020; Published: 23 November 2020

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Abstract: The development of children's fundamental motor skills (FMS) is shaped by the environment surrounding them. The purpose of this study was to examine whether the changes of children's FMS after an intervention program differed between classes conducted in different schooling conditions. Participants were 295 preschool children (62 boys, 133 girls; *M* = 5.4 years; *SD* = 0.28) from eight preschools in Hong Kong. Children participated in an 8-week FMS program and their FMS were assessed using the Test of Gross Motor Development-2 (TGMD-2). A linear mixed model was used to analyze the association on the changes of FMS score between children in different schooling conditions: (1) teaching venue size (large or small); and (2) class size (large, medium, or small), while accounting for the clustering of participants within preschools. The changes of object control skills were significantly different between groups with different teaching venue size (p = 0.000) (small: 5.54 (*SD* = 5.84) vs. large: 2.46 (*SD* = 6.42)) and different class size (p = 0.000) (small: 8.12 (*SD* = 6.34) vs. medium: 2.92 (*SD* = 6.26) vs. large: 4.00 (*SD* = 5.79)). The findings have practical implications for the teaching of FMS in that the social and physical environment in preschools should be considered for the design of FMS intervention programs.

Keywords: early childhood; physical education; motor skill competence; environment; object control

1. Introduction

Fundamental motor skills (FMS) are defined as the building blocks of more advanced, complex movement required to participate in sports, games, and other context-specific physical activity (PA), which include object control skills (e.g., throwing), locomotor skills (e.g., running), and balance skills (e.g., body rolling) [1]. FMS are an important part of childhood development, as proficiency in FMS has been reported to be associated with children with better physical fitness [2], higher levels of physical activity [3], and positive health-related outcomes [4]. Yet, the acquisition of FMS requires interaction with supportive social and physical environments including space and professional instruction [5].

Regarding children's FMS development, Newell's theory of constraints suggests that individual movement development results from interaction among three sets of constraints, which include individual constraints (e.g., gender or heredity of children), task constraints (e.g., the goals or rules in performing the movement), and environmental constraints (e.g., the outdoor geography or the educator's prompts) [6]. Environmental constraints refer to both physical and sociocultural factors that constitute the children's surroundings [7]. An appropriate physical environment provides opportunities for skill-specific practice and a social environment encourages interaction with learners [8].

Previous study on the environmental factors affecting preschool children's FMS development found that variations in rearing conditions are significant factors influencing motor development during infancy and childhood [9]. Most young children attend preschool and spend long hours there. Intervention conducted in preschools generally showed a positive effect on their FMS skills [10]. The intervention protocol involves structured FMS sessions and consists of an overall or specific training of FMS, such as locomotor skill exercises and rhythm with music [5]. The schooling condition is reported to play a positive role in relation to children's FMS competence [11]. For example, a preschool-type setting (private vs. public) was found to be associated with children's FMS ability; private preschool settings were associated with higher motor skills compared with public preschool settings. Researchers claimed that the underlying reason for the association was the availability of open space for play, PA opportunities, play equipment [12], and the scale of the play area size [13]. In one study examining the association between the preschool environment and children's FMS competence, classroom size/child ratio and playground size were predictive factors with medium effect on children's locomotor and total gross motor scores [14]. The role of the teacher is critical in interventions conducted in preschool [15]. Class size, referring to the number of students in a class, was reported to be related to the teachers' and students' behavior in a class [16]. Although many studies have examined the effects of class size on students' learning in academic subjects, little is known about the relationship between class size and students' learning in physical education (PE) classes. In one study, smaller group size in PE class was perceived by teachers to be important to students' learning, enabling more interaction with the equipment [17]. Another study reported that elementary students in smaller groups engaged in more direct interaction with balls during throwing and catching games [18]. However, the study of class size effects on preschool children's FMS learning is limited. The purpose of the present study was to examine whether the intervention effects of a FMS program differed between classes with different schooling conditions (i.e., venue size and class size).

2. Materials and Methods

The current study used a case-control study design to examine changes in FMS scores (object control and locomotor) of preschool children in preschools with different schooling environments (i.e., teaching venue size and class size). Data were collected from eight preschools in Hong Kong. Ethical approval for using human subjects was obtained from the ethical committee (Ref. no.2016-2017-0022) of the research university, and consent for participation was confirmed by the participating schools and children's parents.

2.1. Participants

Eight preschools that joined a FMS program were included as participating preschools in the current study. The inclusion criteria of the children participants were set as K3 children studying in the participating schools. The preschool principals were asked to select any two classes of K3 children (aged 4–6 years) to participate in the study. Participants without parental consent were excluded. As the study was conducted in regular PE lessons, no students in the participating classes were excluded. The preschools were operated differently under the local regulations: the teaching venue size ranged from 23–92 m^2 and the class size ranged from 13–28 students. A total of 302 preschool children were recruited to participate in the study. After the removal of seven cases that did not complete the posttest measurement due to absence from class, the final data set contained 295 children with mean age of 5.38 years (SD = 0.28), while 162 (54.9%) were boys and 133 (45.1%) were girls. Before the first teaching session, the children's anthropometric measurements were collected from the respective preschools. The children's body height and weight were measured by school teachers in regular class with normal school uniform and shoes on. The Body Mass Index (BMI) z-scores were generated using the World Health Organization (WHO) growth standards. There were no significant differences observed in the physiological variables, such as age and BMI z-scores among children in different preschools. Descriptive information about the participants (i.e., age, height, weight, and BMI z-scores) is shown in Table 1.

Table 1. Descriptive data of the participants (n = 295).

	Boys (n = 162)	Girls (n = 133)	Total (n = 295)
Age (years)	5.37 (0.27)	5.38 (0.29)	5.38 (0.28)
Body Height (cm)	111.03 (4.96)	109.87 (5.03)	110.51 (5.02)
Body Weight (kg)	19.05 (3.43)	18.14 (3.04)	18.64 (3.29)
BMI z-score	−0.40 (1.39)	−0.46 (1.30)	−0.42 (1.37)

Note. Standard deviations appear in parentheses after the mean values.

2.2. Program Content and Delivery

The FMS program was designed by the researchers and was based on the core concepts of the Newell's theory of constraints [6], with the focus on the task and environment constraints in FMS acquisition. The program included a 3-min exercise routine, containing FMS movement (e.g., galloping, jumping, throwing, and catching a towel) performed with moderately-paced background music. The program also included 16 FMS games that either involved movements of locomotor (e.g., hopping, leaping, jumping, sliding) or object control skills (e.g., striking, catching, throwing, rowing, dribbling, kicking) using minimal equipment (e.g., hoops, ball) that are available in all participating preschools. In considering the task and environmental constraints, the movements designed were age-specified and the games were expected to be conducted under the teachers' guidance. The program was delivered in 16–30 min teaching sessions conducted in a regular PE lesson schedule twice a week by the regular schoolteacher, while children had the opportunity to perform the FMS. Prior to the study, the preschool teachers attended two 1-day training workshops to learn the teaching content. The lesson plan was prepared to ensure the lessons were conducted in the same pattern, as follows: warm-up (5 min), exercise routine (10 min), FMS games (10 min), and cool-down (5 min) (Appendix A).

2.3. Data Collection Procedure

The research team conducted the measurement on children's FMS two weeks before the commencement (pretest) and one week after the completion (posttest) of the program in each preschool. Measurements were conducted in a 2-h session following the procedure of the Test of Gross Motor Development-2 (TGMD-2) test manual [19] and the measurements were video-taped. Each child's FMS performance was assessed by individual testing personnel, who had received training before data collection. The training session included a video presentation on the testing procedure and assessment criteria, practical assessment, and discussion on commonly encountered problems. To examine the intra-rater reliability, the testing personnel assessed 30 videos on their scores on locomotor or object control skills two weeks after the measurement.

2.4. Measures

FMS. Children's FMS performance was assessed using the Test of Gross Motor Development-2 (TGMD-2) [19]. TGMD-2 is widely used to measure the FMS development of children within different countries [10] and among children in Hong Kong [20,21]. TGMD-2 consists of subtests to assess (1) locomotor skills (running, horizontal jumping, hopping, leaping, galloping, sliding) and (2) object control skills (stationary dribbling, catching, kicking, striking a stationary ball, overhand throwing, underhand rolling). Scoring of the TGMD-2 is according to the fulfillment of 3–5 performance criteria for each skill. The total scores are summed, with a possible range of 0–96 for the overall FMS score and 0–48 for locomotor and object control scores. High scores indicate that the participant had better FMS performance, and vice versa. Standard scores for the sub-items (locomotor and object control skills) are calculated from the raw scores and converted to a gross motor quotient (GMQ) score. The GMQ is adopted to classify the FMS performance of each child's individual overall FMS, from very poor (GMQ < 70) to very superior (GMQ > 130) [19].

Teaching venue size. Although the scale of preschools in Hong Kong varies widely, their operations are all guided by the local Education Bureau [22]. The minimum floor space requirement is 1.8 m^2 per child, and the minimum indoor play area size in a preschool is 123 m^2. In addition, there are guidelines governing staffing in preschools, such as the requirement of a staff to child ratio of 1:15 [23]. There is no standard curriculum for PE lessons, and no standardization of the size of teaching venue or the size of the class. Thus, differences in the environmental setting during PE lesson could potentially influence FMS learning among preschool children. Each participating preschool was asked to identify an available venue to conduct an 8-week FMS program. A site visit was conducted before the commencement of the program, when the school administrator met with the research team and measured the size of the teaching venue. The recorded median venue size (60 m^2) of the eight preschools was adopted as a cut-off to classify whether the class was conducted in a small venue (less than 60 m^2; n = 8) or a large venue (greater than 60 m^2; n = 8).

Class size. Each participating preschool recorded the total numbers of children in each class who participated in the program. As there are no regulations regarding the student to teacher ratio in the teaching of PE, variation in class size is common. Two cut-off points (25th percentile and 75th percentile) were adopted to classify whether the 16 teaching classes were conducted with small (less than 16 students, n = 3), medium (16–19 students, n = 8) or large (more than 20 students, n = 5) class sizes.

2.5. Data Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences, Version 24 (IBM SPSS, Armonk, New York, NY, USA). Descriptive data were presented as mean (*SD*) in FMS score (locomotor, object control, total FMS score) during pre and post measurement. Intra-rater reliability was established by the intra-class correlation coefficient (ICC) with values greater than 0.75 suggesting excellent intra-rater reliability [24]. A Shapiro–Wilks' test was conducted to confirm the data are normally distributed among independent groups: large (p = 0.314) and small (p = 0.242) teaching venue; large (p = 0.543), medium (p = 0.490), and small (p = 0.124) class size. A linear mixed model was used in analyzing the association on the changes of FMS score (posttest–pretest) between children in different schooling conditions while accounting for the clustering of participants within preschools. The dependent variable was the change of FMS score. The school served as a random effect while adjusting for child age, BMI z-score, and pretest FMS score. Two separate models were computed with school size (large and small) and teaching class size (large, medium, and small) as fixed effects, respectively. The criterion for statistical significance was set at $p \leq 0.05$. The effect size of the fixed effects was reported using the Cohen's standard method (d), with 0.2, 0.5, and 0.8 denoting small, moderate, and large effect sizes, respectively [25].

3. Results

3.1. Preschool Children's FMS Performance

The baseline measurements of preschool children's FMS scores are shown in Table 2. Children's object control (standard score = 10.61), locomotor (standard score = 11.44), and overall FMS performance (GMQ = 106.14) were classified as being in the average range, according to the TGMD-2 US norms [19]. There was no significant difference in FMS between boys (raw score = 67.57) and girls (raw score = 68.56).

Table 2. Participants' baseline measurement of fundamental motor skills (FMS) scores (n = 295).

Variables	Total (n = 295) Mean (*SD*)	Boys (n = 162) Mean (*SD*)	Girls (n = 133) Mean (*SD*)	p
Locomotor skills raw score	36.90 (5.61)	36.26 (6.03)	36.67 (4.95)	0.261
Locomotor skills standard score	11.44 (2.20)	11.21 (2.28)	11.71 (2.06)	0.002
Object control skills raw score	31.12 (5.26)	31.31 (5.60)	30.90 (4.83)	0.250

Table 2. *Cont.*

Variables	Total (n = 295) Mean (SD)	Boys (n = 162) Mean (SD)	Girls (n = 133) Mean (SD)	p
Object control skill standard score	10.61 (2.04)	9.88 (1.76)	11.50 (2.01)	0.000
Total FMS raw score	68.02 (8.24)	67.57 (8.82)	68.56 (7.48)	0.149
Total FMS standard score	22.05 (3.20)	21.09 (3.03)	23.21 (3.02)	0.000
Gross motor quotient (GMQ) score	106.14 (9.60)	103.28 (9.09)	109.63 (9.05)	0.000

3.2. Changes in FMS Score between Preschool Children in Different Schooling Conditions

The measurement of FMS (object control skills and locomotor skills) during pretest and posttest classified into different venue sizes are shown in Table 3. The intra-rater reliability of all raters was excellent with an ICC ranging from 0.90–0.96 [23]. The intervention effects on object control and locomotor skills differed between classes with different teaching venue sizes. In the linear mixed model analyses on the changes of FMS score, only object control skills reported with a statistically significant difference (p = 0.000; d = 0.50) between groups in small venue size (mean change: 5.54 (95% CI: 4.62 to 6.46)) compared to that in the large venue size (mean change: 2.46 (95% CI: 1.39 to 3.53)). The change of locomotor skills was not significant (p = 0.110).

Table 3. Changes in FMS score between preschool children in large and small teaching venue (n = 295).

Teaching Venue	FMS Score			95% CI	p	AIC
	Pretest	Posttest	Change			
Locomotor skills						
Large	37.96 (4.81)	42.13 (5.79)	4.17 (5.89)	3.19, 5.15	0.110	1826.57
Small	35.95 (6.09)	40.39 (5.40)	4.44 (6.64)	3.40, 5.48		
Object control skills						
Large	30.94 (5.41)	33.40 (4.42)	2.46 (6.42)	1.39, 3.53	0.000 *	1757.61
Small	31.29 (5.13)	36.83 (5.34)	5.54 (5.84)	4.62, 6.46		

Note: CI = confidence interval; AIC = Akaike's information criterion; Teaching venue size: large = greater than 60 m^2; small = less than 60 m^2; * significance at 0.05. Standard deviations appear in parentheses after the mean values.

The measurement of FMS (object control skills and locomotor skills) during pretest and posttest classified into different class sizes are shown in Table 4. The intervention effects on object control and locomotor skills also differed between different class sizes. In the linear mixed model analyses on the changes of FMS score, only object control skills reported with a statistically significant difference (p = 0.000; d = 0.44) between groups in small class size (mean change: 8.12 (95% CI: 8.12 to 10.00)) compared to those with medium (mean change: 2.92 (95% CI: 1.86 to 3.98)) or large class sizes (mean change: 4.00 (95% CI: 2.96 to 5.04)). The change of locomotor skills was not significant (p = 0.620).

Table 4. Changes of FMS score between preschool children in large, medium, and small teaching class size (n = 295).

Class Size	FMS Score			95% CI	p	AIC
	Pretest	Posttest	Change			
Locomotor skills						
Large	37.03 (5.73)	41.05 (5.68)	4.02 (5.41)	3.04, 5.00	0.620	1831.46
Medium	36.53 (5.81)	41.20 (5.53)	4.67 (7.28)	3.44, 5.90		
Small	37.67 (4.47)	41.67 (6.03)	4.00 (5.14)	2.45, 5.55		
Object control skills						
Large	31.25 (5.55)	35.25 (5.05)	4.00 (5.79)	2.96, 5.04	0.000 *	1774.82

Table 4. *Cont.*

Class Size	FMS Score			95% CI	*p*	AIC
	Pretest	Posttest	Change			
Medium	31.41 (4.83)	34.33 (5.21)	2.92 (6.26)	1.80, 3.98		
Small	29.83 (5.66)	37.95 (4.80)	8.12 (6.34)	8.12, 10.00		

Note: CI = confidence interval; AIC = Akaike's information criterion; * significance at 0.05; Class size: large = more than 20 students; medium = 16–19 students; small = less than 16 students; Standard deviations appear in parentheses after the mean values.

4. Discussion

This study compared the changes in FMS score (i.e., The TGMD-2 score in the subtest object control skills and locomotor skills) among children in preschools with different schooling conditions. The findings supported that teaching venue size and class size are environmental factors that possibly influence the children's learning of FMS, specifically on their object control skills.

4.1. Changes in FMS Score between Preschool Children in Large and Small Teaching Venue

A major finding in the present study was that the intervention effect of the FMS program differed between classes with different teaching venue sizes. However, this difference was only observed in object control skills, and not in locomotor skills. Children who learned object control skills in a small teaching venue exhibited a greater improvement in FMS than those who learned in a large teaching venue (mean score change: 5.54 vs. 2.46). This finding was in accord with the results of a previous study reporting that children from a preschool with a smaller play area exhibited better object control skills [13]. The present study extended previous findings from a cross-sectional study design to an experimental design, confirming that large play areas do not necessitate the development of object control skills. Although another previous study reported a positive association between large playground size and higher total gross motor scores in preschoolers [14] and some researchers have advocated for the importance of space availability on FMS development [26], children in the present study were found to be able to learn object control skills more effectively in a small teaching venue.

One possible explanation for this finding is related to the content of the FMS program. The design of the FMS program considered the task constraint of the acquisition of FMS. For example, in the exercise routines involving object control skills, such as rowing, throwing, and catching, children were required to perform individual actions on the spot, with minimal space requirements. Given the task constraints (performing object control skills on the spot) set up by the exercise routine, the learning environment (small venue) encouraged the children to focus on the required tasks (throwing and catching the towel), which may better facilitate the development of object control skills. Object control skills involve complex interactions between biological constraints and the environment [27]. Children's learning of object control skills is constrained by environmental factors, such as variation in the abilities of children's classmates, the size of the available equipment, and individual factors, such as the size of children's hands.

For the absence of difference on the locomotor skills acquisition in different teaching venue size, the present finding differed from a previous study that linked children's better locomotor skills in preschools with a larger play area [13]. Despite variations in teaching venue size, children involved in the FMS program all received active opportunities and structured activities to practice the locomotor skills. These factors may be more important than physical environment for the development of locomotor skills. The current finding has practical implications regarding pedagogy for teaching FMS in preschools. It indicated that the physical environment with larger teaching venues may not necessarily be better for FMS learning. Instead, teachers may have control over some aspects of the environment to design tasks with interactions for successful movement experience [8]. An appropriately-sized teaching venue [28] and age-appropriate activities [29] can allow children to have more practice time, which may be essential for them to master skills.

4.2. Changes of FMS Score between Preschool Children in Different Teaching Class Sizes

Another finding in the current study was the difference in the intervention effect on FMS learning in groups with different class sizes. Children in classes with a smaller class size (fewer than 16 children) were found to exhibit a greater improvement in object control skills compared with children in medium-sized classes (16–19 children) or large classes (20 or more children) (mean score change: 8.12 vs. 2.9 vs. 4.0). This difference was not observed for locomotor skills learning. Previous studies have reported positive associations [30] or a lack of associations [31] between class size and children's PA levels in PE class. However, those studies focused on elementary schools, and the outcome variable was children's PA levels. One previous study reported that the preschool environment, including classroom size/child ratio and playground size, was a predictor of children's motor scores [14]; the study defined the classroom size/child ratio by dividing the area of each classroom by the number of children in the classroom. This definition coherently infers the available space for children to move in the classroom, which did not indicate an association between teachers' and children's behavior in the class.

To the best of our knowledge, the current study is the first to examine the effects of class size on FMS learning among preschool children. Previous educational studies reported the benefits of small class size, finding that children in small classes experienced greater classroom engagement [28] and improved behavior [32]. In addition, teachers were engaged with more time for positive training and closer relationships with students [32]. Despite differences in class size being expected to influence teaching strategies, empirical study to support this claim was limited [33]. Instead, students were found to be involved in more participation in small classes, shown by their readiness to respond to teachers' prompting [34]. The small-class effects hypothesis [35] proposed that students became more engaged academically and more engaged socially when class sizes are reduced, which benefit learning in all subject areas. In the current study, teachers conducted classes involving movement skills. The amount of time spent on a task and interaction with students would become more important. Smaller classes allow teachers to have more time to interact with each child, pay them more attention, and give feedback on their performance. This social environment generated in a small class size condition could possibly explain the better object control skills improvements found in smaller class sizes. However, the absence of differences in the locomotor skills acquisition in different class size may be possibly explained by the fact that the learning of locomotor skills required more active opportunities for practice [13].

The present study identified the environmental factors that influenced children's FMS, which may be useful for future intervention design. However, the current study involved several limitations that should be considered. The FMS program was conducted in regular PE lessons during school hours. Hence, all children in the selected classes were included without setting specific exclusion criteria. The learning ability of the children may have a potential influence on their pace in acquiring FMS. Nevertheless, as the programs were all conducted in mainstream schools, it may greatly minimize this potential influence. Given its focus on environmental constraints on FMS learning in a preschool setting, the present study did not measure individual factors, such as preschool children's socioeconomic status, PA level, or education-related factors, such as the teacher's knowledge of FMS. In addition, in view of the logistic constraints during school visits, the current study obtained children's body weight and height information from their schoolteachers. The measurement was made during regular class with normal school uniform and shoes on, which may have a slight distortion on rigor, despite all measurement being made in preschools following proper procedures to standardize the measurement of every child. The current study included children from the same class level, and factors such as BMI and age were not used for direct analysis; future studies should explore these factors, which may be related to preschool children's FMS learning. The current study collected data from a small sample in one country, future studies should include samples from a wider geographic area and be expanded to a multi-country analysis. Although the current experimental design compared changes in children's FMS in different schooling conditions, there were no comparisons with control group data.

Future studies should measure the effects of the program using post-intervention measurement of children's FMS.

5. Conclusions

For the learning of FMS among preschool children, smaller teaching venue size and smaller class sizes were better for the learning of object control skills. Future intervention design should consider the organization of classes to maximize training effects on children's FMS ability.

Author Contributions: Conceptualization, P.C. and L.Z.; methodology, P.C. and L.Z.; writing, P.C. and L.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Quality Education Fund, Hong Kong (Ref No. EDB/QEF/2016/0112). The APC was funded by the Department of Health and Physical Education, The Education University of Hong Kong.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. A sample lesson of the FMS program (Theme: Jumping).

Time	Activity
5 min	Warm up game: • Two in a group, hands together, when meet others, hands up and let others walk through
20 min	Routine practice: • perform 4 × 8 count movement (with and without music) • single-leg (right) jump to the front, walk backwards • single-leg (left) jump to the front, walk backwards • two-feet jump right, walk to left • two-feet jump left, walk to right FMS game (Froggy jump): • children line up and use single-leg and or two-feet to jump over the blocks (10 cm high, 50 cm apart)
5 min	Cool down: • Children lie down on the floor, use finger to draw a picture, such as house, people, rainbow

Figure A1. Example of FMS movement in the exercise routine (jumping).

Figure A2. Example of the FMS games (jumping). The game requires children to use single-leg or two-feet to jump over the blocks.

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