# Fundamental movement skills in relation to weekday and weekend physical activity in preschool children


## Abstract

**Objectives:** To examine associations between fundamental movement skills and weekday and weekend physical activity among preschool children living in deprived communities.

**Design:** Cross-sectional observation study.

**Methods:** Six locomotor skills and 6 object-control skills were video-assessed using The Children's Activity and Movement in Preschool Study Motor Skills Protocol. Physical activity was measured via hip-mounted accelerometry. A total of 99 children (53% boys) aged 3-5 years (*M* 4.6, SD 0.5) completed all assessments. Multilevel mixed regression models were used to examine associations between fundamental movement skills and physical activity. Models were adjusted for clustering, age, sex, standardised body mass index and accelerometer wear time.

**Results:** Boys were more active than girls and had higher object-control skill competency. Total skill score was positively associated with weekend moderate-to-vigorous physical activity (p=0.034) but not weekday physical activity categories (p>0.05). When subdomains of skills were examined, object-control skills was positively associated with light physical activity on weekdays (p=0.008) and with light (p=0.033), moderate-to-vigorous (p=0.028) and light- and moderate-to-vigorous (p=0.008) physical activity at weekends. Locomotor skill competency was positively associated with moderate-to-vigorous physical activity on weekdays (p=0.016) and light physical activity during the weekend (p=0.035).

**Conclusions:** The findings suggest that developing competence in both locomotor and object-control skills may be an important element in promoting an active lifestyle in young children during weekdays and at weekends.



**Keywords:** Physical activity; Motor skills; Movement; Cross-sectional studies

## 1. Introduction

In England, over a fifth of children aged 4 to 5 years are overweight or obese[1]. Recent guidelines from the United Kingdom (UK) recommend that preschool children (3-5 years) should participate in at least 180 minutes of physical activity (PA) of any intensity (i.e. light, moderate, vigorous) each day for maintenance of a healthy weight, as well as improved bone and cardiovascular health.[2] The early years are a critical period to promote and establish positive health behaviours, with levels of PA tracking from early to middle childhood.[3] Understanding factors that may influence the PA behaviours of young children is essential for the development of effective interventions.[4]

Distinct patterns of PA have been observed in young children on weekdays and weekends.[5] Participation in PA at weekends is less variable, while the structured nature of weekdays - with young children waking up and going to bed earlier, attending preschool, and parent work commitments - impacts on engagement in PA.[5,6,7] Preschool children participate in more PA during weekends than weekdays,[6] yet both times have been suggested as important contexts for promoting PA in preschool children.[4] The identification of factors that are associated with PA during these periods could therefore help to develop efficacious interventions.

The early years provide a window of opportunity for children to develop fundamental movement skills (FMS), including stability (e.g. balance), locomotor (e.g. hop, jump) and object-control (e.g. catch, throw) skills.[8] These skills are considered the building blocks for more complex and specialised movements.[8] A reciprocal and dynamic relationship, strengthening from early childhood to adolescence, has been proposed between motor skill competence and PA.[9,10] According to Stodden et al.[9] children with higher levels of FMS will seek to participate in PA and sports, whilst failure to master such skills will result in self-selected withdrawal from participation. A recent systematic review examined the health

benefits associated with FMS competence and found strong evidence for a positive association between FMS competence and PA in children and adolescents, though studies using an objective measure of PA were notably lacking.[11]

In preschool children, positive but weak associations have typically been found between FMS competence and PA assessed using accelerometers,[12-16] perhaps supporting that this is an emerging, developmental relationship.[9] These studies have predominantly focused on moderate-to-vigorous PA (MVPA) averaged over the course of a week (i.e. habitual PA). To the authors' knowledge, no studies have explored the influence of FMS competence in relation to weekday and weekend PA in preschool children. Further, whilst the new UK PA guidelines for preschool children do not specify an activity intensity,[2] only one study using a small sample has considered FMS competence in relation to light PA (LPA) and light- and moderate-to-vigorous PA (LMVPA).[16] Preschool children living in areas of low socioeconomic status may be at greater risk of physical inactivity and other health inequalities.[17,18] Whilst a recent study has examined associations between FMS competence and PA among 8-9 year old children living in low-income communities,[18] little is known regarding preschool children from deprived areas. Therefore, this study aimed to examine associations between FMS competence and objectively measured PA during weekdays and weekend days among children living in deprived communities.

## 2. Methods

Baseline data from the Active Play Project was used for the current study. The project has been described in detail elsewhere.[19] In summary, the project consisted of a 6-week educational programme involving staff and children from preschools within disadvantaged communities and targeting children's PA levels, FMS, fitness, and self-confidence. Baseline data collection was conducted in two phases during October 2009 and March 2010. Ethical

approval for the study was obtained from the Liverpool John Moores University Research Ethics Committee (Reference 09/SPS/027).

Twelve preschools located in a large urban city in Northwest England and situated within neighbourhoods within the highest 10% for national deprivation[20] were randomly selected and invited to participate in the study. All preschools provided written informed consent. Details on preschool recruitment and eligibility has been reported elsewhere.[19] All children aged 3-5 at the study preschools were invited to participate and required to return informed written parental consent, demographic information (home postcode, child's ethnicity and date of birth, and mother's highest level of education) and medical assessment forms. From the 673 eligible children, parental consent was obtained for 240 children (35% response rate). No children had known medical conditions that could affect motor proficiency or participation in physical activity.

PA levels were measured every 5-seconds for 7 consecutive days using hip-mounted uni-axial accelerometers (GT1M ActiGraph, Pensacola, FL). Children were asked to wear the accelerometers during all waking hours except for water-based activities. Accelerometer data was reduced and analysed using ActiLife (Version 6). Valid wear time was defined as a minimum of three days, including a weekend day, with at least 9 hours of data recorded between 6am and 9pm (waking hours). Non-wear time was defined as twenty minutes of consecutive zeros. PA was classified into minutes per day spent in sedentary (≤100 counts), light (101-1679 counts), moderate (1680-3367 counts) and vigorous (≥3368 counts) intensities on weekdays and weekend days. These cut-points have recently been recommended for use in preschoolers.[21] PA data was further categorised into average minutes of LMVPA and MVPA during for subsequent analysis. Habitual (weekly) PA [(average weekday value x 0.71) + (average weekend value x 0.29)] was also calculated for descriptive purposes.

FMS measurement was administered by trained research assistants using The Test of Gross Motor Development-2 (TGMD-2) protocol.[22] The TGMD-2 is specifically designed for children aged 3-10 years and assesses six locomotor (run, broad jump, leap, hop, gallop and slide) and six object-control (overarm throw, stationary strike, kick, catch, underhand roll and stationary dribble) skills. Children completed the TGMD-2 in small groups (2-4) in either school halls or on school playgrounds, dependent on available facilities. One research assistant provided a verbal description and single demonstration of the required skill, while a second took recordings of all participants using a video camera placed on a tripod. Each child performed each skill twice and skills were completed in a standardised order, taking approximately 35-40 minutes per group. Video recordings of the skills were assessed using The Children's Activity and Movement in Preschool Study Motor Skills Protocol (CMSP), which has established validity and reliability.[23] The CMSP is a process-orientated assessment that evaluates each skill based on the demonstration of specific movement components.[23] Whilst the CMSP uses an identical protocol to the TGMD-2,[22] it provides additional performance criteria and alternative scoring methods which offer improved assessment sensitivity.[23] During the two trials for each skill, components were marked as being absent (scored 0) or present (1), with the exception of three skills. For the throw and strike hip/trunk rotation was scored as differentiated (2), block (1) or no rotation (0), whilst the catch identified a successful attempt as being caught cleanly with hands/fingers (2) or trapped against body/chest (1). The total number of skill components checked as present over two trials was summed to give a composite FMS score, whilst locomotor and object-control subtest scores were also created by summing the scores of skills within each subscale. All analyses were completed by a single trained assessor. Inter-rater reliability was established prior to assessment using pre-coded videotapes of 10 children, with 83.9% agreement across the twelve FMS (range 72.9-89.3%).

Body mass (to the nearest 0.1 kg) and stature (to the nearest 0.1 cm) were measured by trained researchers using digital scales and a portable stadiometer, respectively. Body mass

index (BMI: kg/m$^2$) was calculated and converted to BMI-z scores using the 'LMS' method for analysis.[24]

Data were analysed using IBM SPSS Statistics Version 21 (IBM Corporation, New York) with statistical significance set at $p<0.05$. Prior to analysis, data was explored and checked for normality. Descriptive statistics were calculated by group and sex and reported as means (± SD). Sex differences in age, BMI, BMI-z score, PA and FMS summary variables were examined using independent t-tests. Multilevel mixed linear regression models were used to assess associations between FMS and PA on weekdays and at weekends, with LPA, MVPA, or LMVPA entered as the outcome variables, FMS (i.e. total, locomotor or object-control skill score) as the predictor variable(s), and preschool centre as a random factor. Interactions between respective predictors and sex were explored if these variables were both significantly associated with the outcome variable. All models were adjusted for age, sex, BMI-z and minutes of accelerometer wear time.

## 3. Results

A total of 99 (41%) children aged 3-5 years (*M* 4.6, SD 0.5; 55% boys) completed all assessments and were therefore included in the final analysis. There was no significant differences in age, ethnicity, deprivation, and BMI-z score between those included in the analysis and those excluded due to either not meeting the PA inclusion criteria (n=103; 43%) or missing/incomplete FMS data (n=72; 30%). Descriptive statistics and sex differences for the study sample are presented in Table 1. Nine out of ten participating children lived in an area ranked within the top 30% for deprivation in England, with 76% of these children ranked within the highest decile for deprivation.[20] Most children were of White British descent (81%), with the remaining participants of another White descent (5%), Mixed Race (3%), Asian (3%), Black African (5%) or other (1%). Almost a quarter of children were overweight (17%) or

obese (7%). On average, children engaged in LMVPA for a total of 266.6±65.2 (36.7%) minutes each day, including 180.2±40.8 (24.8%) minutes of LPA and 86.4±28. (11.9%) minutes of MVPA; 86% of children met the recommended PA guidelines.[2] Children participated in more vigorous PA at weekends than on weekdays. No other differences were found between weekday and weekend PA. Compared to girls, boys engaged in more MVPA and LMVPA on weekdays, and more MVPA at weekends. Boys had significantly higher object-control skill scores than girls, though there was a trend for girls to have better locomotor skills. No other sex differences were found.

Table 2 shows the associations between FMS and weekday PA. Total skill score was not associated with LPA (p=0.238), MVPA (p=0.059) or LMVPA (p=0.057). Object-control skills was positively associated with LPA (p=0.008) but not with either MVPA (p=0.966) or LMVPA (p=0.111). Locomotor skills was positively associated with MVPA (p=0.016) but not with LPA (p=0.165), nor LMVPA (p=0.518).

Table 3 shows the associations between FMS and weekend PA. Total skill score was positively associated with MVPA (p=0.034) but not LPA (p=0.884) or LMVPA (p=0.198). Object-control skills was positively associated with LPA (p=0.033), MVPA (p=0.028) and LMVPA (p=0.008), whilst locomotor skills was positively associated with LPA (p=0.035) but not MVPA (p=0.926) or LMVPA (p=0.211). For model 5, the interaction between sex and object-control skills was not significant (p>0.05).

## 4. Discussion

This unique study explored associations between FMS competence and weekday and weekend PA in preschool children living in deprived communities. Children with higher levels of FMS, as expressed by a total skills composite score, engaged in more MVPA during

weekends. When subdomains of FMS were examined, differential associations were observed for weekday and weekend time periods. Specifically, locomotor skill competency was positively associated with MVPA on weekdays, and LPA at weekends. Object-control skill competency was positively associated with LPA on weekdays and with LPA, MVPA and LMVPA at weekends. Boys had better object-control skills than girls, and spent more time in MVPA and LMVPA on weekdays, and MVPA at weekends.

Weekdays are deemed typically less flexible than weekends as young children follow a structured routine of daily activities and spend most of their waking hours at preschool, whilst parents work commitments may restrict the time that they can spend with their child.[5-7] As children in preschools with PA promoting practices and policies generally participate in more PA,[4,25] the preschool centre has been identified as an important setting for early years PA promotion.[4] The current study found that locomotor skill competency was positively associated with MVPA on weekdays, suggesting that children with higher competence at locomotor skills participated in more MVPA. Alternatively, participation in PA may improve acquisition of FMS, for example through increased neuromotor development.[9,12] This finding may be indicative of the nature of weekday PA for young children, with the majority of MVPA likely accrued at preschool through unstructured, informal play-like activities such as dancing, running and chasing, which require a high level of locomotor rather than object-control skill competence. In support of this notion, a recent study[26] observed that preschool children in the highest locomotor tertile engaged in a higher percentage of intervals of dancing than children in the lowest locomotor tertile, with a trend for similar differences found for jumping/skipping activity types. However, no differences were observed between tertiles in intervals of walking or running activities.[26] In the current study, object-control skill competency was positively associated with LPA on weekdays, suggesting that preschool children with better object-control skills may engage in more LPA. Again, it is also possible that participation in LPA on weekdays may improve object-control skills. These findings open up the possibility that different types of FMS may be required for the promotion of activity of

different intensities or vice versa, though longitudinal and experimental research is needed. In addition, whilst the current study examined associations between FMS and PA across the entire weekday, future research could explore relationships during key weekday time periods for PA, such as recess, lunchtime and afterschool periods. Research conducted in primary school children suggests that both locomotor and object-control skills contribute to MVPA during these discrete time periods.[18]

At weekends, preschool children spend the majority of their time in or around the home environment, where parents have additional flexibility and more consistent engagement with their children.[5-7] Despite differences in preschool children's weekday and weekend environments, and in contrast to previous research,[6] no differences were found between weekday and weekend PA. However, differential associations were found in relation to FMS and PA. Contrary to weekdays, FMS competency was associated with weekend MVPA, moreover, object-control skill competency was associated with all activity intensities. This finding suggests that preschool children who have more competent object-control skills, participate in more PA at weekends. On the other hand, greater participation in weekend PA may improve object-control skill competency. This may be indicative of preschool children participating in more structured and organised sport activities at weekends, which have a larger object-control skill component. In addition, locomotor skill competency was found to be related to LPA at weekends, suggesting that children with better locomotor skills may participate in more light intensity PA or that, though perhaps unlikely, low intensity PA can potentially foster improvements in locomotor skills. Again, this suggests that associations between FMS and PA move beyond MVPA and therefore it is important to consider different intensities as well as different time periods. Weekends provide an opportunity for preschool children to spend more time with their parents, who can directly (e.g. provision of equipment, access to outdoors) and indirectly (e.g. role modelling, encouragement) influence their young child's PA behaviours.[25,27] Parents have a reasonably accurate perception of their preschool child's motor skill abilities,[26] thus it is possible that parents of preschool children with higher

skill competency may provide more support for PA (e.g. encouragement, access to facilities, spaces and equipment) than parents of preschool children with lower levels of skill competency, who may offer more sedentary alternatives. Interventions aiming to increase young children's PA during weekends could be achieved by encouraging parents to be active as a family through a variety of means including natural environments, provision of equipment and active play/games with their children to develop their ball skills. In addition, parents could be encouraged to enrol their child into organised activities to give children more opportunities to practice and nurture FMS.

The current study found that boys were more active than girls, and had higher object-control skills, which is consistent with existing literature.[5-7,28-30] The observed positive associations between total skill score and weekend MVPA, and object-control skill subdomain with weekday LPA and weekend LPA, MVPA and LMVPA is also broadly consistent with other studies in young children.[12-14] In contrast, a recent study[29] found that object-control skill competence was not associated with MVPA, although this finding approached significance ($p=0.092$). Further, Iioven and colleagues[16] found that whilst a throwing and catching combination skill was positively associated with MVPA and LMVPA, ability to kick or throw at a target was not. In addition, two of the three locomotor skills assessed (sliding and galloping) were positively associated with MVPA but jumping was not. In the present study, positive associations were found between a locomotor skill composite score and weekday MVPA and weekend LPA, supporting the results of a previous study that used similar methods.[13] Conversely, Cliff and colleagues[14] found a negative association between locomotor skills and MVPA in young girls. The divergent findings may be explained by differences in sampling (e.g. sample size, age, demographics), as well as the methods used to assess FMS (product or process-based measure, number of performance criteria) and PA (epoch length, cut-off points used). Moreover, it is possible that differing findings can be explained by the fact that associations between FMS and PA are potentially influenced by a range of individual, social and environmental factors.[4,25,27,31,32] In particular, perceptions of

competence may play an important role.[29,33] In addition, preschool children's FMS are somewhat rudimentary and consequently a relationship with PA is weak but emerging.[9] Thus, a broad approach should be taken with motor skill interventions that encourages young children to develop a repertoire of diverse FMS rather than explicitly targeting either object-control or locomotor skills.

The strengths of this study include the use of a sensitive process-based measure of 12 FMS, objective measurement of PA, and adjustments in all analyses for potential confounders. This study is limited by the cross-sectional design, which means that causality cannot be inferred. Whilst a recent longitudinal study[15] lends support to the notion of a bi-directional relationship between FMS and PA,[9,10] further research in young children using prospective designs is needed. A further limitation is that only 42% of recruited children completed all assessments. This reflects the practical challenges of achieving compliance with PA monitoring and measuring FMS in young children. Finally, accelerometers cannot capture water-based or non-ambulatory activity and so may underestimate PA, whilst a lack of consensus amongst researchers for the employed methodologies with this instrument hampers the ability to draw comparisons across studies.

## Conclusions

In conclusion, this study found positive associations between FMS and weekday and weekend PA outcomes among young children living in deprived areas. Preschool children with better locomotor skills participated in more MVPA on weekdays and more LPA on weekends; those with higher object-control skill competency participated in more LPA on weekdays and more LPA, MVPA and LMVPA at weekends. These findings open up the possibility that different types of FMS may be required for the promotion of activity of different intensities and at different time periods or vice versa. However, longitudinal

research is needed to better understand the nature of the relationships between FMS competence and PA. Findings from the current study can be used to inform the design of developmentally-appropriate interventions targeting both physical activity and FMS.

## Practical Implications

- The performance of adequate FMS may be an important element in promoting an active lifestyle in preschool children during weekdays and at weekends.
- Interventions with preschool children should simultaneously target both increasing FMS and greater participation in PA.
- Preschool children, but in particular girls, should be provided with plentiful opportunities for practice and instruction to develop FMS competence and foster greater participation in physical activity.

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431

**Table 1. Descriptive statistics for age, anthropometry, physical activity and fundamental movement skills, and sex differences**

| | Group (n = 99) | | Boys (n = 52) | | Girls (n = 47) | | Sex diff. |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | p value |
| **Age (yrs)** | 4.6 | 0.5 | 4.7 | 0.6 | 4.6 | 0.5 | 0.522 |
| **BMI (kg/m$^2$)** | 16.6 | 1.7 | 16.8 | 1.8 | 16.3 | 1.4 | 0.167 |
| **BMI-z (IOTF)** | 0.7 | 1.0 | 0.7 | 1.1 | 0.6 | 0.9 | 0.419 |
| **Weekday PA** | | | | | | | |
| Sedentary (min./day) | 458.9 | 73.3 | 450.4 | 71.8 | 468.3 | 74.6 | 0.228 |
| Light PA (min./day) | 180.8 | 42.3 | 186.4 | 43.0 | 174.5 | 41.8 | 0.165 |
| Moderate PA (min./day) | 52.7 | 17.4 | 57.4 | 17.8 | 47.6 | 15.6 | 0.005 |
| Vigorous PA (min./day) | 32.4 | 14.4 | 35.5 | 14.7 | 29.1 | 13.3 | 0.026 |
| MVPA (min./day) | 85.2 | 29.8 | 92.8 | 30.7 | 76.7 | 26.7 | 0.007 |
| LMVPA (min./day) | 265.9 | 68.1 | 279.3 | 69.1 | 251.2 | 64.5 | 0.040 |
| Wear time (min./day) | 724.6 | 47.6 | 729.6 | 45.2 | 719.4 | 49.3 | 0.284 |
| **Weekend PA** | | | | | | | |
| Sedentary (min./day) | 459.7 | 95.3 | 452.4 | 99.3 | 467.8 | 91.0 | 0.428 |
| Light PA (min./day) | 178.7 | 42.0 | 182.0 | 38.3 | 175.2 | 45.9 | 0.425 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Moderate PA (min./day) | 53.8 | 29.5 | 58.6 | 20.4 | 48.6 | 17.1 | 0.010 |
| Vigorous PA (min./day) | 35.6 | 15.9 | 38.8 | 14.9 | 32.0 | 16.3 | 0.034 |
| MVPA (min./day) | 89.4 | 33.3 | 97.3 | 33.8 | 80.6 | 30.9 | 0.012 |
| LMVPA (min./day) | 268.1 | 69.3 | 279.3 | 68.1 | 255.8 | 69.2 | 0.092 |
| Wear time (min./day) | 727.9 | 75.1 | 731.8 | 73.1 | 723.5 | 77.9 | 0.485 |
| **Fundamental Movement Skills** | | | | | | | |
| Total skill score (0-138) | 63.2 | 10.8 | 63.8 | 11.8 | 62.6 | 9.6 | 0.572 |
| Locomotor skills (0-70) | 33.4 | 6.0 | 32.4 | 6.4 | 34.6 | 5.4 | 0.068 |
| Object control skills (0-68) | 29.9 | 7.3 | 31.5 | 8.1 | 28.0 | 5.8 | 0.018 |

*Abbreviations:* BMI, body mass index; IOTF, International Obesity Task Force age- and sex-specific weight for height z-scores; LMVPA, Light- and moderate-to-vigorous PA; MVPA, Moderate-to-vigorous PA; PA, physical activity assessed by accelerometry; Wear time, accelerometer wear time.

**Table 2. Summary of mixed regression analyses for fundamental movement skills and weekday physical activity[a]**

| | B | SE B | LCI | UCI | p value |
|---|---|---|---|---|---|
| **FMS composite score & weekday PA** | | | | | |
| ***Model 1: Light PA (min./day)*** | | | | | |
| Age | -6.4 | 4.3 | -14.9 | 2.1 | 0.136 |
| Sex[b] | -6.5 | 4.2 | -14.8 | 1.9 | 0.127 |
| BMI-z | 1.3 | 2.1 | -2.9 | 5.5 | 0.547 |
| Total skill score | 0.3 | 0.2 | -0.2 | 0.7 | 0.238 |
| ***Model 2: MVPA (min./day)*** | | | | | |
| Age | -0.4 | 4.1 | -8.5 | 7.7 | 0.916 |
| Sex[b] | -11.2 | 1.0 | -19.1 | -3.2 | 0.007 |
| BMI-z | 1.0 | 2.0 | -3.0 | 5.0 | 0.616 |
| Total skill score | 0.4 | 0.2 | -0.01 | 0.8 | 0.059 |
| ***Model 3: LMVPA (min./day)*** | | | | | |
| Age | -7.4 | 6.8 | -21.0 | 6.2 | 0.281 |
| Sex[b] | -17.4 | 6.7 | -30.8 | -4.1 | 0.011 |
| BMI-z | 2.6 | 3.4 | -4.1 | 9.3 | 0.447 |
| Total skill score | 0.7 | 0.3 | -0.01 | 1.4 | 0.057 |
| **FMS subdomains & weekday PA** | | | | | |
| ***Model 4: Light PA (min./day)*** | | | | | |
| Age | -7.1 | 4.2 | -15.3 | 1.2 | 0.091 |

| | | | | | |
|---|---|---|---|---|---|
| Sex[b] | -2.7 | 4.3 | -11.3 | 5.9 | 0.537 |
| BMI-z | 1.4 | 2.1 | -2.7 | 5.5 | 0.507 |
| Locomotor skills | -0.5 | 0.4 | -1.3 | 0.2 | 0.165 |
| Object-control skills | 0.9 | 0.3 | 0.1 | 1.6 | 0.008 |
| ***Model 5: MVPA (min./day)*** | | | | | |
| Age | -0.1 | 4.0 | -8.1 | 7.9 | 0.987 |
| Sex[b] | -13.6 | 4.2 | -21.9 | -5.2 | 0.002 |
| BMI-z | 1.0 | 2.0 | -3.0 | 4.9 | 0.621 |
| Locomotor skills | 0.9 | 0.4 | 0.2 | 1.6 | 0.016 |
| Object-control skills | -0.01 | 0.3 | -0.7 | 0.6 | 0.966 |
| ***Model 6: LMVPA (min./day)*** | | | | | |
| Age | -7.6 | 6.9 | -21.2 | 6.0 | 0.269 |
| Sex[b] | -16.2 | 7.2 | -30.4 | -2.0 | 0.026 |
| BMI-z | 2.6 | 3.4 | -4.1 | 9.3 | 0.443 |
| Locomotor skills | 0.4 | 0.6 | -0.8 | 1.7 | 0.518 |
| Object-control skills | 0.9 | 0.5 | -0.2 | 2.0 | 0.111 |

*Note.* B, beta; SE B, standard error beta; 95% CI, confidence interval; L, lower; U, upper; BMI-z, IOTF age- and sex-specific weight for height z scores; Light PA, time spent in light intensity PA, LMVPA, time spent in light- and moderate-to-vigorous PA; MVPA, time spent in moderate-to-vigorous PA.

[a] All models adjusted for potential clustering of preschools and accelerometer wear time

[b] Reference category is boy

**Table 3. Summary of mixed regression analyses for fundamental movement skills and weekend physical activity[a]**

| | B | SE B | LCI | UCI | p value |
|---|---|---|---|---|---|
| **FMS composite score & weekend PA** | | | | | |
| ***Model 1: Light PA (min./day)*** | | | | | |
| Age | -5.0 | 6.2 | -17.3 | 7.3 | 0.424 |
| Sex[b] | -3.5 | 6.1 | -15.6 | 8.6 | 0.565 |
| BMI-z | -1.8 | 3.1 | -7.9 | 4.3 | 0.560 |
| Total skill score | 0.05 | 0.3 | -0.6 | 0.7 | 0.884 |
| ***Model 2: MVPA (min./day)*** | | | | | |
| Age | -8.0 | 5.6 | -19.1 | 3.1 | 0.154 |
| Sex[b] | -16.1 | 5.5 | -27.0 | -5.1 | 0.004 |
| BMI-z | -2.1 | 2.8 | -7.6 | 3.4 | 0.449 |
| Total skill score | 0.6 | 0.3 | 0.04 | 1.2 | 0.034 |
| ***Model 3: LMVPA (min./day)*** | | | | | |
| Age | -13.8 | 10.2 | -34.0 | 6.4 | 0.177 |
| Sex[b] | -19.5 | 10.0 | -39.3 | 0.4 | 0.055 |
| BMI-z | -3.5 | 5.0 | -13.5 | 6.5 | 0.489 |
| Total skill score | 0.7 | 0.5 | 0.2 | 1.7 | 0.198 |
| **FMS subdomains & weekend PA** | | | | | |
| ***Model 4: Light PA (min./day)*** | | | | | |
| Age | -6.5 | 6.0 | -18.4 | 5.5 | 0.284 |

| | | | | | |
|---|---|---|---|---|---|
| Sex[b] | 2.4 | 6.3 | -10.1 | 14.8 | 0.710 |
| BMI-z | -1.6 | 3.0 | -7.5 | 4.3 | 0.585 |
| Locomotor skills | -1.2 | 0.5 | -2.3 | -0.1 | 0.035 |
| Object-control skills | 1.0 | 0.5 | 0.1 | 2.0 | 0.033 |
| | | | | | |
| ***Model 5: MVPA (min./day)*** | | | | | |
| Age | -9.0 | 5.7 | -20.2 | 2.3 | 0.117 |
| Sex[b] | -17.3 | 24.7 | -66.3 | 31.8 | 0.486 |
| BMI-z | -2.0 | 2.8 | -7.5 | 3.5 | 0.475 |
| Locomotor skills | -0.05 | 0.5 | -1.1 | 1.0 | 0.926 |
| Object-control skills | 1.1 | 0.5 | 0.1 | 2.1 | 0.028 |
| | | | | | |
| ***Model 6: LMVPA (min./day)*** | | | | | |
| Age | -16.0 | 9.9 | -35.7 | 3.7 | 0.110 |
| Sex[b] | -10.8 | 10.4 | -31.4 | 9.9 | 0.303 |
| BMI-z | -3.3 | 4.9 | -13.0 | 6.5 | 0.507 |
| Locomotor skills | -1.1 | 0.9 | -2.9 | 0.7 | 0.211 |
| Object-control skills | 2.1 | 0.8 | 0.6 | 3.7 | 0.008 |

*Note.* B, beta; SE B, standard error beta; 95% CI, confidence interval; L, lower; U, upper; BMI-z, IOTF age- and sex-specific weight for height z scores; Light PA, time spent in light intensity PA, LMVPA, time spent in light- and moderate-to-vigorous PA; MVPA, time spent in moderate-to-vigorous PA.

[a] All models adjusted for potential clustering of preschools and accelerometer wear time

[b] Reference category is boy