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Published in:

Journal of Functional Morphology and Kinesiology

Publication date:

2018

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Citation for published version (APA):

Clark, C. C. T., Moran, J., Drury, B., Venetsanou, F., & Fernandes, J. (2018). Actual vs. Perceived Motor Competence in Children (8–10 Years): An Issue of Non-Veridicality. *Journal of Functional Morphology and Kinesiology*, 3(2), 20. <https://doi.org/10.3390/jfmk3020020>

1 Article

2 **Actual vs. Perceived Motor Competence in Children** 3 **(8-10y): An Issue of Non-Veridicality**

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14 Received: date; Accepted: date; Published: date

15 **Abstract:** The purpose of this study was to investigate the between- and within-sex differences in
16 actual and perceived locomotor and object control skills in children (8-10y). All participants (58
17 children [29 boys; 9.5±0.6y; 1.44±0.09m; 39.6±9.5kg; body mass index; 18.8±3.1 kg·m²]) completed the
18 Test of Gross Motor Development (2nd edition) and the Pictorial Scale of Perceived Movement Skill
19 Competence for Young Children. Between- and within-sex differences were assessed using
20 independent and paired samples *t*-tests, respectively. For all tests, effect sizes and Bayes factors were
21 calculated. There were significant differences ($P<0.001$) between sexes for perceived locomotor and
22 perceived object control skills (boys>girls), with Bayes factors extremely in favour of the alternate
23 hypothesis ($BF: 55,344$ and 460 , respectively). A significant difference ($P<0.001$) was found between
24 girls' actual and perceived locomotor skills ($d=-0.88$; 95% CI: -0.46 to -1.34), with Bayes factors
25 extremely in favour of the alternate hypothesis ($BF: 483$). A significant difference ($P<0.001$) was found
26 between boys' actual and perceived object control skills ($d=0.69$; 95% CI: 0.2 to 1.12), with Bayes
27 factors very strongly in favour of the alternate hypothesis ($BF: 41$). These findings suggest that there
28 exists an issue of non-veridicality between actual and perceived motor competence skills, and their
29 subsets, and a sex-mediated discord in children (8-10y).

30 **Keywords:** Motor Competence; Actual; Perceived; Children; Locomotor; Object Control

31

32 **1. Introduction**

33 A substantial literature base now affirms the association between childrens' motor competence
34 (MC) and physical activity (PA) behaviours, potentially, to combat the global obesity epidemic [1-4].
35 Motor competence refers to a child's ability to perform a wide range of motor skills in a proficient
36 manner [5]. During early childhood, motor competence is frequently defined as proficiency in the
37 performance of fundamental motor skills (FMS) [3,6]. Fundamental motor skills are considered to be
38 the basic building blocks to more advanced movement patterns [7], and generally consist of
39 locomotor and object control skills. Locomotor skills necessitate moving the body from one position
40 to another (i.e., running, leaping, jumping, and galloping) while object control skills either refer to
41 the receiving or propulsion of an object with the hand or foot (i.e., throwing, kicking, striking, and
42 catching [8].

43 Despite the mounting evidence for the benefit of qualifying contextual MC or movement quality
44 data, there remains an over-predominance in focusing on the quantity of activity, rather than the

45 quality [9,10]. Only recently, has there been a trend towards a joint consideration of exercise quantity
46 and quality [9-14]. A pivotal meta-analysis highlighted that PA interventions dedicated to improving
47 quantity of PA report little effect [15]. More recently, Adab, *et al.* [16] reported in a longitudinal study,
48 that a one-year, school/community based, PA intervention had no effect on body mass index (BMI)
49 z-scores, at 15- or 30-months post-intervention, highlighting that communities and schools are
50 unlikely to impact on the childhood obesity epidemic by incorporating only PA targeted
51 interventions.

52 Given the above evidence, it is clear that the approach to PA promotion in youth must move
53 beyond the mere use of caloric expenditure as the primary measure of exercise intensity. This notion
54 has been largely influenced by the agglomerative evidence on the complex and dynamic
55 interrelationships between weight status, health related fitness, motor and cognitive development
56 through childhood and beyond [3,17-20]. Further, motor skill competence (i.e., the qualitative
57 proficiency in performing an array of skills requiring motor coordination and control) has been
58 highlighted for its positive associations with PA levels and health benefits in children and adolescents
59 [21].

60 Stodden, Goodway, Langendorfer, Robertson, Rudisill, Garcia and Garcia [6] developed a
61 comprehensive conceptual model that asserts that childhood MC is a determinant of health.
62 Concomitantly, Barnett, *et al.* [22] demonstrated, albeit prospectively, that childhood MC has a
63 fundamental role for long-term PA compliance and is predictive of health-related fitness later in life.
64 These pivotal works have prompted a new line of developmental research that, by means of cross-
65 sectional, longitudinal and experimental evidence [23], have confirmed the inveterate nature of the
66 Stodden, Goodway, Langendorfer, Robertson, Rudisill, Garcia and Garcia [6] conceptual model.
67 Interestingly, children's perception of being competent, and not MC *per se*, matters for promoting and
68 adhering to an active lifestyle, which is necessary for positive trajectories of health and well-being
69 [24]. Longitudinal research has identified perceived MC as a mechanism through which motor skill
70 proficiency in childhood contributes to a physically active and healthy lifestyle in adolescence [25-
71 28]. Given the influence that both actual and perceived MC in childhood can have as health
72 determinants, empirical research has focused on furthering our understanding of their dynamic and
73 changing relationship throughout childhood and adolescence [6,29].

74 Masci, *et al.* [30] highlight that children and adolescents with different MC-based profiles also
75 differ in motivation to practice PA, and actual PA levels. Furthermore, perceived, more than actual
76 competence, appears to determine motivation for PA participation in children [31]. In the studies of
77 Bardid, De Meester, Tallir, Cardon, Lenoir and Haerens [31] and De Meester, *et al.* [32], primary
78 school children had a higher perception of MC resulted in higher motivation with this motivation
79 remaining even when a low level of actual motor proficiency was combined with high self-perception
80 (i.e., overestimation). Commonality exists between the aforementioned studies in the form of
81 (non)veridicality of the physical self-concept, defined as the relation between the subjective
82 perception and the corresponding external validity criterion. However, this issue remains relatively
83 unexplored [33].

84 A general axiom is that boys tend to be more physically active than their female counterparts
85 [34,35], and generally display better object control skills than girls, however, evidence on sex
86 differences in locomotor skills is equivocal [36,37]. Contentiously, many studies show that girls
87 outperform boys in locomotor skills [26,38,39], whilst a comparable number of studies assert that
88 boys have equal [40,41] or higher locomotor skill competence [42]. Concerning the perception of MC,
89 sex differences seem to proliferate during child development [29,43,44]. Whilst some studies report
90 that boys and girls around the pre-school years display equal perceptions of competence, from
91 primary school years onward, higher self-perceptions in boys are consistently found [29,45-47].
92 Notwithstanding, differences between actual and perceived MC in young children are widespread,
93 yet equivocal; as is the discord between sexes, which remains contentious and relatively unexplored.
94 Therefore, the purpose of this study was to investigate the between- and within-sex differences in
95 actual and perceived locomotor and object control skills in children (8-10y).

96 2. Materials and Methods

97 *Participants and settings*

98 A sample of 58 children (29 boys) (mean \pm standard deviation: 9.5 \pm 0.6y, 1.44 \pm 0.09m, 39.6 \pm 9.5kg,
99 body mass index; 18.8 \pm 3.1 kg.m²) from a primary school in the United Kingdom volunteered to take
100 part in this study. Optimal sample size was calculated based upon the ability to detect a smallest unit
101 change (raw score) of 0.5% and a generous between subject standard deviation of 2.0 (alpha = 0.05,
102 power 0.95). This subsequently yielded a sample-size estimation of 57. To equalize the ratio of males
103 to females, 58 participants were recruited and divided into two groups (29 males, 29 females). Prior
104 to the research commencing, parental or legal guardian informed consent and child assent was
105 attained. The study was conducted in agreement with the guidelines and policies of the institutional
106 ethics committee, and in accordance with the Declaration of Helsinki.

107 *Instruments and Procedures*

108 *Actual motor competence.* Childrens' actual MC was measured using the Test of Gross Motor
109 Development (2nd edition) (TGMD-2) [48]. The TGMD-2 includes 12 fundamental movement skills
110 (six locomotor, and six object control skills) and takes approximately 20 min to administer. The
111 locomotor subtest consists of running, galloping, hopping, leaping, horizontal jumping and sliding.
112 The object control subtest contains striking a stationary ball, a stationary dribble, catching, kicking,
113 overhand throwing and underhand rolling. Following a visual demonstration, participants were
114 asked to perform each skill twice. The TGMD-2 is a qualitative measure in which each skill is scored
115 against performance criteria prescribed in an accompanying manual (3-5 criteria per skill); the criteria
116 were scored 1 (present) or 0 (absent). Ratings in each item were summed to compute scores for
117 locomotor and object control skills (each score ranging from 0 to 48). The psychometric properties of
118 the TGMD-2 have been evaluated and the manual reports excellent test-retest reliability and inter-
119 rater reliability ($r > 0.85$) as well as a good internal consistency (Cronbach's $\alpha = 0.85$ and 0.88 for
120 locomotor and object control subtests respectively). Construct, content and concurrent validity have
121 also been determined for children aged 3 to 10 years [48-50]. Two experienced assessors scored the
122 TGMD-2, with excellent inter-rater reliability (ICC: 0.99).

123
124 *Perceived motor competence*

125 Children's perceived MC was assessed via The Pictorial Scale of Perceived Movement Skill
126 Competence for Young Children (PSPMSC) [51] for the same locomotor and object control skills as
127 the TGMD-2. The perceived MC assessment took approximately 10 min to administer. For each skill,
128 children were shown two sex-specific illustrations of a child performing the skill in competent and
129 less-competent ways. Children were asked which depiction they identified themselves with the most
130 with each question having the same standard structure: "This child is pretty good at X, this child is
131 not that good at X: Which child is most like you?" Once children selected a picture, they were then
132 asked to further indicate their perceived MC as more or less identifying with the selected picture. For
133 the picture of the most competent child, the follow-up question was: "Are you pretty good or really
134 good at X?", for the picture of the less competent child, the accompanying question was: "Are you
135 sort of good or not that good at X?", each item was scored 1 (not that good), 2 (sort of good), 3 (pretty
136 good) or 4 (really good). Scores for locomotor and object control skills were summed to compute
137 scores for locomotor and object control skills (each score ranging from 6 to 24). The PSPMSC has been
138 shown to have acceptable face validity as well good test-retest reliability ($r > 0.78$) and internal
139 consistency (Cronbach's $\alpha = 0.60-0.81$; Barnett et al., [51]). Construct validity has also been established
140 in children aged 4 to 10 years [48-50,52].

141 *Data analysis*

142 Raw scores for the TGMD-2 and The PSPMSC were transformed into percentiles to facilitate
143 statistical analyses, per manual guidelines [48]. Data were initially assessed for normality using a
144 Shapiro-Wilk test, and found to be normally distributed ($P > 0.05$). Subsequently, between-sex
145 differences for actual locomotor, actual object control, perceived locomotor and perceived object

146 control percentiles were assessed using independent samples *t*-tests. Within-sex differences for actual
 147 vs. perceived locomotor and object control percentiles were assessed using paired samples *t*-tests.
 148 Bayesian statistical analyses were conducted for within- and between-sex differences utilizing default
 149 priors [53-55], where Bayes factors expressing the probability of the data given H_{10} (alternate
 150 hypothesis) relative to H_{01} (null hypothesis; i.e., values larger than 1 are in favour of H_1) assuming that
 151 H_{01} and H_{10} are equally likely, were produced. Data were reported as mean±SD, with effect sizes
 152 (Cohens's *d*, classified as; small (0.2), medium (0.5), large (0.8), or very large (1.3) [56] and 95%
 153 confidence intervals (CI)). The alpha level was set at 0.05 *a priori*. Bayes factors were reported as the
 154 probability of the data given the alternate, relative to the null hypothesis, or vice-versa (classified as;
 155 anecdotal (BF_{1-3}), moderate (BF_{3-10}), strong (BF_{10-30}), very strong (BF_{30-100}), or extreme ($BF_{>100}$) [53-
 156 55]. All data analyses were conducted using the JASP statistical package (JASP Team, 2018, jasp-
 157 stats.org).

158 **3. Results**

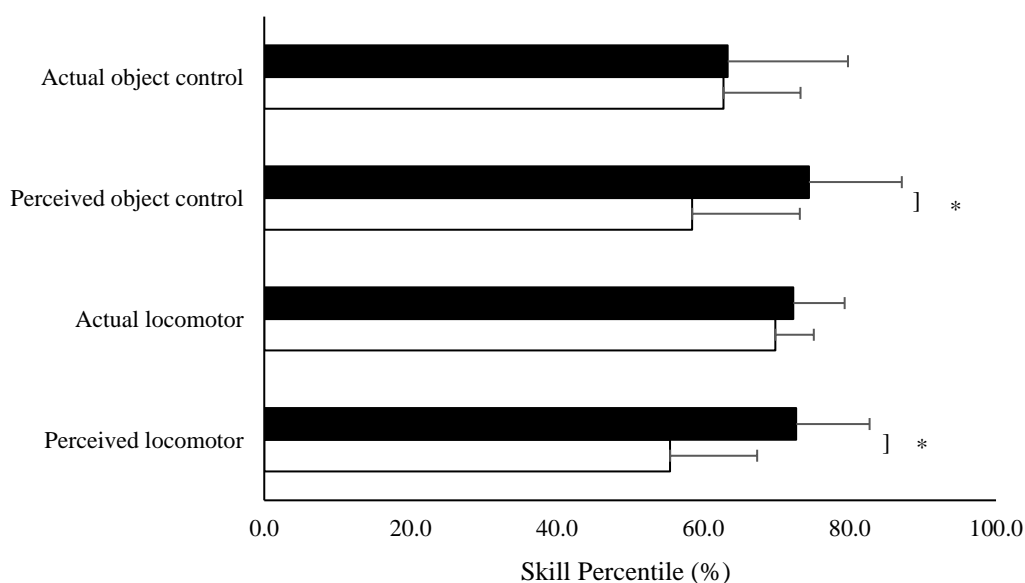
159 *Between sex differences*

160 There was no significant difference ($P=0.15$) found between sexes for actual locomotor skills (F:
 161 69.8 ± 5.27 vs. M: $72.3\pm 7.47\%$; $d = 0.38$, 95% CI: 0.14 to 0.9) (Figure. 1). Bayes factors found anecdotal
 162 evidence in favour of the null vs. alternate hypothesis ($BF: 1.5$, i.e. null 1.5 times more probable than
 163 the alternate).

164 There was no significant difference ($P=0.87$) found between sexes for actual object control skills
 165 (F: 62.75 ± 10.5 vs. M: $63.3\pm 15.2\%$; $d = 0.04$, 95% CI: -0.56 to 0.47) (Figure. 1). Bayes factors found
 166 moderate evidence in favour of the null vs. alternate hypothesis ($BF: 3.72$ i.e. null 3.72 times more
 167 probable than the alternate).

168 There was a significant difference ($P<0.001$) found between sexes for perceived locomotor skills
 169 (F: 55.46 ± 11.8 vs. M: $72.7\pm 10.2\%$; $d = 1.6$, 95% CI: 0.95 to 2.14) (Figure. 1). Bayes factors found extreme
 170 evidence in favour of the alternative vs. null hypothesis ($BF: 55,344$, i.e. alternate 55,244 times more
 171 probable than the null).

172 There was a significant difference ($P<0.001$) found between sexes for perceived object control
 173 skills (F: 58.5 ± 14.7 vs. M: $74.4\pm 12.6\%$; $d = 1.17$, 95% CI: 0.6 to 1.71) (Figure. 1). Bayes factors found
 174 extreme evidence in favour of the alternate vs. null hypothesis ($BF: 460$ i.e. alternate 460 times more
 175 probable than the null).



176
 177 **Figure 1.** Between-sex perceived and actual, locomotor and object control skill percentile scores. Black
 178 bars denote boys; white bars denote girls; * denotes significant difference between sexes ($P<0.05$).

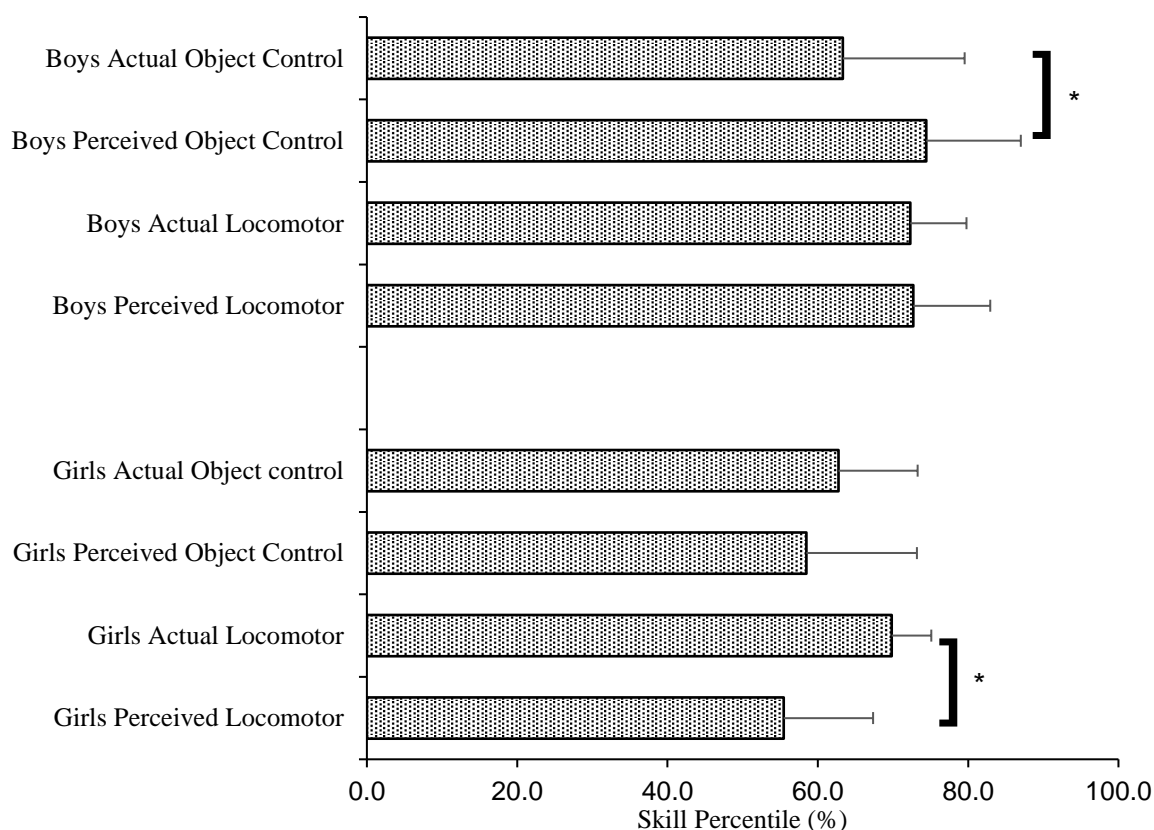
179 *Within sex differences*

180 There was a significant difference ($P < 0.001$) found between girls actual and perceived locomotor
 181 skills (Actual 69.8 ± 5.2 vs. Perceived $55.5 \pm 11.9\%$; $d = -0.88$, 95% CI: -0.46 to -1.34) (Figure. 2). Bayes
 182 factors found extreme evidence in favour of the alternative vs. null hypothesis ($BF: 483$ i.e. alternate
 183 483 times more probable than the null).

184 There was no significant difference ($P = 0.06$) found between girls actual and perceived object
 185 control skills (Actual 62.8 ± 10.5 vs. Perceived $58.4 \pm 14.7\%$; $d = -0.36$, 95% CI: -0.02 to -0.74) (Figure. 2).
 186 Bayes factors found anecdotal evidence in favour of the null vs. alternate hypothesis ($BF: 1.01$ i.e. null
 187 1.01 times more probable than the alternate).

188 There was no significant difference ($P = 0.84$) found between boys actual and perceived locomotor
 189 skills (Actual 72.3 ± 7.5 vs. Perceived $72.7 \pm 10.2\%$; $d = 0.04$, 95% CI: -0.41 to 0.33) (Figure. 2). Bayes
 190 factors found moderate evidence in favour of the null vs. alternate hypothesis ($BF: 4.97$ i.e. null 4.97
 191 times more probable than the alternate).

192 There was a significant difference ($P < 0.001$) between boys actual and perceived object control
 193 skills (Actual 63.3 ± 16.2 vs. Perceived $74.4 \pm 10.2\%$; $d = 0.69$, 95% CI: 0.2 to 1.12) (Figure. 2). Bayes factors
 194 found very strong evidence in favour of the alternative vs. null hypothesis ($BF: 41$ i.e. alternate 41
 195 times more probable than the null).



196

197 **Figure 2.** Within-sex differences for perceived and actual locomotor and object control skill percentile
 198 scores. * denotes significant difference between actual and perceived scores ($P < 0.05$).

199 **4. Discussion**

200 The purpose of this study was to investigate the between- and within-sex differences in actual
 201 and perceived locomotor and object control skills in children (8-10y). In accord with the
 202 aforementioned purpose, the key findings of this study were,

- 203 1) Boys perceived their locomotor and object control skills to be greater than girls.
- 204 2) Girls perceived their locomotor skills to be lower than their actual locomotor skills.
- 205 3) Boys perceived their object control skills to be greater than their actual object control skills.

206 **Between-sex differences**

207 Evidence on sex differences in locomotor skills is equivocal [26,36,37,57]. Contentiously, many
208 studies show that girls outperform boys in their locomotor skills [26,38,39], whilst almost an equal
209 number of studies assert that boys have equal [40,41] or higher locomotor skill competence [42]. It is,
210 therefore, unsurprising that the findings of the present study should be equally equivocal for actual
211 MC (locomotor and object control). There was no significant difference ($P=0.15$) between boys and
212 girls for actual locomotor skills (Figure. 1), highlighting very little discord between actual locomotor
213 skills between sexes. Furthermore, Bayes factors indicated that there was only anecdotal evidence to
214 separate the null and alternate hypotheses. Similarly, there was no significant difference ($P=0.87$)
215 between sexes for actual object control skills (Figure. 1), further supporting the observations of
216 Bardid, De Meester, Tallir, Cardon, Lenoir and Haerens [31] and Slykerman, Ridgers, Stevenson and
217 Barnett [41].

218 There was a significant difference ($P<0.001$) found between sexes for perceived locomotor skills,
219 where boys perceived themselves to be ~20 percentage points higher than girls (Figure. 1). This is
220 supported by Bayes factors analysis, which found extreme evidence in favour of the alternative vs.
221 null hypothesis ($BF: 55,344$). Similarly, boys also perceived their object control skills to be greater than
222 that of the girls with a significant difference ($P<0.001$) found between sexes (Figure. 1). Bayes factors
223 found 'extreme' evidence in favour of there being a difference between sexes ($BF: 460$). Whilst the
224 present study highlights differences in perceived, but not in actual, object control and locomotor
225 skills, Brian, *et al.* [58] concluded that there was relatively little sex-related discord for perceived and
226 actual locomotor skills, however there were evident differences for perceived and actual object
227 control skills. This difference is likely influenced by age with Brian, *et al.* [58] assessing 4 to 5 year
228 olds, contrasting with the 8 to 10 year olds in the present study. Concerning the perception of MC,
229 sex-mediated differences are found to proliferate during child development [43,44]. The modal
230 finding in the literature is that boys and girls around the pre-school years display equal perceptions
231 of competence [59,60]. However, from primary school years onward, higher self-perceptions in boys
232 are consistently found [45,46], which supports the findings in the present study.

233 **Non-veridicality in boys and girls**

234 Masci, Schmidt, Marchetti, Vannozzi and Pesce [30] highlighted low agreement between motor skill
235 competence perceived by children and their actual skill observed by experts, as the percentage of
236 variance of perceived competence explained by actual competence was low (5% and 6% for locomotor
237 and object control skills, respectively). The authors' speculated that this was due to the low accuracy
238 of self-perceptions when cognitive capabilities necessary to make a realistic domain-specific self-
239 evaluation are still immature [43,44]. Substantial evidence suggests that girls have lower perceived
240 and actual ball skill competence than boys as early as young childhood [26,38,39,51,61].
241 Independently of their actual proficiency level, Masci, Schmidt, Marchetti, Vannozzi and Pesce [30]
242 suggest that girls more frequently underestimated their actual object control skills than boys. The
243 observation that girls more frequently underestimate their actual object control skills compared to
244 boys may be pertinent in light of evidence that object control skills predict involvement in PA and
245 health related fitness later in life [25,57,62]. Further, evidence suggests that the perception of
246 competence in object control skills mediates the translation of actual MC into health-related outcomes
247 [22,51,62]. The present study supports these findings, but for boys only, where a significant difference
248 ($P<0.001$) was found between boys actual and perceived object control skills (Figure. 2). Further,
249 Bayes factors confirmed, very strongly, in favour of the alternative vs. null hypothesis ($BF: 41$). Whilst,
250 conversely, for girls, with regards to object control skills, high veridicality was displayed, with only
251 a small, negative effect size being found (Figure. 2).

252 Masci, Schmidt, Marchetti, Vannozzi and Pesce [30] reported that around one quarter of boys
253 overestimated their object and locomotor control skills more frequently than girls. The present study
254 supports the inference that boys overestimate and girls underestimate MC levels. Interestingly, this
255 study also found that actual levels of locomotor and object control skills were comparable. Despite
256 this, a large sex-mediated discord was evident for girls locomotor skills, indicating that they

257 systematically under-perceived their actual locomotor competence. Boys, however, systematically
258 over-perceived their actual object control skills. *De Meester, et al. [63]* noted four distinct groups for
259 actual and perceived MC, two groups with high veridicality, i.e. high actual and high perceived, or
260 low actual and low perceived MC. However, the authors also identified a subset of their sample
261 which systematically over or underestimated its actual MC skill. Interestingly, the strongest correlate
262 of high PA and low BMI was not high actual MC, but high perceived MC. Furthermore, in a
263 comparable population, *De Meester, Maes, Stodden, Cardon, Goodway, Lenoir and Haerens [63]* found no
264 apparent sex-mediated discord, yet *De Meester, Stodden, Brian, True, Cardon, Tallir and Haerens [32]*
265 highlighted this as an issue. Whilst the present study focused on the sex-mediated differences
266 between actual and perceived MC, and not the concept of over- or under-estimation, the present
267 findings are in general concordance with recent evidence [30,63].

268 Limitations

269 One limitation of the present study is its cross-sectional design. Causal inference cannot be
270 assumed regarding actual MC and perceived MC. To gain more insight into these differences and to
271 understand how differences within- and between-the sexes may change or develop over time,
272 longitudinal studies must be conducted. Another possible limitation is the use of a convenience
273 sample, which may result in under or over-representation of particular groups within a sample, but
274 should not detract from the suitably (statistically) powered nature of the study.

275 Conclusion

276 To the authors' knowledge, this is the first study to assess between and within-sex differences
277 for actual and perceived locomotor and object control skills. Furthermore, this would appear to be
278 the first study to incorporate Bayes factor inferences in the analyses of children's MC.

279 The finding that boys' and girls' actual locomotor and actual object control skills are comparable,
280 despite differences in perceptions, is in line with current literature. The novel analytical approach
281 taken in this study to focus on sex-mediated differences in MC adds clarity to an equivocal set of
282 results in the literature. Given the large (effect sizes) and extreme (Bayes factors) differences found
283 between actual and perceived locomotor and object control skills, it is clear that non-veridicality, with
284 regard to MC, in young children is a problem. Further, the propensity of young boys and girls to
285 over, or under perceive, respectively, needs to be acknowledged and addressed by, in particular,
286 schools and key stakeholders in childrens' PA and this should be considered in any related
287 intervention. It is advisable that future research considers not only variable and person-centered
288 approaches, but also the clear sex-mediated differences in perceived and actual MC, including its
289 subsets, and the impact on PA.

290 **Acknowledgments:** The authors wish to acknowledge the time, effort and dedication of the children involved
291 in this study.

292 **Supplementary material:** Figure 1 (Between-sex perceived and actual, locomotor and object control skill
293 percentile scores) and Figure 2 (Within-sex differences for perceived and actual locomotor and object control
294 skill percentile scores). Research data also supplied as supplementary file.

295 **Author Contributions:** CC conceived and designed the experiments; CC performed the experiments; CC and JF
296 analyzed the data; CC, BD, FV, JF and JM wrote the paper.

297 **Conflicts of Interest:** The authors declare no conflict of interest.

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