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1 **Fundamental movement skills in relation to weekday and weekend physical activity in**
2 **preschool children**

3

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28 **Abstract**

29

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

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

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

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

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

51

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

53 **1. Introduction**

54

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

62

63 Distinct patterns of PA have been observed in young children on weekdays and weekends.⁴
64 Participation in PA at weekends is less variable, while the structured nature of weekdays -
65 with young children waking up and going to bed earlier, attending preschool, and parent
66 work commitments - impacts on engagement in PA.⁴⁻⁶ Preschool children participate in more
67 PA during weekends than weekdays,⁵ yet both times have been suggested as important
68 contexts for promoting PA in preschool children.³ The identification of factors that are
69 associated with PA during these periods could therefore help to develop efficacious
70 interventions.

71

72 The early years provide a window of opportunity for children to develop fundamental
73 movement skills (FMS), including stability (e.g. balance), locomotor (e.g. hop, jump) and
74 object-control (e.g. catch, throw) skills.⁷ These skills are considered the building blocks for
75 more complex and specialised movements.⁷ A reciprocal and dynamic relationship,
76 strengthening from early childhood to adolescence, has been proposed between motor skill
77 competence and PA.^{8,9} According to Stodden et al.⁸ children with higher levels of FMS will
78 seek to participate in PA and sports, whilst failure to master such skills will result in self-
79 selected withdrawal from participation. A recent systematic review examined the health
80 benefits associated with FMS competence and found strong evidence for a positive
81 association between FMS competence and PA in children and adolescents, though studies
82 using an objective measure of PA were notably lacking.¹⁰

83

84 In preschool children, positive but weak associations have typically been found between
85 FMS competence and PA assessed using accelerometers,¹¹⁻¹⁵ perhaps supporting that this
86 is an emerging, developmental relationship.⁸ These studies have predominantly focused on
87 moderate-to-vigorous PA (MVPA) averaged over the course of a week (i.e. habitual PA). To
88 the authors' knowledge, no studies have explored the influence of FMS competence in
89 relation to weekday and weekend PA in preschool children. Further, whilst the new UK PA
90 guidelines for preschool children do not specify an activity intensity,¹ only one study using a
91 small sample has considered FMS competence in relation to light PA (LPA) and light- and
92 moderate-to-vigorous PA (LMVPA).¹⁵ Children living in areas of low socioeconomic status
93 may be at greater risk of physical inactivity and other health inequalities.¹⁶ Whilst a recent
94 study has examined associations between FMS competence and PA among 8-9 year old
95 children living in low-income communities,¹⁶ little is known regarding preschool children from
96 deprived areas. Therefore, this study aimed to examine associations between FMS
97 competence and objectively measured PA during weekdays and weekend days among
98 children living in deprived communities.

99

100

101 **2. Methods**

102

103 Baseline data from the Active Play Project was used for the current study. The project has
104 been described in detail elsewhere.¹⁷ In summary, the project consisted of a 6-week
105 educational programme involving staff and children from preschools within disadvantaged
106 communities and targeting children's PA levels, FMS, fitness, and self-confidence. Baseline
107 data collection was conducted in two phases during October 2009 and March 2010. Ethical
108 approval for the study was obtained from the Liverpool John Moores University Research
109 Ethics Committee (Reference 09/SPS/027).

110

111 Twelve preschools located in a large urban city in Northwest England and situated within
112 neighbourhoods within the highest 10% for national deprivation¹⁸ were randomly selected
113 and invited to participate in the study. All preschools provided written informed consent.
114 Details on preschool recruitment and eligibility has been reported elsewhere.¹⁷ All children
115 aged 3-5 at the study preschools were invited to participate and required to return informed
116 written parental consent, demographic information (home postcode, child's ethnicity and
117 date of birth, and mother's highest level of education) and medical assessment forms. From
118 the 673 eligible children, parental consent was obtained for 240 children (35% response
119 rate). No children had known medical conditions that could affect motor proficiency or
120 participation in physical activity.

121

122 PA levels were measured every 5-seconds for 7 consecutive days using hip-mounted uni-
123 axial accelerometers (GT1M ActiGraph, Pensacola, FL). Children were asked to wear the
124 accelerometers during all waking hours except for water-based activities. Accelerometer
125 data was reduced and analysed using ActiLife (Version 6). Valid wear time was defined as a
126 minimum of three days, including a weekend day, with at least 9 hours of data recorded
127 between 6am and 9pm (waking hours). Non-wear time was defined as twenty minutes of
128 consecutive zeros. PA was classified into minutes per day spent in sedentary (≤ 100 counts),
129 light (101-1679 counts), moderate (1680-3367 counts) and vigorous (≥ 3368 counts)
130 intensities on weekdays and weekend days. These cut-points have recently been
131 recommended for use in preschoolers.¹⁹ PA data was further categorised into average
132 minutes of LMVPA and MVPA during for subsequent analysis. Habitual (weekly) PA
133 $[(\text{average weekday value} \times 0.71) + (\text{average weekend value} \times 0.29)]$ was also calculated for
134 descriptive purposes.

135

136 FMS measurement was administered by trained research assistants using The Test of
137 Gross Motor Development-2 (TGMD-2) protocol.²⁰ The TGMD-2 is specifically designed for
138 children aged 3-10 years and assesses six locomotor (run, broad jump, leap, hop, gallop and

139 slide) and six object-control (overarm throw, stationary strike, kick, catch, underhand roll and
140 stationary dribble) skills. Children completed the TGMD-2 in small groups (2-4) in either
141 school halls or on school playgrounds, dependent on available facilities. One research
142 assistant provided a verbal description and single demonstration of the required skill, while a
143 second took recordings of all participants using a video camera placed on a tripod. Each
144 child performed each skill twice and skills were completed in a standardised order, taking
145 approximately 35-40 minutes per group. Video recordings of the skills were assessed using
146 The Children's Activity and Movement in Preschool Study Motor Skills Protocol (CMSP),
147 which has established validity and reliability.²¹ The CMSP is a process-orientated
148 assessment that evaluates each skill based on the demonstration of specific movement
149 components.²¹ Whilst the CMSP uses an identical protocol to the TGMD-2,²⁰ it provides
150 additional performance criteria and alternative scoring methods which offer improved
151 assessment sensitivity.²¹ During the two trials for each skill, components were marked as
152 being absent (scored 0) or present (1), with the exception of three skills. For the throw and
153 strike hip/trunk rotation was scored as differentiated (2), block (1) or no rotation (0), whilst
154 the catch identified a successful attempt as being caught cleanly with hands/fingers (2) or
155 trapped against body/chest (1). The total number of skill components checked as present
156 over two trials was summed to give a composite FMS score, whilst locomotor and object-
157 control subtest scores were also created by summing the scores of skills within each
158 subscale. All analyses were completed by a single trained assessor. Inter-rater reliability was
159 established prior to assessment using pre-coded videotapes of 10 children, with 83.9%
160 agreement across the twelve FMS (range 72.9-89.3%).

161

162 Body mass (to the nearest 0.1 kg) and stature (to the nearest 0.1 cm) were measured by
163 trained researchers using digital scales and a portable stadiometer, respectively. Body mass
164 index (BMI: kg/m²) was calculated and converted to BMI-z scores using the 'LMS' method
165 for analysis.²²

166

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

178

179

180 **3. Results**

181

182 A total of 99 (41%) children aged 3-5 years (M 4.6, SD 0.5; 55% boys) completed all
183 assessments and were therefore included in the final analysis. There was no significant
184 differences in age, ethnicity, deprivation, and BMI-z score between those included in the
185 analysis and those excluded due to either not meeting the PA inclusion criteria ($n=103$; 43%)
186 or missing/incomplete FMS data ($n=72$; 30%). Descriptive statistics and sex differences for
187 the study sample are presented in Table 1. Nine out of ten participating children lived in an
188 area ranked within the top 30% for deprivation in England, with 76% of these children ranked
189 within the highest decile for deprivation.¹⁸ Most children were of White British descent (81%),
190 with the remaining participants of another White descent (5%), Mixed Race (3%), Asian (3%),
191 Black African (5%) or other (1%). Almost a quarter of children were overweight (17%) or
192 obese (7%). On average, children engaged in LMVPA for a total of 266.6 ± 65.2 (36.7%)
193 minutes each day, including 180.2 ± 40.8 (24.8%) minutes of LPA and 86.4 ± 28 . (11.9%)
194 minutes of MVPA; 86% of children met the recommended PA guidelines.¹ Children

195 participated in more vigorous PA at weekends than on weekdays. No other differences were
196 found between weekday and weekend PA. Compared to girls, boys engaged in more MVPA
197 and LMVPA on weekdays, and more MVPA at weekends. Boys had significantly higher
198 object-control skill scores than girls, though there was a trend for girls to have better
199 locomotor skills. No other sex differences were found.

200

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

206

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

213

214

215 **4. Discussion**

216

217 This unique study explored associations between FMS competence and weekday and
218 weekend PA in preschool children living in deprived communities. Children with higher levels
219 of FMS, as expressed by a total skills composite score, engaged in more MVPA during
220 weekends. When subdomains of FMS were examined, differential associations were
221 observed for weekday and weekend time periods. Specifically, locomotor skill competency
222 was positively associated with MVPA on weekdays, and LPA at weekends. Object-control

223 skill competency was positively associated with LPA on weekdays and with LPA, MVPA and
224 LMVPA at weekends. Boys had better object-control skills than girls, and spent more time in
225 MVPA and LMVPA on weekdays, and MVPA at weekends.

226

227 Weekdays are deemed typically less flexible than weekends as young children follow a
228 structured routine of daily activities and spend most of their waking hours at preschool, whilst
229 parents work commitments may restrict the time that they can spend with their child.⁴⁻⁶ As
230 children in preschools with PA promoting practices and policies generally participate in more
231 PA,^{3,23} the preschool centre has been identified as an important setting for early years PA
232 promotion.³ The current study found that locomotor skill competency was positively
233 associated with MVPA on weekdays, suggesting that children with higher competence at
234 locomotor skills participated in more MVPA. Alternatively, participation in PA may improve
235 acquisition of FMS, for example through increased neuromotor development.^{8,11} This finding
236 may be indicative of the nature of weekday PA for young children, with the majority of MVPA
237 likely accrued at preschool through unstructured, informal play-like activities such as dancing,
238 running and chasing, which require a high level of locomotor rather than object-control skill
239 competence. In support of this notion, a recent study²⁴ observed that preschool children in
240 the highest locomotor tertile engaged in a higher percentage of intervals of dancing than
241 children in the lowest locomotor tertile, with a trend for similar differences found for
242 jumping/skipping activity types. However, no differences were observed between tertiles in
243 intervals of walking or running activities.²⁴ In the current study, object-control skill
244 competency was positively associated with LPA on weekdays, suggesting that preschool
245 children with better object-control skills may engage in more LPA. Again, it is also possible
246 that participation in LPA on weekdays may improve object-control skills. These findings open
247 up the possibility that different types of FMS may be required for the promotion of activity of
248 different intensities or vice versa, though longitudinal and experimental research is needed.
249 In addition, whilst the current study examined associations between FMS and PA across the
250 entire weekday, future research could explore relationships during key weekday time periods

251 for PA, such as recess, lunchtime and afterschool periods. Research conducted in primary
252 school children suggests that both locomotor and object-control skills contribute to MVPA
253 during these discrete time periods.¹⁶

254

255 At weekends, preschool children spend the majority of their time in or around the home
256 environment, where parents have additional flexibility and more consistent engagement with
257 their children.⁴⁻⁶ Despite differences in preschool children's weekday and weekend
258 environments, and in contrast to previous research,⁵ no differences were found between
259 weekday and weekend PA. However, differential associations were found in relation to FMS
260 and PA. Contrary to weekdays, FMS competency was associated with weekend MVPA,
261 moreover, object-control skill competency was associated with all activity intensities. This
262 finding suggests that preschool children who have more competent object-control skills,
263 participate in more PA at weekends. On the other hand, greater participation in weekend PA
264 may improve object-control skill competency. This may be indicative of preschool children
265 participating in more structured and organised sport activities at weekends, which have a
266 larger object-control skill component. In addition, locomotor skill competency was found to
267 be related to LPA at weekends, suggesting that children with better locomotor skills may
268 participate in more light intensity PA or that, though perhaps unlikely, low intensity PA can
269 potentially foster improvements in locomotor skills. Again, this suggests that associations
270 between FMS and PA move beyond MVPA and therefore it is important to consider different
271 intensities as well as different time periods. Weekends provide an opportunity for preschool
272 children to spend more time with their parents, who can directly (e.g. provision of equipment,
273 access to outdoors) and indirectly (e.g. role modelling, encouragement) influence their young
274 child's PA behaviours.^{23,25} Parents have a reasonably accurate perception of their preschool
275 child's motor skill abilities,²⁴ thus it is possible that parents of preschool children with higher
276 skill competency may provide more support for PA (e.g. encouragement, access to facilities,
277 spaces and equipment) than parents of preschool children with lower levels of skill
278 competency, who may offer more sedentary alternatives. Interventions aiming to increase

279 young children's PA during weekends could be achieved by encouraging parents to be
280 active as a family through a variety of means including natural environments, provision of
281 equipment and active play/games with their children to develop their ball skills. In addition,
282 parents could be encouraged to enrol their child into organised activities to give children
283 more opportunities to practice and nurture FMS.

284

285 The current study found that boys were more active than girls, and had higher object-control
286 skills, which is consistent with existing literature.^{4-6, 26,27} The observed positive associations
287 between total skill score and weekend MVPA, and object-control skill subdomain with
288 weekday LPA and weekend LPA, MVPA and LMVPA is also broadly consistent with other
289 studies in young children.¹¹⁻¹³ In contrast, a recent study²⁷ found that object-control skill
290 competence was not associated with MVPA, although this finding approached significance
291 ($p=0.092$). Further, Iovene and colleagues¹⁵ found that whilst a throwing and catching
292 combination skill was positively associated with MVPA and LMVPA, ability to kick or throw at
293 a target was not. In addition, two of the three locomotor skills assessed (sliding and galloping)
294 were positively associated with MVPA but jumping was not. In the present study, positive
295 associations were found between a locomotor skill composite score and weekday MVPA and
296 weekend LPA, supporting the results of a previous study that used similar methods.¹²
297 Conversely, Cliff and colleagues¹³ found a negative association between locomotor skills
298 and MVPA in young girls. The divergent findings may be explained by differences in
299 sampling (e.g. sample size, age, demographics), as well as the methods used to assess
300 FMS (product or process-based measure, number of performance criteria) and PA (epoch
301 length, cut-off points used). Moreover, it is possible that differing findings can be explained
302 by the fact that associations between FMS and PA are potentially influenced by a range of
303 individual, social and environmental factors.^{3,23,25,28,29} In particular, perceptions of
304 competence may play an important role.^{27,30} In addition, preschool children's FMS are
305 somewhat rudimentary and consequently a relationship with PA is weak but emerging.⁸ Thus,
306 a broad approach should be taken with motor skill interventions that encourages young

307 children to develop a repertoire of diverse FMS rather than explicitly targeting either object-
308 control or locomotor skills.

309

310 The strengths of this study include the use of a sensitive process-based measure of 12 FMS,
311 objective measurement of PA, and adjustments in all analyses for potential confounders.

312 This study is limited by the cross-sectional design, which means that causality cannot be
313 inferred. Whilst a recent longitudinal study¹⁴ lends support to the notion of a bi-directional
314 relationship between FMS and PA,^{8,9} further research in young children using prospective
315 designs is needed. A further limitation is that only 42% of recruited children completed all
316 assessments. This reflects the practical challenges of achieving compliance with PA
317 monitoring and measuring FMS in young children. Finally, accelerometers cannot capture
318 water-based or non-ambulatory activity and so may underestimate PA, whilst a lack of
319 consensus amongst researchers for the employed methodologies with this instrument
320 hampers the ability to draw comparisons across studies.

321

322

323 **Conclusions**

324

325 In conclusion, this study found positive associations between FMS and weekday and
326 weekend PA outcomes among young children living in deprived areas. Preschool children
327 with better locomotor skills participated in more MVPA on weekdays and more LPA on
328 weekends; those with higher object-control skill competency participated in more LPA on
329 weekdays and more LPA, MVPA and LMVPA at weekends. These findings open up the
330 possibility that different types of FMS may be required for the promotion of activity of
331 different intensities and at different time periods or vice versa. However, longitudinal
332 research is needed to better understand the nature of the relationships between FMS
333 competence and PA. Findings from the current study can be used to inform the design of
334 developmentally-appropriate interventions targeting both physical activity and FMS.

|

335

336

337 **Practical Implications**

338

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

346

347

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349

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358

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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/m²)	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-	29.9	7.3	31.5	8.1	28.0	5.8	0.018

68)

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					
<i>Model 1: Light PA (min./day)</i>					
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
<i>Model 2: MVPA (min./day)</i>					
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
<i>Model 3: LMVPA (min./day)</i>					
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					
<i>Model 4: Light PA (min./day)</i>					
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