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Motor competence and characteristics within the preschool environment

Larissa True, PhD[a], **Karin Allor Pfeiffer, PhD**[b], **Marsha Dowda, DrPH**[c], **Harriet G. Williams, PhD**[c], **William H. Brown, PhD**[d], **Jennifer R. O'Neill, PhD, MPH**[c], and **Russell R. Pate, PhD**[c]

[a]Kinesiology Department, School of Professional Studies, State University of New York at Cortland, Cortland, New York (full address below)

[b]Department of Kinesiology, Michigan State University, 308 W. Circle Drive, East Lansing, Michigan, 13045, USA

[c]Department of Exercise Science, Arnold School of Public Health, University of South Carolina, 921 Assembly Street, Columbia, South Carolina, 29208, USA

[d]Department of Educational Studies, Wardlaw College of Education, University of South Carolina, Columbia, South Carolina

Abstract

Objectives—Environmental characteristics within preschools that influence children's motor competence are largely unknown. The purpose of the present study was to examine the contribution of various preschool environmental characteristics to children's locomotor, object control, and total gross motor scores.

Design—Cross-sectional, observational study of 3–5 year-old children (n = 229) from 22 preschools in South Carolina.

Methods—The Children's Activity and Movement in Preschool Study (CHAMPS) Motor Skills Protocol assessed MC. Preschool directors provided information regarding policies and practices. The research team measured playgrounds and classrooms, and the Early Childhood Environment Rating Scale-Revised assessed preschool quality. Time spent in open space and electronic media use were also assessed using direct observation. The aforementioned variables predicted children's object control, locomotor, and total gross motor scores.

Results—Classroom size/child ratio, teacher education, playground size, electronic media use, and trips to outside organizations emerged as significant predictors of locomotor score and total motor score. The object control model was non-significant.

Correspondence concerning this article should be addressed to Larissa True, Kinesiology Department, 47 Pashley Drive, 1173 Professional Studies Building, Cortland, NY, 13045; (607) 773-4562; Larissa.true@cortland.edu.

Conclusions—Preschools may be able to promote motor competence by allowing children more time in open spaces, structured activity experiences, and by expanding existing outdoor playground space whenever possible.

Keywords

motor development; motor competence; fundamental movement skills; children; childcare; preschool

Introduction

Approximately 6 million American children spend a significant portion of their day attending preschool [1]. Many preschool children (41%) spend as much time per week in care as the average American adult spends working a full time job, 35–40 hours per week [2, 3]. Because children spend a significant amount of time in out-of-home care [4], parents commonly share the responsibility of child-rearing practices with the preschool their children attend, thus relying on such centres to provide opportunities for development of skills and behaviours that children should acquire before entering elementary school.

The term “motor competence” (MC) is a globally-understood term that describes the level at which children can execute fundamental motor skills, which are basic gross movements used throughout the lifespan for activities of daily living and physically-demanding pursuits [5]. Motor competence is an important element of children’s social, cognitive, and physical development, and the preschool years are a critical time for developing fundamental motor skills [6]. Preschool children should be provided with a means to establish a foundation of basic fundamental motor skills that can be developed throughout early and middle childhood. The preschool years are a crucial time for improving MC because of a hypothesized “proficiency barrier,” which likely inhibits those with poor levels of MC from participating in lifelong physical activity (PA) [7, 8]. There is significant empirical information regarding the MC of pre-schoolers with coordination disorders and developmental delays. However, recent evidence linking typically-developing preschool children’s poor MC to low levels of PA[9] highlights the importance of monitoring typically-developing children, particularly within the preschool environment where activities intended to improve MC exist. Further, given that preschool years are a highly critical time for the development of healthy lifestyle behaviours [10], it is necessary to examine which environmental characteristics within the preschool setting promote MC.

Three of the five Active Start: Guidelines for Physical Activity in Preschool Children [11] concern fundamental motor skills (guidelines 3, 4, and 5), and the 2011 Institute of Medicine guidelines [12] offer suggestions for environmental improvements to promote PA in pre-schoolers, but little is known about characteristics within preschool environments that specifically promote MC. This study is exploratory and primarily follows a structural theoretical framework of preschool quality, implying that the physical environmental characteristics within the preschool may be important underlying contributors to MC. The purpose of the present study was to examine the contribution of various preschool

environmental characteristics to children's locomotor, object control, and total gross motor scores.

Methods

Participants were 3- to 5-year-old children (n = 229) in South Carolina who attended one of three types of preschools: Head Start (n = 4), faith-based (n = 7), or commercial (n = 11). A detailed description of school recruitment can be found in Dowda, Brown, McIver, Pfeiffer, O'Neill, Addy, Pate [13]. Each child's parent/guardian provided written informed consent, and the university's Institutional Review Board approved the study. Trained researchers collected data at preschools in two-week waves during different times throughout the year to address potential seasonality issues.

The Children's Activity and Movement in Preschool Study (CHAMPS) Motor Skills Protocol (CMSP) is a valid and reliable tool used to assess pre-schoolers' motor skill performance in field-based settings [14]. The CMSP is similar in nature to the Test of Gross Motor Development-2 [15], but was developed for explicit examination of behavioural characteristics of motor skills in children 3 to 5 years of age (as were the participants in our sample) in a field-based setting. The CMSP has very high concurrent validity with the TGMD-2 (r = .94). This protocol examines process characteristics of frequently-used motor skills: locomotor skills (run, jump, gallop, slide, leap, hop), and object control skills (throw, roll, kick, catch, strike, and dribble). Participants are scored on individual criterion of the skills rather than the performance outcome. Reliability estimates ranged from r = .88 – .97 across locomotor, object control, and total score [14]. Participants performed 2 trials of each skill, and process characteristics were determined as present or absent by two trained testers. Each skill has 3–5 performance criteria; a score of 1 was given if the child performed the criterion correctly and a score of zero was given if the criterion was not present. Criterion scores for the two trials were added together to represent a skill score for each of the 12 skills. Skill scores were summed to create 3 scores: locomotor, object control, and total motor score. These scores were used as separate outcome variables. Higher scores indicated greater proficiency of motor skill performance. A two-person motor skill research team underwent extensive training prior to data collection [14]. Intraclass correlation analyses indicated that inter-rater reliability was high (locomotor, R = 0.99; object control, R = 0.98; total, R = 0.94).

A member of the research team conducted a structured interview with directors from each preschool to identify policies and practices concerning PA and MC within the preschool setting. Directors also described specific characteristics of those settings (e.g., teacher education, field trips that encourage children to be physically active, visits from community organization that provide PA programs at the school, and minutes spent outside each day). Interviewers used a pre-determined set of questions that allowed for probing additional information, such as time of day or weekly frequency.

The Observational System for Recording Physical Activity in Children-Preschool Version (OSRAC-P) determined electronic media use within the preschools and amount of play occurring in open space[16]. This is a valid [17] and reliable [16] system that records activity

codes for preschool children's PA behaviours. During the 2-week wave at each preschool, children were observed for a minimum of 5 non-consecutive hours (i.e., 600 30-second intervals per child) at random 30-minute intervals throughout the school day. Electronic media use was calculated as the percent of intervals children were observed using a television or computer while indoors. Open space usage was determined by the number of intervals children were observed playing outside in open space environments, such as a grassy space or open field (i.e., portion of the playground containing no fixed equipment).

The Early Childhood Environment Rating Scale-Revised Edition (ECERS-R) evaluated preschool quality on the basis of current recommendations for appropriate practices in early childhood education. A trained rater administered the ECERS-R [18] to one randomly selected classroom at each preschool. Total quality was based on 7 dimensions: space and furnishings, personal care routines, language-reasoning, activities, interaction, program structure, and provisions for parents and staff. A Likert scale rated 43 items from 1–7, with higher scores indicating better quality.

Researchers took measurements and equipment counts inside classrooms and in outdoor areas used by pre-schoolers. Classroom sizes were averaged across each preschool. Classroom size/child ratios were determined by dividing the area of each classroom by the number of children in the classroom. The research team measured all playgrounds in square metres and counted pieces of fixed playground equipment (e.g., monkey bars, slides). Portable equipment (e.g., balls, hula hoops) brought to the playground was counted.

Weight was measured to the nearest 0.1 kg (Seca, Model 770; Hamburg, Germany), and height was measured to the nearest 0.1 cm using a portable stadiometer (Shorr Productions; Olney, MD). These measurements were taken twice and the average was retained for analysis. BMI was calculated by dividing weight in kilograms by height in meters squared (kg/m^2).

Each child's parent or guardian completed a survey with questions about level of adults' education in the household and child's sex, race/ethnicity, and birthdate. Parent education estimated socioeconomic status and was entered as a fixed effect in the statistical models.

Descriptive statistics were calculated for all participants ($n = 229$). Three separate linear mixed models examined the effects of various preschool environmental characteristics on motor scores (locomotor, object control, and total motor). Estimation of parameters and significance testing were conducted with the MIXED procedure and the restricted maximum likelihood (REML) estimation method in SAS version 9.4. We chose the multiple regression procedure because of the fixed and random effects present within the model. Each statistical model included fixed effects of sex, parent education, and race/ethnicity. Preschool was entered in the models as a random effect. This nested approach is advantageous because it allows for "tracking" of children in preschools and reduces the risk of Type I error associated with making numerous comparisons in a traditional model such as ANOVA. Cohen's *d* was calculated to report effect sizes.

Results

Table 1 summarizes demographic information and raw scores from the CMSP. Of the 229 participants, 51.5% were male. The majority of the sample was African American (51.9%), while 38.4% were White or classified as “other” (9.6%). Boys and girls had the same average BMI (16.2 kg/m^2) and average age (4.2 years). Boys had higher total skill scores (86.4) than girls (82.7), and demonstrated significantly higher object control scores than girls, $t(227) = 3.60$, $p < 0.001$. Values for each of the measured preschool environmental characteristics/policies and the source of the measurement are presented by centre type and for the total sample in Table 2.

Table 3 shows results from linear mixed models. For each model (locomotor, object control, and total motor), all 11 preschool environment predictor variables were entered in the initial analysis. Per the recommendation of Seltman [19], predictor variables that did not have a significant fixed effect (e.g., $p < .05$) were removed one at a time and subsequent mixed effect analyses were conducted (i.e., backward elimination).

Total gross motor score and the preschool environment

Seven variables that were non-significant predictors were removed (time spent in outdoor open spaces, preschool quality, fixed and portable playground equipment, number of field trips per month, visits from community organizations, and minutes outside per day) and a subsequent model was run (Table 3). The adjusted model indicated that child age, $F(1, 159) = 31.99$, $p < 0.0001$, $d = 0.89$, classroom size/child ratio, $F(1, 159) = 5.34$, $p < 0.05$, $d = 0.36$, teacher education, $F(1, 159) = 6.63$, $p < 0.01$, $d = 0.41$, playground size, $F(1, 159) = 4.30$, $p < 0.05$, $d = 0.33$, and electronic media use, $F(1, 159) = 5.49$, $p < 0.05$, $d = 0.37$ were all significant positive predictors of total motor score.

Locomotor score and the preschool environment

Seven variables that were non-significant predictors were removed (time spent in outdoor open spaces, preschool quality, fixed and portable playground equipment, playground size, visits from community organizations, and minutes outside per day) and a subsequent model was run (Table 3). The adjusted model indicated that age, $F(1, 163) = 18.93$, $p < 0.0001$, $d = 0.68$, classroom size/child ratio, $F(1, 163) = 7.08$, $p < 0.01$, $d = 0.42$, teacher education, $F(1, 163) = 10.00$, $p < 0.001$, $d = 0.49$, field trips per month, $F(1, 159) = 5.51$, $p < 0.05$, $d = 0.37$, and electronic media use, $F(1, 159) = 5.49$, $p < 0.05$, $d = 0.44$ were all significant predictors of locomotor score.

Object control score and the preschool environment

In the initial model, none of the preschool characteristic variables were significant predictors of object control score. Variables that neared significance were entered in subsequent models while deleting other non-significant predictors, but no preschool characteristics emerged as significant predictors in any subsequent models. As such, these results were not included in Table 3.

Discussion

This study highlights the important role that preschool environments play with respect to movement opportunities for children. A few structural and psychosocial properties of preschools were salient indicators of MC: classroom size/child ratio, teacher education, playground size, electronic media use, and trips to outside organizations. Our study is unique because it takes a holistic approach to examining differences in MC across differing preschool environments. As children are spending a large portion of the day in out-of-home care [4], careful attention to the relationship between MC and preschool environmental characteristics is warranted.

Teacher education seems to play a salient role in promoting higher levels of MC, at least with respect to locomotor score and total motor score. Children attending preschools where >50% of teachers had a college degree had significantly better locomotor and total gross motor scores than their peers at preschools with a lower percentage of college-educated teachers. Other factors, namely teacher quality, likely compounds this finding. A recent meta-analysis revealed that preschool teachers with a Bachelor's degree generally provided better quality of experiences and exhibited optimal teacher behaviour towards pre-schoolers than teachers who were less-formally educated [20], and our results suggest that these findings may extend to educated teachers promoting MC. While it is unclear why there was no significance with object control scores, we propose that teachers with a formal education may have gained knowledge about optimal preschool environments and mediums for child movement opportunity through their 4-year college degree. More research is necessary to determine how college-educated preschool teachers contribute to the preschool environment.

Another important predictive characteristic was classroom size/child ratio. Children attending preschools with more favourable classroom size/child ratios had higher locomotor and total gross motor scores than children who attended schools with less space in the classroom. One can infer that a smaller class ratio limits the amount of space a child has to move and explore the environment. Providing an adequate amount of space in the classroom for each child may contribute to MC through opportunities for free play, which has been associated with MC in preschool children [21]. Evidence suggests that when children spend time in open space (e.g., in a classroom with a favourable classroom size/child ratio), the likelihood for free play and gross motor activity increases[22, 23]. The importance of having adequate room to move about within the classroom may be particularly important for young children, who may not have opportunities to participate in structured physical education classes or organized sports. According to the best practices of Caring for Our Children, for 4- to 5-year-olds, a limit of 12 children per class is recommended and the maximum child:staff ratio is 8:1 [24]. The minimum amount of indoor space per child is 42 square feet, but 50 square feet is preferred [24]. The minimum amount of outdoor space is 75 square feet per child, [24] but these values are suggestions and not federal mandates. More research is necessary to determine whether most preschool adhere to these recommendations and what impact the recommendations have on MC.

More intervals of electronic media use were associated with higher locomotor and total gross motor scores. An observation of the data indicate that faith-based preschools had the

most electronic media use, but also the highest total gross motor scores. It is possible, but should be interpreted with caution as was not the aim of our statistical analyses, that children in centres with more access to electronic media also come from higher-income families, and thus income is a mediating factor between the electronic media-MC relationship. Another explanation is that the electronic media used in the preschools promotes movement (e.g., Nintendo Wii, Xbox One) and thus is a positive influence on MC. Unfortunately, we did not collect specific information regarding the type of electronic media use in the preschool. Future research could explore the potential of electronic media use as a tool for MC promotion in preschools.

Larger playground size was significantly associated with higher total gross motor score. These findings agree with those of Worobey, Worobey, Adler [25] who found that children attending centres with large playgrounds had higher motor activity than children attending centres with playgrounds half the size. Finn, Johannsen, Specker [26] hypothesized that differences in PA by centre type could be due to movement restrictions imposed by smaller play areas. It is intuitive to conclude that more space provides more opportunities for active play and skill acquisition.

Though it may seem counterintuitive that none of the preschool environmental characteristics significantly predicted object control score, these findings are in line with extant literature, which demonstrates that very young children have not fully acquired competence in many object control skills before the age of 5 [27–29]. In addition, children may not be provided with opportunities to practice object control skills, such as throw, catch, kick, strike, roll, and dribble, in preschool settings. As such, there are few predictors of object control skills in preschool children. Regardless, object control skills have shown cross-sectional as well as longitudinal predictive significance towards persistence in lifelong PA [30] and physical fitness [8, 31], and should not be ignored in preschool age children.

The purpose of our study was to examine specific characteristics of the preschool environment and pre-schoolers' MC. We found that children who attended preschools with larger playgrounds, more educated teaching staff, more favourable classroom size/child ratios, more electronic media use and more trips to outside organizations demonstrated better MC compared to children at other preschools. Preschools may be able to promote MC by allowing children more time in open outdoor spaces and by expanding existing outdoor playground space whenever possible.

Conclusion

Our study had several strengths, including sample size and diversity, use of direct observation, and the CMSP protocol. Limitations include an inability to suggest causality, as this was a cross-sectional study with limited generalizability because data were collected in only one state. Additionally, it is important to note that not all preschool characteristics will reflect the findings of this study, as individual variation, in terms of the preschools themselves, is inevitable. In particular, the characteristic of preschool quality—as measured by the ECERS-R—is limited as only one classroom at each preschool was assessed using this tool, which is sensitive to teacher and environment conditions.

Research in this area could benefit from longitudinal studies that collectively examine MC, characteristics within the preschool environment, and other health-related behaviours known to manifest during the preschool years, as specific preschool environment characteristics may impact other important child behaviours. Interventions aimed at promoting MC in preschools should consider these findings with particular respect to classroom size/child ratio and playground size. The specific impact that the type of open space, in terms of topography or type of indoor environment, is worthy of further exploration.

Though our study focused on the typical preschool day, our findings should not be interpreted to mean that preschool children do not require and benefit from formal motor skill training. Our data suggest that in addition to formal motor skill training during the preschool years, opportunities to spend time in open spaces are valuable for children to practice skills they have learned. Because large-scale physical changes to playgrounds may be costly and unrealistic, children who attend preschools with smaller playgrounds may benefit from time spent outside in their current space and by being encouraged to participate in unstructured free play, a change which would be low-cost and easy to implement [32]. Rearrangement of indoor classroom spaces could allow for more open space (e.g., more favourable classroom size/child ratios) and provide similar movement benefits during cold months. Additionally, given the importance of teacher education on MC, it may be beneficial to provide specific motor development training for early childhood teachers. Finally, preschool educators should be well-informed of the relationships among MC, PA and children's health, and the impact that preschool environmental characteristics can have on MC.

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Practical implications

Preschool characteristics that contribute to motor competence are identified Larger playgrounds, class ratio, and teacher education contributed to skill score Suggestions for promoting motor competence in preschools are outlined

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Table 1

Demographic Information and CMSP Scores

	Male mean(SD)	Female mean(SD)	Commercial mean(SD)	Faith-Based mean(SD)	Head Start mean(SD)	Total mean(SD)
n	118	111	106	70	53	229
BMI (kg/m^2)	16.2(1.7)	16.2(1.8)	16.2(1.6)	16.1(1.6)	16.3(2.0)	16.2(1.8)
Age (y)	4.2(0.7)	4.2(0.6)	4.1(0.7)	4.2(0.6)	4.1(0.5)	4.2(0.7)
Parent education[a]	50.9%	58.6%	65.1%	64.3%	20.8%	62.5%
Locomotor score	38.5(12.0)	40.0(11.5)	36.7(11.5)	42.3(11.2)	40.1(12.1)	39.3(11.8)
Object control score[b]	48.0(11.7)	42.7(10.5)	43.2(10.6)	49.1(11.5)	45.0(11.8)	45.4(11.1)
Total gross motor skill score[c]	86.4(21.0)	82.7(20.0)	79.9(19.4)	91.5(19.5)	85.1(21.7)	84.6(20.5)

[a]Percent completed technical school or college; commercial and faith-based > Head Start, $p < .001$

[b]Males > females, $p < .001$; faith-based > commercial ($p < .001$) and Head Start ($p < .05$)

[c]Faith-based > commercial, $p < .005$

CMSP – CHAMPS motor skill protocol

Table 2

Characteristics and Policies of Preschools by Centre Type and Total Sample

Characteristic	Source	Commercial (*n* = 106)	Faith-Based (*n* = 70)	Head Start (*n* = 53)	Total Sample (*n* = 229)
Time spent in outdoor open space (intervals)	OSRAC-P	4.01 (1.91)	4.40 (3.66)	5.26 (2.05)	4.42 (2.63)
Classroom size/child ratio (m^2/child)	Measured	0.13 (0.06)	0.15 (0.07)	0.17 (0.02)	0.14 (0.06)
Teacher education (percent of teachers with college degree)	Director interview	32.08 (22.91)	39.83 (21.10)	18.62 (11.12)	31.26 (21.40)
Quality of preschool	ECERS-R	5.03 (0.57)	5.01 (0.49)	4.89 (0.49)	5.00 (0.53)
Fixed playground equipment (number of pieces)	Observation	8.75 (4.27)	8.61 (2.99)	4.85 (1.29)	7.81 (3.76)
Portable playground equipment (number of pieces)	Observation	1.50 (1.53)	2.02 (2.59)	1.66 (1.07)	1.70 (1.85)
Playground size (m^2)	Measured and averaged over all playgrounds	541.34 (286.93)	1236.55 (1023.26)	1236.68 (375.62)	875.34 (718.46)
Field trips/month	Director interview	1.22 (1.42)	1.16 (1.23)	1.06 (0.59)	1.17 (1.21)
Community organization visits/month	Director interview	2.49 (1.95)	4.00 (0.00)	0.00 (0.00)	2.38 (1.97)
Minutes outside/day	Director interview	78.02 (16.38)	53.14 (30.40)	30.00 (0.00)	59.30 (27.88)
Electronic media use (intervals)	OSRAC-P	3.48 (3.62)	4.46 (4.07)	3.42 (3.28)	3.77 (3.70)

Note: Data by centre type and for total sample are at the child level

“Intervals” – number of observed intervals of the noted behaviour during an observation session

ECERS-R – Early Childhood Environment Rating Scale-Revised

OSRAC-P – Observation System for Recording Physical Activity in Children –Preschool version

Table 3

Results of Adjusted Linear Mixed Models for Total Motor and Locomotor Scores

Total Motor Score					
Parameter	**Estimate**	**SE**	***F***	***p***	***d***
Intercept	0.74	13.18	--	--	
Sex	5.05	2.80	3.24	0.07	
SES	1.52	3.01	0.26	0.61	
Race/ethnicity	4.45	5.05	0.45	0.38	
Age	12.14	2.14	31.99	0.00**	0.89
Classroom size/child ratio	7.14	3.09	5.34	0.02*	0.36
Teacher education	0.22	0.08	6.63	0.01**	0.41
Playground size	0.00	0.00	4.30	0.03*	0.33
Electronic media use	1.44	0.61	5.49	0.02*	0.37
Locomotor Score					
Parameter	Estimate	SE	*F*	*p*	*d*
Intercept	3.60	7.26	--	--	
Sex	−1.24	1.59	0.61	0.44	
SES	−0.06	1.71	0.00	0.97	
Race/ethnicity	3.69	2.91	0.88	0.20	
Age	5.44	1.25	18.93	0.00**	0.68
Classroom size/child ratio	4.29	1.61	7.08	0.00**	0.42
Teacher education	0.14	0.04	10.00	0.00**	0.49
Field trips/month	−1.83	0.78	5.51	0.02*	0.37
Electronic media use	0.85	0.31	7.67	0.00**	0.44

*$p < 0.05$

**$p < 0.01$