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Physical activity level correlates with obesity-related factors, but not with fundamental movement skills in preschool children: a cross-sectional study

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This study aimed to examine the differences in physical activity (PA) level, fundamental movement skill (FMS), and obesity-related factors in preschoolers. A cross-sectional study was conducted in 426 preschool children aged 3–5 years. Participants were assigned to the low PA group (LPAG), moderate PA group (MPAG), and high PA group (HPAG) according to the total score obtained in the PA questionnaire for young children. FMS and obesity-related factors were also analyzed. PA was compared by age and sex, and FMS and obesity-related factors were compared between groups. Significant differences were found according to sex. Boys were more active than girls in the 3–4 years age group, but no significant differences were observed at the age of 5 years. LPAG showed lower FMS than MPAG and HPAG, although this was not statistically significant. However, body mass index (BMI), BMI *z*-score, body fat, and muscle mass showed significant differences in terms of PA levels. Consideration of age and sex is crucial in promoting PA among preschoolers. Additionally, better obesity-related factors are associated with higher PA levels, and FMS may be a useful tool in evaluating health and fitness.

Keywords: Physical activity, Fundamental movement skill, Body mass index, Child, Preschool

INTRODUCTION

Participation in physical activity (PA) during childhood can improve physical, social, cognitive, and psychological development (Janssen and LeBlanc, 2010). An increased level of PA could also enhance cardiorespiratory fitness, muscle strength (Morrow et al., 2013), bone growth (Janssen and LeBlanc, 2010), and motor skill development (Tandon et al., 2016). Furthermore, PA is an essential component of the strategies to prevent obesity because behaviors such as sitting time and screen time have been linked to childhood obesity (Jebeile et al., 2022). Like other most of countries the prevalence of obesity in Chinse children was also increased from 0.1% in 1985 to 6.4% (Dong et al., 2019). Since obesity is a significant concern due to its impact on children's health, leading to diseases such as diabetes, cardiovascular diseases, and nonalcoholic fatty liver diseases, monitoring the status of obesity in children is crucial (Hong et al., 2023). Additionally, PA plays a key role in body composition and metabolism (Nowicka and Flodmark, 2007), making physical inactivity a critical health issue for preschool children.

While it was recognized in 2011 that preschoolers should be physically active for at 3 hr/day or the equivalent of 15 min/hr for 12 hr (McGuire, 2012), the level of PA in preschool children has been reported to be extremely low (Pate et al., 2013; Russel et al., 2015). In China, for example, the PA level of preschoolers tends to be low, with only 33.2% of children satisfying the PA criteria (Xu and Gao, 2018), and only 52.5% engaging in at least 1 hr of PA at school (Song et al., 2019). Inadequate PA in preschool chil-

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dren is problematic as it leads to an increased rate of obesity (Frey et al., 2006; Trost et al., 2001) and potential increases in both physical and mental health risks (Pulgarón, 2013; Sanders et al., 2015). Thus, PA must be taken seriously during childhood, since obesity in childhood increases its probability in adulthood (Simmonds et al., 2015).

Fundamental movement skills (FMS) are abilities that play a significant role in the health and development of infants and children (Wrotniak et al., 2006). FMS is most commonly defined as an organized series of basic movement patterns that use two or more body limbs (Logan et al., 2017). Locomotion, object control, and stability motor skills are measured to assess FMS (Lubans et al., 2010). A child with excellent FMS can independently control and navigate his or her environment (Clark, 2007). Additionally, FMS proficiency is positively associated with PA, fitness levels (Morgan et al., 2013), and motor competence, helping predict PA and subsequent obesity from childhood to adulthood (Stodden et al., 2008). Moreover, sufficient FMS in early childhood may result in high PA levels in adolescence (Lopes et al., 2011; Robinson et al., 2015). Meanwhile, inadequate motor skills in childhood cause delayed development in gross motor ability (Goodway and Branta, 2003). Together, these findings emphasize the importance of developing movement skills as part of early childhood education.

FMS competence in childhood can be associated with PA, and given the association between PA and obesity, FMS may also be correlated with obesity. The level of FMS is higher in children with a high level of PA (Cohen et al., 2014; Larouche et al., 2014; Westendorp et al., 2011), while childhood obesity is negatively associated with lower FMS level (Han et al., 2018; Liang et al., 2014). These findings from previous studies indicate that FMS assessment in childhood could help inform healthcare guidelines. However, the unclear association between FMS and PA in preschoolers requires further investigation (McKenzie et al., 2002; Slotte et al., 2015).

Therefore, this study aimed to comprehensively analyze the relation between different PA levels, obesity-related factors, and FMS in children aged 3–5 years in China. The results of this study provide theoretical and scientific references for lifestyle behavior education and recommendations for children.

MATERIALS AND METHODS

Participants

The participants in this study were recruited from three preschools in the Chinhwangtao region in China. The eligibility criteria were as follows: age range 3–5 years; determined by the teacher as physically, emotionally, and psychologically healthy; and those children whose parents voluntarily consented to participation. For all participants, the tests and surveys were conducted only after receiving signed written consent from a parent or legal guardian. This study was approved by the Research Ethics Committee of Sangmyung University (No. ex-2022-009).

Experimental procedures

For this study, the measurement methods and questionnaire were selected through a review of the literature. Research assistants who would participate in data collection and measurements received training for the tasks by one of the authors of this study. Subsequently, the researcher led a preliminary investigation using the PA questionnaire for young children (PAQ-YC) and measuring FMS in 25 preschoolers to assess and resolve potential problems in preparation for the survey and the tests. All survey and measurements after this preliminary test were conducted by an author and research assistants.

PA level

To assess the level of PA, the PAQ-YC (Amor-Barbosa et al., 2021), which is a method based on the recalling of a parent or preschool teacher regarding the child's PA, was used. PAQ-YC is an appropriate, valid, and reliable tool for young children's assessment (Amor-Barbosa et al., 2021). The questionnaire consists of 10 items, including eight questions on PA (at home, at school, and at places outside school) and two questions on sedentary time (at places outside school). Questions 1, 2, 3, 4, and 7 were scored based on the time spent for PA (min/day or min/wk). For questions 8, 9, and 10, the responses were rated on a scale of 0 to 2. The total score was calculated by adding the obtained scores, with higher total scores indicating higher PA levels. Based on the total PAQ-YC score, the participants were divided into three groups, each consisting of 142 participants: the low PA group (LPAG), moderate PA group (MPAG), and high PA group (HPAG).

Fundamental movement skills

To assess FMS, the Test of Gross Motor Development-III (TGMD-III) was used. TGMD-III is an acceptable method to be used in preschool children (Chen et al., 2022), and its reliability has been verified (Kim et al., 2014). The tested items and respective movements were categorized as follows: locomotor skill (run, gallop, hop, skip, horizontal jump, and slide) and object control skill (two-hand strike of a stationary ball, forehand strike of a self-bounced ball, one-hand stationary dribble, two-hand catch, kick a stationary ball, overhand throw, and underhand throw). Each movement was tested and scored as 0 if performed incorrectly and as 1 if performed correctly. All scores were added to estimate the total score, with higher scores indicating better FMS. The rater demonstrated how the test would be performed and allowed participants to practice 2–3 times prior to the test. Each movement was performed twice, and the higher score was selected as the final score.

Obesity-related factors

A stadiometer (SZG-180, Shanghai Zhengdahengqi Company, Shanghai, China) was used to measure the height, and a bioelectrical impedance analyzer (Inbody H20B, Biospace, Korea) was used to measure the body weight, body fat (%), muscle mass (kg), and visceral fat index. The body mass index (BMI) was calculated using the body weight and height measurements. The BMI *z*-score was obtained using the following equation:

Z = x-u / σ (x: BMI based on height and body weight; u: BMI of identical age and sex groups; σ: mean BMI and standard deviation of identical age and sex groups).

Waist circumference was measured using a tape measure passed along the upper part of the iliac crest and the lower midpoint of the ribs. Two measurements were taken, and the mean value was used in the analysis.

Statistical analysis

Differences in the PA level by age and sex were analyzed using the analysis of variance (ANOVA) with factorial design, while one-way ANOVA was used to compare the differences in FMS and obesity-related factors according to the PA level (LPAG, MPAG, and HPAG). For *post hoc* analysis of significant differences, the Scheffé test was used. Pearson correlation test was used to analyze the correlations across the PA level, FMS, and obesity-related factors. IBM SPSS statistics ver. 23.0 (IBM Co., Armonk, NY, USA) was used for statistical analysis. Statistical significance was set at $P = 0.05$.

RESULTS

In total, 550 children participated in the study. Of them, 70 participants who did not complete the tests and surveys and 54 participants with unclear survey responses were excluded. Ultimately, the data of 426 participants (205 boys and 221 girls) were analyzed. Each of the three groups—LPAG, MPAG, and HPAG—had 142 participants.

When analyzing differences in the PA level, the interaction between age and sex was found to be significant ($F = 3.440$, $P < 0.05$). Differences in the PA level were significant only in girls when the effect of age in relation to sex was analyzed ($F = 4.138$, $P < 0.05$). Meanwhile, the effect of sex in relation to age indicated significant differences in the PA level in 3- ($t = 2.679$, $P < 0.01$) and 4-year-olds ($t = 1.202$, $P < 0.05$) (Table 1).

Differences in FMS were compared according to the PA level, and MPAG and HPAG showed higher scores than LPAG, although no statistical significance was observed (Table 2).

The comparison of obesity-related factors according to the PA level indicated significant differences in terms of BMI ($F = 3.282$, $P < 0.05$), BMI *z*-score ($F = 3.280$, $P < 0.05$), body fat ($F = 4.822$, $P < 0.01$), and muscle mass ($F = 73.779$, $P < 0.01$). For higher PA levels, BMI, BMI *z*-score, and muscle mass (kg) tended to be higher (Table 3).

Across all measured variables, body weight ($r = 0.154$, $P < 0.01$), BMI ($r = 0.127$, $P < 0.01$), BMI *z*-score ($r = 0.126$, $P < 0.01$), and muscle mass ($r = 0.484$, $P < 0.001$) were found to be significantly correlated with PAQ-YC. Meanwhile, FMS showed significant correlations with BMI ($r = 0.107$, $P < 0.05$) and BMI *z*-score ($r = 0.111$, $P < 0.05$) (Table 4).

Table 1. Physical activity level differences by age and sex

Age (yr)	PAQ-YC total score		*t*	*P*-value	*F* (*P*-value)
	Boys (n = 205)	Girls (n = 221)			
3 (n = 67)	10.00 ± 2.96	8.95 ± 2.60[b)]	2.679	0.009**	Age 2.633 (0.073) Sex 4.937 (0.027*) Age × sex 3.440 (0.033*)
4 (n = 279)	9.76 ± 2.23	9.44 ± 2.29[a,b)]	1.202	0.230*	
5 (n = 80)	10.20 ± 2.48	10.42 ± 2.97[a)]	-0.357	0.722	
F	2.240	4.138			
P-value	0.108	0.017*			

Values are presented as mean ± standard deviation.
PAQ-YC, physical activity questionnaire for young children.
[a)]$P < 0.001$ compared with 3-year-olds. [b)]$P < 0.001$ compared with 5-year-olds. *$P < 0.05$, **$P < 0.01$ tested using analysis of variance with factorial design.

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Table 2. Differences in fundamental movement skills by physical activity levels

Variable	LPAG (n=142)	MPAG (n=142)	HPAG (n=142)	*F*	*P*-value
Locomotor movements	17.63±3.59	18.37±3.11	18.11±3.22	1.821	0.163
Object control movement	22.80±3.53	23.18±3.26	23.23±2.98	0.772	0.463
Total point	40.42±5.22	41.56±4.53	41.34±4.40	2.298	0.102

Values are presented as mean±standard deviation.
LPGA, low physical activity group; MPGA, moderate physical activity group; HPAG, high physical activity group.

Table 3. Differences in obesity-related factors by physical activity levels

Variable	LPAG (n=142)	MPAG (n=142)	HPAG (n=142)	*F*	*P*-value
BMI (kg/m^2)	14.71±2.33[a)]	15.24±2.81[b)]	15.50±2.79[b,c)]	3.282	0.039*
BMI *z*-score	-0.257±0.98[a)]	-0.03±1.17[b)]	0.07±1.17[b,c)]	3.280	0.039*
WC (cm)	53.69±4.49	54.92±5.05	54.86±5.05	2.899	0.056
Body fat (%)	20.05±3.27[a)]	21.22±3.69[a,b)]	20.26±3.18[c)]	4.822	0.008**
Visceral fat index	1.90±0.99	2.14±1.24	2.06±1.47	1.358	0.258
Muscle mass (kg)	6.72±1.07[a)]	7.17±1.31[b)]	8.36±1.11[c)]	73.779	0.000***

Values are presented as mean±standard deviation.
LPGA, low physical activity group; MPGA, moderate physical activity group; HPAG, high physical activity group; BMI, body mass index; WC, waist circumference.
[a)]$P<0.001$ compared with the MPAG, HPAG. [b)]$P<0.05$ compared with the LPAG, HPAG. [c)]$P<0.05$ compared with the LPAG, HPAG. *$P<0.05$, **$P<0.01$, *** $P<0.001$ tested using one-way analysis of variance.

Table 4. Correlations between factors

	PAQ-YC	FMS	Obesity-related factors						
	1	2	3	4	5	6	7	8	9
1	-	0.052 (0.284)	0.154 (0.001**)	0.127 (0.009**)	0.126 (0.009**)	0.088 (0.070)	0.484 (0.000***)	0.029 (0.557)	0.039 (0.420)
2	-	-	0.087 (0.074)	0.107 (0.027*)	0.111 (0.022*)	-0.022 (0.645)	0.008 (0.864)	0.007 (0.878)	-0.057 (0.244)
3	-	-	-	0.787 (0.000***)	0.794 (0.000***)	0.471 (0.000***)	0.417 (0.000***)	0.278 (0.000***)	0.436 (0.000***)
4	-	-	-	-	1 (0.000***)	0.377 (0.000***)	0.214 (0.000***)	0.242 (0.000***)	0.347 (0.000***)
5	-	-	-	-	-	0.373 (0.000***)	0.213 (0.000***)	0.242 (0.000***)	0.344 (0.000***)
6	-	-	-	-	-	-	0.367 (0.000***)	0.503 (0.000***)	0.671 (0.000***)
7	-	-	-	-	-	-	-	0.157 (0.001***)	0.265 (0.000***)
8	-	-	-	-	-	-	-	-	0.372 (0.000***)
9	-	-	-	-	-	-	-	-	-

1, PAQ-YC score; 2, FMS total scores; 3, weight; 4, body mass index; 5, body mass index z-scores; 6, waist circumference; 7, muscle mass; 8, body fat percentage; 9, visceral fat index; PAQ-YC, physical activity questionnaire for young children; FMS, fundamental movement skill.
*$P<0.05$, **$P<0.01$, ***$P<0.001$ tested using Pearson correlation.

DISCUSSION

This study examined differences in the PA level in preschoolers by age and sex and how FMS and obesity-related factors varied according to PA. The main finding of this study lies in the higher PA levels in 3- and 4-year-old boys, although sex differences were not significant among 5-year-olds. Furthermore, the FMS did not vary according to PA, while differences were found in terms of BMI, BMI *z*-score, body fat, and muscle mass.

Regarding the PA level, age was found to be significantly correlated with sex. Only in girls did the PA level significantly increase with age, whereas, in boys, the increase was inconsistent. Additionally, within the same age group (3–4 years old), the PA level was partially higher in boys, whereas in 5-year-olds, girls exhibited higher PA levels. These results contrasted with numerous previous studies reporting that boys are more active than girls. For instance, a previous study indicated that 3- to 5-year-old boys exhibit higher PA levels (Pate et al., 2015), and boys in grades 1–12 are more active (Trost et al., 2002). Meanwhile, a systematic review found that 2- to 6-year-old boys are more active (Tucker, 2008).

The discrepancy in the results could be attributed to differences in participant age, sample size, and statistical methods. The results of this study provide evidence for differences in PA by sex as children grow up, indicating the importance of encouraging preschool children to perform an adequate level of PA according to age and sex differences.

FMS are considered foundation skills that lead to the development of specialized movement sequences necessary for several organized and nonorganized physical activities in children (Morgan et al., 2013). Increased PA levels are associated with greater proficiency in FMS. Additionally, children proficient in motor skills are more likely to remain active in adolescence (Barnett et al., 2009). These findings highlight the importance of participation in physical activities. Although the current results did not show significant differences in FMS based on the PA level, scores for locomotor and object control movements were higher in MPAG and HPAG than in the LPAG. Thus, better FMS may result from partially improved PA levels. The lack of significant between-group differences according to the PA levels may be attributed to several causes. A first possible explanation is the narrow ranges of the assessment scales used in this study. In the assessment of FMS, a score of 0 was given to a movement performed incorrectly and a score of 1 to a movement performed correctly, which limited the discriminatory range. Second, the sample size was small for all three groups, and the discriminatory power was negligible across all groups in terms of the PA level. Nonetheless, a strong positive association between FMS competence and PA in children was reported (Cohen et al., 2014; Larouche et al., 2014; Westendorp et al., 2011). Third, some scholars have claimed that movement skills are determined not by a physiological reason but by factors such as opportunity, parental expectations, and importance within a particular culture. Consequently, based on the correlation between FMS and BMI in this study, there could be differences in FMS. Nevertheless, no differences in FMS were found, possibly due to the lack of analysis of environmental, social, and cultural influences. These factors can affect the lifestyle of preschoolers and the educational curricula at the daycare center or kindergarten, and the participants in this study may not be familiar with the movement patterns encompassed in FMS, leading to similarly low FMS scores due to a floor effect. Finally, participants in this study demonstrated lower FMS scores than children in other countries. The total score of FMS was 49.2 in preschool children in the United States and was 40–41 in the Chinese preschoolers in this study. Comparing the locomotor and object control skills, the scores were also lower in the participants in this study compared to children in Australia (Cohen et al., 2014). Hence, the discriminatory power of PA on the differences in FMS was low despite using three different groups classified according to the PA level, possibly due to the lower FMS scores in this study and the generally low level of FMS competence. To elucidate the association between PA and FMS, further studies in preschool children residing in other Asian countries and investigating other factors, such as cultural and educational environments (Arundell et al., 2013) and daycare center curricula (Ridgers et al., 2006), are warranted. Further studies using data on PA level obtained through objective measurements are also required.

Correlations between PA or FMS and all measured variables (Table 4) suggested that muscle mass could be a contributing factor in the significant correlation between PA and FMS. Higher BMI values resulted from the muscle mass than the fat mass in this study; thus, a higher FMS competence may be associated with muscular development through PA. Our finding supports that FMS requires high levels of muscular fitness (Stodden et al., 2009). In addition, the correlation between higher PA level and higher muscle mass, and the lack of correlation between PA and body fat percentage may be attributed to the normal body weight range of all participants. Previous studies showed that a relatively high body weight and BMI reduced gait abilities (Cimolin et al., 2015) and the efficiency of exercise techniques (Krombholz, 2012; Niederer et al., 2013). Meanwhile, obesity had a negative impact on the body geometry, and an increased weight at other segments of the body reduced the movement efficiency (Kim and Lee, 2016). Thus, this study and published reports indicate the importance of the management of muscle mass and body fat percentage to gain benefits associated with FMS competence.

This study has some limitations. First, in China, no PA or movement programs are available in the preschool system, unlike in Western countries. Thus, the preschool children in this study may be unfamiliar with the movements of FMS, which could have affected the results. Second, the differences in PA, movements, and activity times across the three preschools in this study were not reflected in the analysis.

Nevertheless, the strengths of this study included the involvement of preschoolers aged 3–5 years, in contrast to many previous studies conducted in children aged ≥6 years. In addition, FMS was assessed because the fitness of preschoolers could predict the fitness of subsequent ages, or there could be potential correlations with the fitness of subsequent age groups. Furthermore, the study findings provide basic data regarding the health education of preschool children.

In conclusion, sex differences in each age group should be con-

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sidered when providing instructions to increase PA levels in preschool children. Moreover, more favorable levels of obesity-related factors were found to be associated with higher PA levels. Finally, FMS can be used in the assessment of the health and physical fitness of preschoolers.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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