

FMS AND HEALTH-RELATED OUTCOMES

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3 **Sex-related differences in the association of fundamental movement skills and health**
4 **and behavioral outcomes in children**

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Abstract

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This study aimed to assess whether sex moderates the association of fundamental movement skills (FMS) and health and behavioral outcomes. In 170 children (10.6 ± 0.3 years; 98 girls), path-analysis was used to assess the associations of FMS (Get Skilled, Get Active) with perceived sports competence (Children and Youth - Physical Self-Perception Profile), time spent in vigorous-intensity physical activity (VPA), sedentary time and body mass index (BMI) z-score. For boys, object control skill competence had a direct association with perceived sports competence ($\beta = 0.39$; 95% CI: 0.21 to 0.57) and an indirect association with sedentary time, through perceived sports competence ($\beta = -0.19$; 95% CI: -0.09 to -0.32). No significant association was observed between FMS and perceived sports competence for girls, although locomotor skills were found to predict VPA ($\beta = 0.18$; 95% CI: 0.08 to 0.27). Perceived sports competence was associated with sedentary time, with this stronger for boys ($\beta = -0.48$; 95% CI: -0.64 to -0.31), than girls ($\beta = -0.29$; 95% CI: -0.39 to -0.19). The study supports a holistic approach to health-related interventions and highlights a key association of perceived sports competence and the time children spend sedentary.

Key words: Exercise, Motor development, Physical activity, Self-efficacy, Motor performance, Pediatrics

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46 Sex-related differences in the association of fundamental movement skills and health
47 and behavioral outcomes in children

48 Fundamental movement skills (FMS), which include object control and locomotor
49 skills, are referred to as foundational ‘building-block movements’ and are proposed to provide
50 a crucial underpinning to the development of more complex movement patterns (Gallahue,
51 Ozmun, & Goodway, 2012). Object control skills refer to FMS that allow for the manipulation
52 and controlling of objects, such as throwing and catching, whilst locomotor skills consist of
53 those FMS associated with the propulsion and navigation of individuals through space, such as
54 running and hopping (Gallahue et al., 2012). FMS are primarily ontogenetic; competence is
55 influenced through dynamic interactions with the environment, coupled with biological and
56 psychological constraints that change over time (Robinson et al., 2015). Along with being
57 associated with health and behavioral outcomes, FMS are identified as a precursor to physical
58 activity, and more recently, time spent sedentary (Adank et al., 2018; Robinson et al., 2015).
59 Current physical activity guidelines state that children and young people aged 5-18 years
60 should engage in an average of at least 60 minutes moderate-to-vigorous physical activity
61 (MVPA) per day across the week, and should minimize time spent sedentary (Davies et al.,
62 2019). Despite this, few children accrue the required levels of physical activity, with less than
63 25% of school-aged children meeting recommended guidelines (National Health Service,
64 2019). Furthermore, sedentary behavior, attributable in part to reductions in active play,
65 organized sport, and a concomitant rise in exposure to screen devices, has been highlighted as
66 an independent risk factor for many non-communicable diseases (Saunders, Chaput, &
67 Tremblay, 2014).

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68 Typically developing children have the potential to be proficient in many FMS by six
69 years (Gallahue et al., 2012). However, the literature has shown that proficiency remains low,
70 with the standardized fundamental movement skill levels of children aged 6-10 years deemed
71 “below average”, and less than half of all children aged 9-15 years proficient across all FMS
72 (Bolger et al., 2020; Hardy, Barnett, Espinel, & Okely, 2013). Sex-specific differences also
73 exist, with boys consistently reported as being more proficient in object control skills, though
74 evidence relating to locomotor skills remains equivocal (Barnett et al., 2016). Such sex-specific
75 differences in fundamental movement skill competence likely reflect the influence of
76 environmental and socio-cultural factors, such as the level of family support and
77 encouragement. These factors are proposed to underpin physical activity and sport participation
78 choice, with boys often engaging in activities requiring a high object control skill competence,
79 such as rugby, football and basketball, and girls often engaging in activities underpinned by
80 locomotor skill competence, such as gymnastics and dance (Barnett, Hinkley, Okely, &
81 Salmon, 2013; Slykerman, Ridgers, Stevenson, & Barnett, 2016).

82 Stodden and colleagues (2008) proposed a conceptual model that represented the inter-
83 dependence of the developmental trajectories of FMS, physical activity and associated health-
84 related outcomes. The narrative review of Robinson and colleagues (2015) alongside more
85 recent meta-analyses (Barnett et al., 2016; Utesch et al., 2019) have supported the direct and,
86 to a lesser degree, indirect, associations of FMS and the health and behavioral outcomes
87 included within the Stodden et al. (2008) model. From mid-childhood, the association between
88 FMS and physical activity is hypothesized to become increasingly reciprocal, with FMS a
89 driver for sustained engagement in a variety of physical activities that subsequently promote
90 perceived competence, physical fitness, and a healthy weight status (Stodden et al., 2008).
91 Whilst a positive association between perceived and actual competence has been identified as

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92 a key predictor of health benefits (De Meester, Stodden, et al., 2016), high perceived
93 competence, irrespective of actual competence, may induce similarly favorable outcomes (De
94 Meester, Maes, et al., 2016). The model further proposes that poor competence in FMS,
95 coupled with low self-perception, is a precursor to a negative spiral of disengagement,
96 expressed through a higher risk of being physically inactive and obese (Stodden et al., 2008).

97 Evidence suggests that the role of FMS may differ according to age, sex and the specific
98 health and behavioral outcomes of interest (Barnett, Morgan, Van Beurden, Ball, & Lubans,
99 2011; Luz, Cordovil, Almeida, & Rodrigues, 2017). The developmental influences on the
100 associations between FMS and health and behavioral outcomes are emphasized in the Stodden
101 et al. (2008) model. Increasing age has been found to positively moderate the relationship
102 between FMS and physical fitness (Utesch, Bardid, Büsch, & Strauss, 2019). In addition,
103 competence in object control skills, rather than locomotor skills, has been found to be more
104 strongly associated with physical activity (Barnett et al., 2011), whilst a stronger association
105 between FMS and physical activity has been observed in girls (Jarvis et al., 2018). Given the
106 role of perceived competence within the Stodden et al. (2008) model, further evidence is
107 required to identify whether its association with additional outcomes is moderated by sex and
108 fundamental movement skill construct (Barnett, Morgan, van Beurden, & Beard, 2008;
109 Khodaverdi, Bahram, Stodden, & Kazemnejad, 2016). Previous studies have reached little
110 consensus on which skills are most strongly associated with perceived competence (Barnett,
111 Ridgers, & Salmon, 2015; Khodaverdi et al., 2016).

112 Although the association between FMS and MVPA has been consistently reported
113 (Robinson et al., 2015), there is a need to better understand the association between FMS and
114 specific intensities and characteristics of physical activity (Lima et al., 2017). Time spent in
115 vigorous physical activity (VPA) has been shown to provide enhanced benefits in comparison

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116 to light- and moderate-intensity physical activity across a range of cardiometabolic, cognitive
117 and fitness indicators (Carson et al., 2014; Poitras et al., 2016). VPA is also proposed to be
118 more strongly associated with participation in sport than lower intensities of physical activity
119 (Kokko et al., 2019; Pfeiffer et al., 2006). Children can accrue high levels of MVPA from free-
120 play, where proficiency in FMS may be less critical to engagement (Lubans, Morgan, Cliff,
121 Barnett, & Okely, 2010) and therefore the influence of FMS may become more evident in VPA.
122 Conversely, a reciprocal association between FMS and time spent sedentary may exist, fostered
123 by the same confounders that promote inactivity (i.e., weight status, perceived competence and
124 sex). Sedentary behavior has been found to track from childhood into adolescence, and an
125 inverse influence of time spent sedentary on wider outcomes, such as academic attainment, has
126 also been identified (Biddle, Pearson, Ross, & Braithwaite, 2010; Haapala et al., 2017). As
127 such, understanding the role of FMS as a mechanism through which to reduce time spent
128 sedentary is warranted. Few studies have investigated the sex-related influence of FMS on
129 these characteristics of physical activity and sedentary time, with an absence of available
130 evidence pertaining to how these associations may be moderated by sex and additional health-
131 related outcomes.

132 Guided by the Stodden et al. (2008) conceptual framework, the aim of this study was
133 to use path-analysis to investigate the influence of sex on the associations between FMS,
134 perceived sports competence, time spent in VPA, time spent sedentary and BMI z-score in late
135 childhood. It was hypothesized that for girls, locomotor skill competence, and for boys, object
136 control skill competence, would be associated with time spent in VPA. In addition, irrespective
137 of sex, perceived sports competence would have an important mediating role on the association
138 of fundamental movement skill constructs with VPA, time spent sedentary and BMI z-score.

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Methods

Participants

143 Following written informed parental consent and child assent, 190 (110 girls; 80 boys)
144 children from school year 6 (10.6 ± 0.3 years), recruited from 16 primary (elementary) schools
145 within the Borough of Wigan, England, participated in this study. School year 6 represents the
146 final year of primary education prior to the transition to secondary education, and as such is a
147 key developmental stage for children where they have the potential to have mastered FMS. All
148 children were invited to participate and were only excluded if they had any functional
149 impairment that precluded regular physical activity participation. Home postcodes were used
150 to generate Indices of multiple deprivation (IMD) scores for each participant and these along
151 with the percentage of children per school eligible for free school meals were used to define
152 school-level socio-economic status (SES). Within each neighbourhood management area, one
153 high and one low SES school were randomly selected to take part to ensure acceptable
154 representation. Participant data has been combined from one cross-sectional study ($n = 46$) and
155 baseline sub-sample data from one cluster randomized controlled trial ($n = 144$; Fairclough et
156 al., 2013; Fairclough, Boddy, Mackintosh, Valencia-Peris, & Ramirez-Rico, 2015). Ethical
157 approval was obtained from the Liverpool John Moores University Research Ethics Committee
158 (application references 8.56 and 10/ECL/039, respectively). Ethical principles of the
159 Declaration of Helsinki were adhered to throughout this research.

Anthropometric measures

161 All anthropometric measurements were conducted by a trained researcher. Standing
162 and sitting stature were measured to the nearest 0.1cm using a stadiometer (Seca, Bodycare,

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163 Birmingham, UK). Body mass were measured to the nearest 0.1kg using calibrated scales
164 (Seca, Bodycare, Birmingham, UK). BMI was calculated as body mass (kg) divided by height
165 squared (m^2) and subsequently standardized using BMI z-scores. Biological maturity was
166 assessed using a predictive equation (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002), which
167 estimates the years from or post peak height velocity and has been validated with standard error
168 of estimates of 0.57 and 0.59 years for boys and girls, respectively (Mirwald et al., 2002).

169 Instruments

170 The Children and Youth Physical Self-Perception Profile (CY-PSPP; Whitehead, 1995)
171 was used to determine self-perceived competence. The CY-PSPP consists of four sub-domains
172 (sports competence, physical condition, body attractiveness, and physical strength) positioned
173 underneath a domain (self-worth) and global domain (global self-esteem). Each sub-domain
174 comprises of six individual questions rated on a four-point Likert scale in a structured
175 alternative format. For each question, the participant is initially presented with two statements
176 from which they must select the one most identifiable to themselves and then select either ‘sort
177 of true’ or ‘very true’. Akin to previous studies, the CY-PSPP was completed in full, with the
178 sub-scale for sports competence analyzed as the measure of perceived sports competence
179 (Barnett et al., 2011, 2008; De Meester, Stodden, et al., 2016). Each sub-domain has been
180 previously shown to provide a sensitive and reliable measure, irrespective of sex (Fox, 1989),
181 and in the current study, the perceived sports competence sub-domain demonstrated acceptable
182 internal consistency ($\alpha = 0.65$).

183 Three locomotor (sprint, hop and vertical jump) and three object control (catch, kick,
184 overarm throw) skills were assessed using the Get skilled, Get active protocol (Department of
185 Education and Training, 2000). These FMS are identified as core curriculum movement skills
186 and underpin the specialized movements that are desirable for organized sport participation

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187 (Department for Education, 2013). Children were given a verbal description and a
188 demonstration of each skill. Each fundamental movement skill has six individual grading
189 components that relate to a specific technical characteristic of the movement skill. FMS were
190 completed five times, if the individual grading component was checked as being present on
191 four out of five trials then the child was marked as possessing that specific technical
192 characteristic of the movement skill. The summed score of the trials was used to provide an
193 overall score for object control and locomotor skills. Following the assessment session, video
194 analysis of each performance was completed by two trained assessors who scored a separate
195 sub-sample of children. Inter-rater reliability was established prior to data collection
196 (Kappa=0.77; 90% CI: 0.71 to 0.83).

197 Physical activity was objectively assessed using an ActiGraph GT1M accelerometer
198 (ActiGraph, LLC, Pensicola, Florida) worn on the right hip for seven consecutive days
199 measuring at 5s epochs. Evenson et al. (2008) cut-points were used to determine physical
200 activity intensity. These cut-points have been shown to have acceptable classification accuracy
201 for physical activity and inactivity in children and adolescents (Trost, Loprinzi, Moore, &
202 Pfeiffer, 2011). Non-wear time was defined as 20 minutes of consecutive zero counts (Catellier
203 et al., 2005). To classify wear-time and sleep-time, children completed a log sheet to record
204 any periods during which the accelerometer was removed for sleep and additional activities
205 (i.e., contact sport, showering). These log sheets were checked and initialed by parents at the
206 end of each day. A minimum daily wear-time of 540 minutes on at least two weekdays and 480
207 minutes on a weekend day was required to be included in the analyses. These inclusion criteria
208 have previously shown acceptable reliability in similarly aged children (Fairclough et al., 2015;
209 Mattocks et al., 2008). From the initial sample, 20 participants were omitted from the analyses

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210 (incomplete FMS and physical activity data), leaving a sample of 170 children (10.6 ± 0.3
211 years; 98 girls).

212 Statistical analysis

213 Data were analyzed using IBM SPSS and AMOS for Windows, Version 25 [IBM SPSS
214 Statistics Inc., Chicago, IL, USA]. All descriptive results are presented as means \pm standard
215 deviation (SD), with Student t-test for independent samples used to analyse between-sex
216 differences. Path-analysis was conducted to determine direct and indirect associations between
217 FMS (object control and locomotor skill competence), perceived sports competence, VPA,
218 sedentary time and BMI z-score. Bootstrapping for indirect effects was based on 2,000
219 bootstrap samples, and confidence intervals were set as 95% (MacKinnon, Lockwood, &
220 Williams, 2004). Path coefficients and correlations were reported as standardized estimates.
221 Statistically significant criterion for all paths was set at $p < 0.05$. The hypothesized model was
222 tested initially to ensure its viability. Global model fit was assessed using Chi-square
223 statistic/Degrees of Freedom (CMIN/DF), Comparative fit index (CFI), Goodness of fit index
224 (GFI), Root mean square error of approximation (RMSEA), and p of Close Fit (P-Close).
225 Multi-group analysis was used to examine the moderating role of sex. This was performed by
226 testing a constrained model (paths constrained to be equal for both sexes) and comparing this
227 against an unconstrained model (i.e., sex-specific). A chi-squared difference test was then used
228 to determine whether the models differed significantly by sex.

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Results

230 Descriptive statistics are provided in Table 1. Results indicated no significant sex
231 differences in fundamental movement skill constructs, BMI z-score, and perceived sports
232 competence. However, boys were significantly more competent in the throw ($p < 0.05$), and
233 accrued significantly more time in VPA ($p < 0.01$) and significantly less time sedentary

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234 ($p < 0.05$). The overall model demonstrated excellent global model fit (CMIN/DF = 1.418; CFI
235 = 0.989; GFI = 0.989; RMSEA = 0.050; P-Close = 0.416). Maturity was removed as a covariate
236 from the initial model because it did not have a significant effect. The multi-group analysis
237 showed that the structural model was significantly different between girls and boys ($X^2(17) =$
238 20.9, $p = 0.023$).

239 For girls (Figure 1), locomotor skill competence had a direct association with VPA
240 ($\beta = 0.18$, $p = 0.03$). Additionally, perceived sports competence was found to have a direct
241 association with time spent sedentary ($\beta = -0.29$, $p = 0.002$) and BMI z-score ($\beta = -0.23$,
242 $p = 0.01$). A further direct association was found between time spent in VPA and BMI z-score
243 ($\beta = -0.37$, $p < 0.001$). For boys (Figure 2), a direct association between object control skill
244 competence and perceived sports competence was observed ($\beta = 0.39$, $p < 0.001$) and an
245 indirect association was found between object control skills competence and time spent
246 sedentary ($\beta = -0.19$, $p < 0.001$), mediated by perceived sports competence. In contrast,
247 locomotor skill competence was negatively associated with perceived sports competence ($\beta = -$
248 0.28, $p = 0.01$). Perceived sports competence was found to have a direct association with time
249 spent sedentary ($\beta = -0.48$, $p < 0.001$). Additionally, time spent in VPA was found to be directly
250 associated with BMI z-score ($\beta = -0.25$, $p = 0.03$).

251 Discussion

252 This study sought to explore whether sex moderates the association between FMS,
253 perceived sports competence, time spent in VPA, sedentary time and BMI z-score during late
254 childhood. Overall, the results provide evidence of the moderating role of sex on the association
255 of FMS and selected health and behavioral outcomes, during late childhood. For boys, object
256 control skill competence was directly associated with perceived sports competence and had an

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257 indirect association with time spent sedentary. For girls, only a direct association between
258 locomotor skill competence and VPA was found. These results suggest that the underpinning
259 factors most influential to the developmental health trajectories of children may differ with sex.

260 The present study failed to provide support to previous research that has found marked
261 sex differences in fundamental movement skill competence (Barnett, van Beurden, Morgan,
262 Brooks, & Beard, 2010; Bolger et al., 2018). Although no significant sex differences in the
263 object control and locomotor skill constructs were found, boys were significantly more
264 competent in the overhand throw. The higher competence of boys in the overhand throw may
265 suggest that sex-related norms associated to sport participation still exist, with these supported
266 by parental and societal beliefs (Clément-Guillotin & Fontayne, 2011). Coupled with boys
267 spending more time in VPA, the higher competence of boys in the overhand throw may indicate
268 a greater participation in sport-related activity, and fewer opportunities and/or less support for
269 girls to develop these skills in similar contexts (Barnett et al., 2016).

270 Interestingly, the present study found only object control skill competence to be
271 positively associated with perceived sports competence, which was only significant for boys.
272 The results concur with the majority of previous studies finding object control competence as
273 the only significant predictor of perceived sports competence (Barnett et al., 2016; Robinson
274 et al., 2015). Proficiency in object control skills has a greater influence in many of the sports
275 traditionally defined as masculine and within which boys commonly participate (i.e., rugby,
276 tennis, football; Barnett et al., 2011; Clément-Guillotin & Fontayne, 2011). Boys will likely
277 align their perceived sports competence to object control skills, as these are deemed more
278 important to their activity choices. For boys in the current study, locomotor skills were found
279 to be negatively associated with perceived sports competence. Although unexpected, these
280 results may indicate a lack of alignment between actual and perceived competence with regards

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281 to locomotor skills and may also reflect that locomotor skill competence is less important for
282 perceptions of sport competence.

283 As previous studies have found FMS to be positively associated with MVPA, we
284 expected a similar influence to be evident with VPA and that this association would be
285 mediated through perceived sports competence. VPA was selected as an independent indicator
286 of physical activity as it has been shown to have additional health benefits, beyond those of
287 MVPA (Carson et al., 2014; Poitras et al., 2016). Whilst our study did not provide support for
288 an indirect association between FMS and BMI z-score, for either sex, the models for girls and
289 boys did identify VPA as a predictor of BMI z-score. This is an important finding as this
290 provides further evidence of the importance of VPA for achieving health-enhancing benefits
291 (Carson et al., 2014). It was hypothesized that FMS would be more influential to activities
292 incorporating VPA (i.e., sport participation). However, although a direct association between
293 locomotor skills and VPA was observed for girls, object control skills were not associated with
294 VPA, irrespective of sex. Similarly, an indirect association between FMS and VPA, through
295 perceived sports competence, was not evident. It is possible that children at this age are still
296 achieving a large proportion of VPA through active play, where actual and perceived
297 fundamental movement skill competence has less influence on engagement. Additionally, sport
298 participation in late childhood is still underpinned by development and enjoyment, with less
299 emphasis on performance indicators (Barnett, Vazou, et al., 2016; Malina, Cumming, & Silva,
300 2016). For girls, the direct association between locomotor skills and VPA may reflect the
301 greater direct importance to the physical activity and sport-related choices of many girls at
302 these ages (i.e., track, gymnastics; Barnett et al., 2016). The lack of association between
303 perceived sports competence and time spent in VPA particularly in early-maturing girls may
304 suggest that other barriers, such as physical self-perception, motivation, and societal context,

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305 exert a greater influence on time spent in VPA in comparison to perceived sports competence
306 (Malina et al., 2016).

307 To our knowledge, this is the first study to use path analysis to assess both the direct
308 and indirect association between FMS and sedentary time specific to sex. Advancing previous
309 research, which has focused largely on the influence of FMS on physical activity levels
310 (Robinson et al., 2015), the present study found perceived sports competence to have a crucial
311 association with time spent sedentary. Irrespective of physical activity levels, sedentary time
312 has been identified as an independent construct associated with acute and chronic health
313 consequences (Saunders, Chaput, & Tremblay, 2014). Yet, in line with studies that have
314 observed the influence of self-perception on physical inactivity (Barnett et al., 2011, 2008;
315 Robinson et al., 2015), the present results show that, whilst independent, there are similarities
316 in the underpinning attributes associated with sedentary time and physical inactivity. Perceived
317 competence has previously been suggested to be as important as actual competence in
318 predicting physical inactivity (Robinson et al., 2015). Advancing this, the present results found
319 perceived sports competence to be strongly associated with sedentary time. Along with
320 fundamental movement skill competence, it can be postulated that psychosocial factors (i.e.,
321 low perceived competence, lack of enjoyment) influence sedentary behaviors in children,
322 especially during weekdays where leisure-time is more finite (Hardy, Ding, Peralta, Mihrshahi,
323 & Merom, 2018). This association between FMS, self-perception, and sedentary time may
324 become amplified in adolescents with greater autonomy and where the biological drive to be
325 physically active is less (Malina et al., 2016).

326 Whilst there are numerous strengths associated with the present study, such as using
327 device-measured physical activity and using a validated fundamental movement skill
328 assessment, it is important to acknowledge the limitations. As a cross-sectional study, causal

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329 inferences were not possible, and it is therefore important that future studies seek to identify
330 bidirectional associations. The hypothesized directionality of the data in the current study was
331 based on the conceptual model of Stodden et al. (2008). In addition, the questions used to
332 analyze perceived sports competence (i.e., some kids do very well at all kinds of sports, but
333 other kids don't feel they are good when it comes to sport) were not specific to the assessed
334 FMS. Similarly, the use of accelerometers to measure sedentary time has been challenged,
335 although $100 \text{ counts} \cdot \text{min}^{-1}$, as used in the current study, has been identified as a valid measure
336 of youth sedentary time (Kim, Lee, Peters, Gaesser, & Welk, 2014). Future research should
337 also look to incorporate a fitness measurement, such as peak oxygen uptake, to provide analysis
338 of all parameters within the Stodden et al. (2008) model.

339 Conclusion

340 The findings from the current study extend previous research by identifying sex-related
341 differences in the influence of FMS upon health and behavioral outcomes. Specifically, for
342 boys in late childhood, object control skills appear more important to a positive trajectory of
343 health than their female counterparts. In contrast, for girls, it is locomotor skills that may have
344 a greater association with health and behavioural outcomes. Importantly, this study highlights
345 the crucial role of perceived competence in predicting time spent sedentary, irrespective of sex.
346 These results support the adoption of a more holistic pedagogical approach that seeks to
347 understand and enhance a child's perceived competence along with FMS. Furthermore, this
348 study emphasizes the importance of adopting this form of approach during childhood to provide
349 children with a strong movement profile and a motivation from which they can embrace a
350 physically active lifestyle during adolescence.

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542 **Table 1**543 *Participant characteristics*

Variables	Boys (N = 72)	Girls (N = 98)	All (N = 170)
Age (years)	10.6 ± 0.3	10.7 ± 0.3	10.6 ± 0.3
Height (cm)	143.1 ± 7.6	144.7 ± 8.2	144.0 ± 8.0
Body mass (kg)	36.3 ± 7.9	38.3 ± 9.5	37.4 ± 8.9
BMI (kg·m ⁻²)	17.6 ± 2.6	18.3 ± 3.8	18.0 ± 3.4
BMI z-score	0.12 ± 1.28	0.06 ± 1.32	0.09 ± 1.30
Maturity offset (years)	-3.1 ± 0.4	-1.3 ± 0.6	-2.0 ± 1.1
Catch (0-6)	4.8 ± 1.6	4.8 ± 1.5	4.8 ± 1.5
Throw (0-6)	3.6 ± 1.8	2.8 ± 1.7*	3.2 ± 1.8
Kick (0-6)	3.1 ± 1.6	2.8 ± 1.5	2.9 ± 1.5
Sprint (0-6)	3.0 ± 1.1	2.7 ± 1.2	2.9 ± 1.2
Vertical jump (0-6)	4.2 ± 0.9	4.1 ± 0.9	4.1 ± 0.9
Hop (0-6)	4.1 ± 0.9	3.9 ± 0.9	4.0 ± 0.9
Object control skills (0-18)	11.5 ± 4.1	10.5 ± 3.6	10.9 ± 3.8
Object control skills (range)	3-18	4-18	3-18
Locomotor skills (0-18)	11.3 ± 1.9	10.7 ± 2.2	11.0 ± 2.1
Locomotor skills (range)	7-16	7-17	7-17
Perceived sports competence	16.1 ± 3.4	15.6 ± 3.0	15.8 ± 3.2
VPA (min/day)	22.8 ± 6.8	17.4 ± 6.4**	19.7 ± 7.1
Sedentary time (min/day)	563.5 ± 63.9	579.0 ± 56*	572.4 ± 59.8

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545 Means ± SD. BMI = Body mass index, VPA = Vigorous physical activity

546 * Significant difference between boys and girls (p < 0.05)

547 ** Significant difference between boys and girls (p < 0.01)

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FMS AND HEALTH-RELATED OUTCOMES

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553 **Figure 1**

554 Structural equation model of FMS (locomotor skills and object control skills) and their
555 influence on perceived sports competence, VPA (vigorous-intensity physical activity),
556 sedentary time, and BMI z-score in girls, with standardized beta coefficients (* $p < 0.05$;
557 ** $p < 0.01$).

558

559 **Figure 2**

560 Structural equation model of FMS (locomotor skills and object control skills) and their
561 influence on perceived sports competence, VPA (vigorous-intensity physical activity),
562 sedentary time, and BMI z-score in boys, with standardized beta coefficients (* $p < 0.05$;
563 ** $p < 0.01$).

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