

FUNDAMENTAL MOVEMENT SKILLS OF PRESCHOOL CHILDREN IN NORTHWEST  
ENGLAND<sup>1,2,3</sup>

J. D. FOULKES AND Z. KNOWLES

*Physical Activity Exchange, Research Institute for Sport & Exercise Sciences, Liverpool John Moores  
University, UK*

S. J. FAIRCLOUGH

*Department of Sport and Physical Activity, Edge Hill University, UK; Department of Physical  
Education and Sports Science, University of Limerick, Ireland*

G. STRATTON

*Applied Sports Technology Exercise and Medicine Research Centre College of Engineering, Swansea  
University, UK*

M. O'DWYER

*Early Childhood Ireland, Dublin, Ireland*

N. D. RIDGERS

*Centre for Physical Activity and Nutrition Research (C-PAN), Deakin University, Australia*

---

<sup>1</sup> Address correspondence to Jonathan Foulkes, Physical Activity Exchange, 62 Great Crosshall Street, Liverpool, L3 2AT, UK or email (J.D.Foulkes@2007.ljmu.ac.uk)

<sup>2</sup> Nicola Ridgers is supported by an Australian Research Council Discovery Early Career Researcher Award (DE120101173)

<sup>3</sup> Funding for the Active Play Project was provided by Liverpool Area Based Grants and the SportsLinx Programme and Liverpool John Moores University. We would like to thank our partners from Liverpool City Council/SportsLinx (Liz Lamb), the Active Play management (Pam Stevenson) and delivery team (Richard Jones, Adam Tinsley and Julie Walker), the Liverpool Early Years Team and the LJMU Physical Activity, Exercise and Health research group work bank volunteers who assisted with data collection.

L. FOWEATHER

*Department of Sport and Physical Activity, Edge Hill University, UK*

1 *Summary.* - This cross-sectional study examined fundamental movement skill competency among  
2 deprived preschool children in Northwest England and explored sex differences. A total of 168  
3 preschool children (age 3-5 years) were included in the study. Twelve skills were assessed using the  
4 Children's Activity and Movement in Preschool Motor Skills Protocol and video analysis. Sex  
5 differences were explored using independent t-tests, Mann-Whitney U-test and Chi Square analysis at  
6 the subtest, skill and component levels, respectively. Overall competence was found to be low  
7 amongst both sexes, although it was higher for locomotor skills than for object-control skills. Similar  
8 patterns were observed at the component level. Boys had significantly better object-control skills than  
9 girls, with greater competence observed for the kick and overarm throw, whilst girls were more  
10 competent at the run, hop and gallop. The findings of low competency suggest that developmentally-  
11 appropriate interventions should be implemented in preschool settings to promote movement skills,  
12 with targeted activities for boys and girls.

13

14

15           Physical literacy can be considered as having the motivation, confidence, physical  
16 competence, knowledge and understanding that underpin one's values and responsibilities for life-  
17 long purposeful activity and pursuits (Whitehead, 2013). One important element of physical  
18 competence is the acquisition of fundamental movement skills (FMS), which include stability (e.g.  
19 static or dynamic balance), locomotor (e.g. hopping, running and jumping) and object-control skills  
20 (e.g. catching, throwing and kicking) (Gallahue & Donnelly, 2003). FMS are considered the initial  
21 building blocks of more complex movements (Gallahue, Ozmun, & Goodway, 2011), with the  
22 development of FMS competence noted as an important prerequisite for daily life skills and  
23 participation in sports and physical activities (Cools, De Martelaer, Samaey, & Andries, 2009;  
24 Stodden et al., 2008).

25           Physical activity guidelines from the United Kingdom (Department of Health, 2011),  
26 Australia (Department of Health and Aging, 2010), and Canada (Tremblay et al., 2012) broadly  
27 recommend that preschool children engage in at least 180 minutes of physical activity a day, whilst  
28 U.S. guidelines suggest that a minimum of 120 minutes is necessary (National Association for Sport  
29 and Physical Education Active Start, 2009). Cross-sectional studies of European (Burgi et al., 2011;  
30 Fisher et al., 2005; Foweather et al., 2014; Iivonen et al., 2013), Australian (Cliff, Okely, Smith, &  
31 McKeen, 2009) and North American (Williams et al., 2008) preschoolers have found positive  
32 associations between FMS competence and objectively measured light-, moderate- to vigorous-  
33 intensity and total daily physical activity. Whilst these studies mostly indicate a weak association in  
34 young children, the relationship between FMS competence and physical activity is hypothesised to  
35 strengthen with age (Stodden et al., 2008) and two systematic reviews have found strong evidence for  
36 a positive association between FMS competence and physical activity in children and adolescents  
37 (Holfelder & Schott, 2014; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Further, longitudinal  
38 evidence suggests that previous levels of FMS competence amongst British primary school children  
39 (age 6-11 years) positively predicted pedometer-determined daily physical activity one year later  
40 (Bryant, James, Birch, & Duncan, 2014). Likewise, FMS competence during the primary school years  
41 has also been shown to positively, albeit weakly, predict self-reported physical activity in adolescents  
42 (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009). Notably, recent prospective studies have

43 demonstrated that development of FMS competence may have other tangible benefits for health and  
44 development. For example, higher levels of FMS competence have positively predicted  
45 cardiorespiratory fitness (Vlahov, Baghurst, & Mwavita, 2014), improved academic performance  
46 (Jaakkola, Hillman, Kalaja, & Liukkonen, 2015), and are protective against overweight and obesity  
47 (Rodrigues, Stodden, & Lopes, 2015). Together, these studies indicate that improving FMS  
48 competence may be a potential mechanism to increase children's physical activity and improve their  
49 health.

50         Given that the development of FMS competence is important for both the health and wider  
51 development of young children, there is a rationale for establishing the level of competence at these  
52 skills. FMS competence can be evaluated by considering both process and product characteristics of  
53 movement. Product-based measures of FMS are typically quantitative and focus on the end product or  
54 outcome of the movement, e.g. a time, speed or distance (Logan, Robinson, Wilson, & Lucas, 2012).  
55 On the other hand, process-based measures assess how children move and provide rich and detailed  
56 qualitative information on the characteristics or quality of movement patterns (Hardy, King, Farrell,  
57 Macniven, & Howlett, 2010). Thus, process-based measures allow researchers the opportunity to  
58 identify the developmental skill level of the child, rather than their physical growth or maturational  
59 status (Hardy, King, Farrell, et al., 2010), and can therefore be used to plan effective FMS  
60 programmes for young children. Assessments can be undertaken by examiners in situ or subsequently  
61 with video recording, offering more precision in analysis as trials can be replayed and skills  
62 performed at high speeds can be watched in slow-motion playback.

63         The acquisition of FMS is influenced by a range of bio-psychosocial and environmental  
64 factors (Hardy, King, Farrell, et al., 2010; Iivonen et al., 2013). With appropriate encouragement and  
65 opportunities for learning and practice, children have the developmental potential to achieve  
66 competence at FMS by age six (Gallahue & Donnelly, 2003). Yet previous studies using process-  
67 based measures of FMS have indicated low levels of competence among UK (Bryant, Duncan, &  
68 Birch, 2013), Canadian (LeGear et al., 2012) and Australian (Okely & Booth, 2004; Van Beurden,  
69 Zask, Barnett, & Dietrich, 2002) primary school aged children. The suboptimal levels of FMS  
70 competence in older children highlights a need to examine early childhood (2-5 years), which is

71 considered a critical phase for FMS development as a failure to make advancements during this stage  
72 may result in children attaining lower competence levels later on in their development (Gallahue &  
73 Donnelly, 2003). Moreover, this period sees the rapid growth of the brain and neuromuscular  
74 maturation (Malina, Bouchard, & Bar-Or, 2004), which has important implications for motor skill  
75 acquisition. Further, early childhood is considered a ‘window of opportunity’ for FMS development  
76 as young children have high levels of perceived competence (LeGear et al., 2012). From a practical  
77 perspective, this confidence and fearlessness may encourage engagement and persistence in activities  
78 that foster FMS competence (Stodden et al., 2008).

79         Several studies to date have documented levels of FMS competence among preschool  
80 children (Barnett, Ridgers, & Salmon, 2014; Cliff et al., 2009; Goodway, Robinson, & Crowe, 2010;  
81 Hardy, King, Farrell, et al., 2010; Robinson, 2011; Ulrich, 2000) and conclude that, as expected in  
82 young children, these skills are at the rudimentary stage of development. Ulrich (2000) reported low  
83 competency at FMS in a representative sample of 332 US preschool children (ages 3-5) as part of  
84 normative data collected for the Test of Gross Motor Development-2 (TGMD-2), a process-based  
85 measurement tool that assesses six locomotor skills (run, horizontal jump, slide, gallop, leap, and hop)  
86 and six object-control skills (strike, basketball dribble, throw, catch, kick, underhand roll). Hardy,  
87 King, Farrell, et al. (2010) assessed eight skills (run, gallop, hop, horizontal .jump; strike, catch, kick,  
88 throw) in situ using the TGMD-2 in a sample of 330 four-year-old children from New South Wales,  
89 Australia. Although the majority of children were competent at the run, competence levels differed  
90 across the remaining seven skills, ranging from low to moderate. Both studies (Hardy, King, Farrell,  
91 et al., 2010; Ulrich, 2000) also provide detailed descriptive information on competency at the  
92 component level, which is useful for guiding teaching strategies to master individual skill components.  
93 Findings broadly indicated that competency was lowest for skills requiring the use of the arms,  
94 coordinated trunk movement and the transfer of body weight, and highest for locomotor skills  
95 requiring only leg movements (Hardy, King, Farrell, et al., 2010; Ulrich, 2000). Thus whilst  
96 descriptive data is available from preschool samples in Australia (Hardy, King, Farrell, et al., 2010;  
97 Okely & Booth, 2004) and the USA (Ulrich, 2000), data on FMS competence among European  
98 preschool children is lacking (Cools et al., 2009). Such data is important considering that international

99 cultural differences, for example in the educational curriculum or traditional sporting pursuits, may be  
100 reflected in levels of FMS competence (Simons & Van Hombreeck, 2003).

101 A number of studies have examined sex differences in FMS competence amongst young  
102 children using in situ observations (Barnett et al., 2014; Hardy, King, Farrell, et al., 2010) or video  
103 analysis (Cliff et al., 2009; Goodway et al., 2010; Robinson, 2011; Spessato, Gabbard, Valentini, &  
104 Rudisill, 2012) of performance at the TGMD-2. Barnett et al. (2014) and Hardy, King, Farrell, et al.  
105 (2010) assessed FMS competency in 102 and 330 Australian young children, respectively. Both  
106 studies reported boys to have higher levels of object-control competency than girls. Similarly,  
107 Robinson (2011) and Goodway et al. (2010) assessed FMS among 119 and 469 American  
108 preschoolers, respectively, also noting that boys outperformed girls at object-control skills. Moreover,  
109 a recent study of 560 Brazilian children aged 3-6 years provided further evidence that boys have  
110 higher competency for object-control skills (Spessato et al., 2012). However, Cliff et al. (2009) found  
111 no sex differences in object-control skill raw score in a small sample of 46 Australian preschool  
112 children. Findings observed for sex differences among locomotor skills are mixed. Two studies found  
113 that girls had a higher locomotor skill subtest score than boys (Cliff et al., 2009; Hardy, King, Farrell,  
114 et al., 2010). In contrast, Robinson (2011) found boys to be more competent at locomotor skills, while  
115 two other studies found no sex difference (Goodway et al., 2010; Spessato et al., 2012). Only Hardy,  
116 King, Farrell, et al. (2010) have investigated potential sex differences with regards to individual skills  
117 among preschoolers using process-based measures of FMS, though differences in skill components  
118 (performance criteria) were not explicitly examined. Amongst the four locomotor skills assessed in  
119 this study, girls were more competent at the hop, whilst no difference was found for the run, gallop or  
120 horizontal jump. Conversely, for the four object-control skills assessed, boys were found to be more  
121 competent at the strike, kick and overhand throw, although no difference was reported for the catch.  
122 Taken collectively, the evidence examining skill competence in young children suggests that boys  
123 out-perform girls at object-control skills, though there is a lack of consensus in the literature regarding  
124 sex differences in locomotor skills. These findings are consistent with studies in primary school aged  
125 children (LeGear et al., 2012; Bryant et al., 2013; Okely & Booth, 2004; Van Beurden et al., 2002),  
126 and indicate that sex differences and low competence levels track into childhood and adolescence

127 (Hardy, King, Espinel, Cosgrave, & Bauman, 2010; O'Brien, Issartel, & Belton, 2013), highlighting  
128 that both sexes may benefit from interventions. Given the lack of research conducted in UK children  
129 to date, it is important to establish whether similar levels of competence are evident before developing  
130 targeted interventions.

131         Whilst sex may potentially account for differences in FMS development, it has been observed  
132 that socioeconomic (SES) status may also affect competence levels. Previous research amongst  
133 primary-aged children found FMS competence was both positively and consistently related to SES  
134 among girls, although not as consistently as boys (Booth et al., 1999). More recent evidence suggests  
135 that similar aged girls with low SES were twice as likely to be less competent in locomotor skills than  
136 their peers with high SES (Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012). Limited  
137 evidence also indicates that differences in FMS competency exist amongst young children from  
138 differing SES. Goodway et al. (2010) reported that young Hispanic and African-American children  
139 from low SES areas showed delays in locomotor and object-control skill development compared to  
140 those from areas of high SES. Following Newell's (1986) dynamic theory of motor skill development,  
141 whereby development is based on the interaction between the individual, the task constraints and the  
142 surrounding environment, physical and social-cultural environment may affect young children's FMS  
143 development. For example, young children from deprived areas may have limited access to safe  
144 outdoor play areas and lack the necessary family and neighbourhood resources to access equipment  
145 (Goodway & Smith, 2005). Nevertheless, further investigations considering levels of FMS  
146 competence among young children from disadvantaged areas are warranted.

147         To the authors' knowledge, no previous study has assessed FMS competency in European  
148 preschool children from low SES using process-orientated (technique-based) measures and video-  
149 analysis. In addition, we know of no empirical study in young children that has examined sex  
150 differences in all the major individual object-control and locomotor FMS at the component level.  
151 Therefore, the aims of this study were to (i) report detailed FMS competence data among a sample of  
152 preschool children from a deprived area of Northwest England and (ii) to investigate sex differences  
153 in FMS and their respective components. It was hypothesised that boys will show greater competence



154 at object-control skills than girls, though no sex differences were expected for locomotor skill  
155 competency.

156

157 Method

158 *Participants and settings*

159 Baseline data for this study were drawn from the Active Play Project, which has been  
160 described in detail elsewhere (O'Dwyer et al., 2013). Briefly, the project was funded by the Local  
161 Authority in response to a growing awareness of the need to establish health behaviours, such as  
162 participation in physical activity, from an early age. The project consisted of a six-week educational  
163 programme directed at preschool staff and children with the aim of increasing children's physical  
164 activity levels, developing FMS, strength, agility, co-ordination and balance, and increasing children's  
165 self-confidence. Baseline data collection took place over two phases, with six schools assessed in  
166 October 2009 and the remaining six assessed in March 2010. This design was used in order to  
167 maximise recruitment and to control for the influence of any seasonal variation (Kolle, Steene-  
168 Johannessen, Andersen, & Anderssen, 2009). Both the Active Play Project and the present study were  
169 approved by the University Ethics Committee (Reference 09/SPS/027).

170 Twelve preschools located in a large urban city in Northwest England were randomly selected  
171 and invited to participate in the study. Due to funding requirements, each preschool was situated in a  
172 neighbourhood within the highest 10% for national deprivation (i.e. most deprived) (Department of  
173 Communities and Local Government, 2010). These preschools were selected in order to help address  
174 health inequities and improve indicators of child health such as childhood obesity (12.2% of five year  
175 olds were obese) and physically active children that were significantly worse than the national  
176 average (Association of Public Health Observatories, 2009). Each preschool was attached to a  
177 SureStart children's centre, the role of these centres was to provide advice, support and services for  
178 parents and carers of children aged 5 years or under who resided in the most disadvantaged parts of  
179 England (Children, Schools and Families Committee, 2010). All twelve preschools agreed to  
180 participate in the study. At the time of data collection, all three and four year old children in England  
181 were entitled to 15 hours of free preschool education for 38 weeks of the year. Classes occurred from

182 Monday to Friday, starting at 09:00 and finishing at approximately 15:00. Preschools were required to  
183 follow the Early Years Foundation Stage curriculum (Department for Children, Schools and Families,  
184 2008), which emphasised play-based learning and development in six main areas (personal, social and  
185 emotional development; communication, language and literacy; problem solving, reasoning and  
186 numeracy; knowledge and understanding of the world; physical development, and creative  
187 development).

188 All children aged 3-4.9 years old from the twelve preschools were invited to participate ( $n =$   
189 673). To participate in the study active consent was required, which involved parents providing  
190 informed written consent, demographic information (home postcode, child ethnicity and child's date  
191 of birth) and medical assessment forms. All children were eligible to participate, however, those  
192 diagnosed with health or co-ordination issues that could affect motor development were excluded  
193 from analysis. Of 240 children who provided full parental consent, 168 children ( $M$  age = 4.65 yr.,  $SD$   
194 = 0.58; 54.1% boys; 25.8% Overweight/Obese; 80.9% White British; 93.6% lived in low SES area)  
195 completed FMS assessments and were included in the final analysis. Reasons for missing or  
196 incomplete data included absence from testing days and children unexpectedly having to return to  
197 class prior to completion of all skill assessments due to curricular demands.

198

### 199 *Measures*

200 *Fundamental Movement Skills* - Testing followed the protocol laid out in the Test of Gross  
201 Motor Development-2 (TGMD-2) (Ulrich, 2000), which is specifically designed and validated for use  
202 with children aged 3-10 years (Ulrich, 2000). The TGMD-2 measures the performance of 12 FMS,  
203 including six locomotor (run, broad jump, leap, hop, gallop and slide) and six object-control (overarm  
204 throw, stationary strike, kick, catch, underhand roll and stationary dribble) skills. Prior to data  
205 collection field testers were trained by a senior member of the research team (LF) who has significant  
206 experience in administering the TGMD-2, through in-situ observation. Children completed the  
207 TGMD-2 in small groups (2-4) led by two field testers, in either school halls or on school playgrounds,  
208 dependent on available facilities. The first tester was responsible for recording each trial, using a  
209 tripod mounted video camera (Sanyo, Japan), while the second provided a verbal description and

210 single demonstration of the required skill. Children performed each skill twice. If a child did not  
211 understand the task correctly (for example, running in the wrong direction) then they were given a  
212 further verbal description of the skill and asked to repeat the trial. The twelve skills were completed in  
213 a standardised order, taking approximately 35-40 minutes per group.

214 All video recordings were transferred to DVD for subsequent video analysis. Skill  
215 competence was assessed using The Children's Activity and Movement in Preschool Study Motor  
216 Skills Protocol (CMSP; (Williams et al., 2009), which was developed using the TGMD-2 (Ulrich,  
217 2000) and has an identical protocol. The CMSP is a process-orientated assessment, evaluating each  
218 skill based on the child's demonstration of specific movement components, such as "*arms move in*  
219 *opposition to legs, elbows bent*" (see Tables 1 and 2 of (Williams et al., 2009). The CMSP was  
220 selected for the assessment of FMS as its additional performance criteria and alternate scoring  
221 methods improved assessment sensitivity (Williams et al., 2009). The CMSP has demonstrated high  
222 reliability ( $R=0.94$ ), interobserver reliability ( $R=0.94$ ) and concurrent validity when compared with  
223 the TGMD-2 ( $R=0.98$ ) (Williams et al., 2009). In the present study all analyses were completed by a  
224 single trained assessor (JF) who received 30 hours of training from a member of the research team  
225 experienced in conducting video analysis (LF). Inter-rater reliability was established prior to  
226 assessment using pre-coded videotapes of 10 children, with 83.9% agreement across the twelve skills  
227 (range 72.9-89.3%). Likewise, intra-rater reliability was established using pre-coded videotapes of a  
228 further 10 children, with test-retest conducted one week apart, with 91.9% agreement established  
229 across the twelve skills (range 89.0-96.0%). Whilst there is no accepted minimum level of percentage  
230 agreement, 80-85% agreement has been previously deemed to be acceptable (van der Mars, 1989). If  
231 the assessor was unsure whether a child had met a performance criteria then the footage was viewed  
232 by both JF and LF, with final scoring agreed upon between the two.

233 In line with the CMSP's (Williams et al., 2009) assessment criteria, for each skill and during  
234 both trials, individual components (ranging from 3 to 8, dependent upon the skills) were marked as  
235 being absent (0) or present (1). The only exceptions to this scoring system were components 4 and 5  
236 of the throw and strike, whereby hip/trunk rotation was scored as differentiated (2), block (1) or no  
237 rotation (0), whilst the catch identified a successful attempt as having been "*caught cleanly with*

238 *hands/fingers*” (2) or “*trapped against body/chest*” (1). If a skill component was successfully  
239 demonstrated in both trials, then it was classed as present. Following the outcome measures of the  
240 CMSP (Williams et al., 2009), the number of skill components classed as present were summed to  
241 create a total score, whilst locomotor and object-control scores were created by summing the number  
242 of components present within each subscale.

243 *Anthropometry* - Body mass (to the nearest 0.1 kg) and stature (to the nearest 0.1 cm) were  
244 measured using digital scales (Tanita WB100-MA, Tanita Europe, The Netherlands) and a portable  
245 stadiometer (Leicester Height Measure, SECA, Birmingham, UK), respectively. Body mass index  
246 (BMI, kg/m<sup>2</sup>) was calculated and converted to BMI-z scores using the “LMS” method of analysis  
247 (Cole, Bellizzi, Flegal, & Dietz, 2000).

248 *Analysis* - Data were analysed using SPSS v20.0. Descriptive statistics were calculated by sex  
249 and reported as means ( $\pm$  SD) and median ( $\pm$  IQR) for normally (decimal age, total score, locomotor  
250 score, object-control score, BMI score and deprivation level) and non-normally distributed (individual  
251 skill scores) data, respectively. Normality was assessed using the Kolmogorov-Smirnov test and the  
252 interpretation of histogram and q-q plots. Transformation did not improve distribution, therefore sex  
253 differences in individual skill scores were examined using Mann-Whitney U tests and differences in  
254 total, locomotor and object-control scores were examined using independent t-tests. Sex differences in  
255 competence level for individual skill components were tested using chi-square analysis. Univariate  
256 ANCOVAs were conducted to examine sex differences in total and subscale scores, controlling for  
257 age, deprivation score (home postcode data was entered into ‘Geoconvert’, a free online tool that  
258 calculates indices of multiple deprivation based on income, employment, education, health, crime,  
259 access to services and living environment) and body mass index z score. However, differences  
260 between adjusted and unadjusted models were negligible and therefore all results are presented  
261 unadjusted. Statistical significance was set at  $p < 0.05$ .

262

263

## Results

264

265 Table 1 presents descriptive statistics and sex differences for the study sample. There were no  
266 significant sex differences in age, deprivation level or anthropometric variables. Competency levels  
267 were found to be low among both sexes for all skills, except for the run, slide and leap, with greater  
268 competency found for locomotor skills in comparison to object-control skills. No significant  
269 differences in either total ( $p = 0.411$ ) or locomotor ( $p = 0.108$ ) score were observed between sexes.  
270 However, a significant difference in object-control score was found ( $p = 0.002$ ), with boys showing  
271 greater competence than girls.

272

273

Insert Table 1 here

274

275 Table 2 provides data on individual skill scores. For object-control skills, boys scored  
276 significantly higher than girls in both the throw ( $z = -1.97$ ,  $p = 0.049$ ) and kick ( $z = -4.20$ ,  $p = <0.001$ ).  
277 For locomotor skills, girls scored significantly higher than boys in the run ( $z = -2.00$ ,  $p = 0.046$ ), hop  
278 ( $z = -2.57$ ,  $p = 0.010$ ) and gallop ( $z = -2.98$ ,  $p = 0.003$ ). No further sex differences were found.

279

280

Insert Table 2 here

281

282 Tables 3 and 4 provide descriptive information on the proportion of boys and girls  
283 successfully demonstrating competency at individual skill components. Significant sex differences  
284 were observed for seven of the 35 locomotor skill components (see Table 3). Boys were significantly  
285 more competent than girls for two components, the first of which required the use of the arms during  
286 the run (C1) and the second related to maintaining correct body position during the slide (C2). Four of  
287 the components girls were found to be significantly more competent at required correct leg  
288 movement/feet placement, during the run (C4), hop (C2 and C5) and gallop (C4), with competency  
289 levels ranging between 16.6% and 22.9% higher than boys. Girls were also found to be significantly  
290 more competent for an additional criterion of the run (C6). Both boys and girls showed high levels of  
291 competence ( $\geq 80.0\%$ ) for the following components: run (C2 and C3), leap (C2), gallop (C1 and C5)  
292 and slide (C1). Conversely, low levels of competence ( $\leq 30\%$ ) were observed for both sexes for skill

293 components in the jump (C1 and C2), hop (C4 and C6), gallop (C6) and slide (C2), with even lower  
294 competency levels ( $\leq 5.0\%$ ) observed for the jump (C4), leap (C3), hop (C3), gallop (C2 and C3) and  
295 slide (C3).

296

297 Insert Table 3 here

298

299 Boys were more competent than girls for each of the five object-control skill components that  
300 showed a significant sex difference (see Table 4). Boys were significantly more competent for three  
301 components of the kick requiring coordination of the legs (C1, C2 and C5), with competency levels  
302 between 20.9% and 33.8% higher than that of girls. Boys showed further significant differences in  
303 competency relating to trunk movement (throw, C2) and body position (strike, C2). Low competence  
304 was observed for the majority of components, with competency levels of  $\geq 50\%$  for both sexes found  
305 in only eight of the 39 object-control skill components; strike (C2, C5, C6 and C7), kick (C2, C4 and  
306 C6) and roll (C4). Competence levels were found to be  $\leq 30\%$  for both sexes in at least one component  
307 of each object-control skill; throw (C1, C2, C3, C6 and C7), strike (C2), kick (C4) catch (C1), roll (C2  
308 and C6) and dribble (C3 and C4). Whilst a further six components had competence levels of  $\leq 5.0\%$   
309 for both sexes; throw (C4), strike (C4), catch (C3 and C4) and dribble (C2 and C5).

310

311 Insert Table 4 here

312

313 Discussion

314

315 This study examined FMS competency in preschool boys and girls living in a low SES area of  
316 North-West England. Low competence levels were found across all skills, with the exception of the  
317 run, leap and slide, whilst children performed better at locomotor skills than object-control skills. No  
318 significant sex differences were observed for either total or locomotor score, though boys were found  
319 to have a significantly higher object-control score than girls. These findings support the study's  
320 hypothesis and are consistent with previous research in young children (Barnett et al., 2014; Hardy,

321 King, Farrell, et al., 2010). Furthermore, sex differences were observed for individual skill scores,  
322 with boys more competent at the throw and kick and girls more competent at the run, hop and gallop.  
323 Whilst at the component level, girls were more proficient at components requiring correct leg  
324 movement/feet placement, with boys more proficient at components requiring coordination of the legs  
325 and correct trunk movement/body position. These findings are able to add to the limited evidence base  
326 that is available on FMS competency among preschool children from low SES areas.

327 Little research has documented the FMS competency of typically developing young children  
328 (aged 2-5 years) (Cools et al., 2009). This is despite the preschool years having been described as a  
329 critical period for FMS development (Gallahue & Donnelly, 2003; Hardy, King, Farrell, et al., 2010).  
330 In the present study, competence scores were found to be low across all skills, with the exception of  
331 the run, leap, and slide. Whilst direct comparisons between international studies are not possible due  
332 to methodological (different FMS assessment tools) and cultural differences (Simons & Van  
333 Hombeeck, 2003), the findings of low competence in the present study are in agreement with previous  
334 research (Barnett et al., 2014; Cliff et al., 2009; Goodway et al., 2010; Hardy, King, Farrell, et al.,  
335 2010; Robinson, 2011; Ulrich, 2000). As expected, both sexes demonstrated lower competency levels  
336 among object-control skills in comparison to locomotor skills. This finding is also consistent with  
337 previous research (Hardy, King, Farrell, et al., 2010; Ulrich, 2000) and reflects the greater complexity  
338 of learning object-control skills, which require more sophisticated visual-motor requirements, as well  
339 as enhanced coordination and stability of the limb and trunk (Hardy, King, Farrell, et al., 2010). The  
340 low competency at FMS observed in this study and others may reflect the developmental status  
341 expected of the young child. For example, Butterfield, Angell, and Mason (2012) assessed the object-  
342 control competency of 186 5- to 14-year-old American schoolchildren using the TGMD-2 (Ulrich,  
343 2000). They reported that competency levels increased rapidly between the ages of 5 and 10 years but  
344 prior to 5 years of age there was a very low probability of children displaying competency. Thus,  
345 whilst children may have the *potential* to demonstrate competence at FMS by six years of age  
346 (Gallahue & Donnelly, 2003), observed competence levels suggest that preschool children are  
347 typically only at the initial or elementary stages of FMS development (Gallahue & Donnelly, 2003)

348 and require further practice, encouragement and instruction to reach mature patterns of movement  
349 before primary school.

350         The analysis of skill competence at the component level further extends the available  
351 evidence and revealed that few children demonstrated competency in several locomotor and object-  
352 control skill components. Of concern from a developmental perspective was the number of skill  
353 components within both the locomotor and object-control subscales that showed competence levels to  
354 be below 5% for both sexes. These included the leap (C3), hop (C3), gallop (C3), catch (C3) and  
355 dribble (C2 and C5), with a further six skill components where competence scores of 0% were  
356 observed; gallop (C2), slide (C3), throw (C4), strike (C4) and catch (C3 and C4). Broadly, this  
357 suggests that competence levels were lowest in components requiring the use of the arms, coordinated  
358 trunk and limb movements, contralateral actions and the transferring of weight – patterns consistent  
359 with descriptive data from Australian (Hardy, King, Farrell, et al., 2010) and North American (Ulrich,  
360 2000) young children collected using the TGMD-2. Analysing skill competence at the component  
361 level provides information on the specific component(s) of a skill that are lagging or deficient, which  
362 can subsequently be used to guide instructional practices. Young children may therefore require more  
363 tailored instruction and practices in order to demonstrate control of more complex skill components,  
364 whilst given the overall low competence levels found it would appear that both locomotor and object-  
365 control skills should be targeted.

366         A number of individual, family and environmental factors have been associated with FMS  
367 competence (Barnett, Hinkley, Okely, & Salmon, 2013; Cools, De Martelaer, Samaey, & Andries,  
368 2011) and may have contributed to the study findings. Children in the present study were recruited  
369 from low SES areas and consequently may have fewer opportunities to engage in physical activities  
370 which foster FMS or may lack safe outdoor spaces in which to do so (Giagazoglou, 2013; Goodway et  
371 al., 2010). However, competence levels were only marginally lower than those reported in similar-  
372 aged counterparts from more representative SES samples (Hardy, King, Farrell, et al., 2010; Ulrich,  
373 2000). Previous cross-sectional studies among preschoolers have found positive associations between  
374 FMS competence and objectively measured light, moderate-to-vigorous and total daily physical  
375 activity (Burgi et al., 2011; Cliff et al., 2009; Fisher et al., 2005; Foweather et al., 2014; Iivonen et al.,



2013; Williams et al., 2008). This relationship is considered bi-directional, with participation in physical activity thought to drive gains in FMS competence through a “positive feedback loop” (Barnett, Morgan, Van Beurden, Ball, & Lubans, 2011). For example, Williams et al. (2008) study of 198 preschool children using the CMSP (Williams et al., 2009) alongside accelerometer data observed that the associations between FMS competency and physical activity were more significant at the extremes of their distribution, highlighting that the most active participants also had the highest FMS competency levels and vice versa. The present study formed part of a larger study; valid accelerometer was obtained for a sub-sample of 99 participants and used to examine associations between FMS and physical activity in a recent publication (Foweather et al., 2014). Results showed that 86% of children met the recommended physical activity guidelines and that both locomotor and object control skills were positively but weakly associated with various intensities of physical activity on weekdays and weekends. If these findings are extrapolated to the present sample, which was somewhat larger (n=168), this suggests that the majority of children are gaining a sufficient dose of physical activity. The low levels of FMS competence observed implies that the type and quality of preschool children’s physical activity experiences (structured or unstructured) may not be sufficient for the levels of neuromuscular development necessary to reach mature patterns of FMS. However, future research is needed.

The family and home environment is also important for FMS development, with parents potentially influencing their child’s PA behaviours through direct (e.g. providing adequate equipment, outdoor access), and indirect (modelling behaviour, providing encouragement) actions. In a large study (n=846) examining FMS performance in relation to family context among Belgian 4-6 year old children, Cools et al. (2011) observed positive associations between father’s physical activity levels and boys’ FMS competency levels, alongside a further positive association between girls FMS competency and the provision of equipment. Likewise, Barnett et al. (2013) also noted that prior to adjustments for age, the provision of equipment in the home environment showed a positive association with FMS competency for both locomotor and object-control skills among 76 three-to-six year old children.

403           The facilities and equipment provided in preschools and the childcare setting may also affect  
404 FMS development. Brown et al (2009) found that children in preschools or childcare settings with  
405 larger playgrounds and increased availability of balls and objects engaged in more moderate-to-  
406 vigorous physical activity. School/daycare settings that promote physically active play through  
407 enabling outdoor environments (e.g. provision of balls, beanbags and hoops, etc.; longer periods of  
408 active and/or outdoor play) may therefore facilitate improvements in FMS. Whilst active play  
409 provides an opportunity for children to practice FMS, instruction and encouragement are also  
410 necessary for children to reach mature patterns of FMS (Gallahue et al., 2011). Parents, preschool  
411 educators and structured early childhood programmes can therefore play a key role in promoting FMS  
412 development but intervention deliverers may need additional training and support (Riethmuller, Jones,  
413 & Okely, 2009).

414           Among the mixed results that have been reported in the literature, the current findings support  
415 those studies that have found no sex difference in locomotor score (Goodway et al., 2010; Spessato et  
416 al., 2012). Although girls were more competent than boys at the run, hop and gallop, this did not  
417 translate into a significant sex difference in overall locomotor score. Consistent with previous  
418 research in young children (Barnett et al., 2014; Goodway et al., 2010; Hardy, King, Farrell, et al.,  
419 2010; Robinson, 2011; Spessato et al., 2012), boys in the present study showed greater competency  
420 for object-control skills than girls, and performed better at the overarm throw and kick (Hardy, King,  
421 Farrell, et al., 2010). Evidence indicates that similar patterns exist among older children (LeGear et al.,  
422 2012; Bryant et al., 2013; Okely & Booth, 2004; Van Beurden et al., 2002) and adolescents (Hardy,  
423 King, Espinel, et al., 2010; O'Brien et al., 2013), indicating that sex differences in object-control skills  
424 are established in early childhood and may track into later childhood and adolescence.

425           During the preschool years the physical characteristics of boys and girls are very similar,  
426 meaning that physiological differences are unlikely to affect FMS competency, therefore these  
427 differences may be due to the influence of socio-cultural or environmental factors. Boys and girls  
428 likely participate in differing games and physical activities that may contribute to observed sex  
429 differences in competence. For example, Barnett et al. (2013) found an inverse association between  
430 participation in dance classes and object-control skill competence amongst preschool girls. Evidence

431 from the wider Active Play research project (Foweather et al., 2014) showed that boys were more  
432 active than girls and had higher object-control skill competency, suggesting that levels of physical  
433 activity may also explain sex differences. Whilst boys and girls show competence at differing skills,  
434 the low competence levels observed across the sample suggest that future preschool interventions  
435 should target a broad array of FMS. Nevertheless, girls may require additional or specific approaches  
436 in early childhood (2-4 years) to help them develop object-control skills. The component level  
437 analysis provides precise information that can assist with the design of instructional programmes and  
438 targeted activities so that both boys and girls can achieve developmentally-appropriate levels of  
439 competence. For example, in a session to improve running, boys could be given additional  
440 instructions and activities to assist them with keeping their eyes focused forwards, whilst girls worked  
441 on moving their arms in opposition to the legs, with their elbows bent.

442         The strengths of this study include the use of a validated process-based measure, allowing a  
443 detailed analysis of competency for each of the twelve skills assessed, to that of an individual  
444 component level. Whilst two previous studies have reported a component level analysis among  
445 preschool children (Hardy, King, Farrell, et al., 2010; Ulrich, 2000), the present study is the first to  
446 explore sex differences at the component level. Furthermore, the use of video analysis, allowing slow-  
447 motion and repeated playback, alongside a single assessor gives confidence in the precision and  
448 consistency of measurement. A limitation of this study was the 25.0% participation rate of those  
449 initially invited to take part in the study ( $n = 673$ ). Parents were required to provide active consent,  
450 which may have influenced study recruitment. Whilst 240 children (35.6% response rate) were  
451 recruited to the study, the final sample size ( $n=168$ ) reflects the challenges of FMS data collection  
452 with younger populations in a busy preschool setting. A further limitation is that participants were  
453 recruited from areas of low SES, thus limiting the generalizability of the results.

454         With the preschool years being a key developmental stage for the acquisition and  
455 development of FMS, the findings of low competence and sex differences in object-control and  
456 locomotor skills among the children assessed highlights the need for improvements in competency,  
457 especially when improved competence has been associated with a range of health and fitness benefits  
458 (Lubans et al., 2010; Rodrigues et al., 2015; Vlahov et al., 2014) and in helping to prevent declines in

459 physical activity (Barnett et al., 2009; Holfelder & Schott, 2014; Stodden et al., 2008). Further  
460 research will be beneficial not only to help monitor current levels of competence amongst low SES  
461 preschool children, but in helping to develop targeted interventions aimed at increasing overall  
462 competence and helping to reduce sex differences in competency.  
463

## 464 References

465

466 Department of Health and Aging. (2010). *Get up and Grow: Healthy Eating and Physical Activity for*  
467 *Early Childhood*. Canberra, Australia: Australian Government.

468 Barnett, L. M., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Child, family and environmental  
469 correlates of children's motor skill proficiency. *Journal of Science and Medicine in Sport*,  
470 *16*(4), 332-336. doi: <http://dx.doi.org/10.1016/j.jsams.2012.08.011>

471 Barnett, L. M., Morgan, P. J., Van Beurden, E., Ball, K., & Lubans, D. R. (2011). A reverse pathway?  
472 Actual and perceived skill proficiency and physical activity. *Medicine and Science in Sports*  
473 *and Exercise*, *43*(5), 898-904. doi: 10.1249/MSS.0b013e3181fdfadd

474 Barnett, L. M., Ridgers, N. D., & Salmon, J. (2014). Associations between young children's perceived  
475 and actual ball skill competence and physical activity. *Journal of Science and Medicine in*  
476 *Sport*(0). doi: <http://dx.doi.org/10.1016/j.jsams.2014.03.001>

477 Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood  
478 motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent*  
479 *Health*, *44*(3), 252-259. doi: 10.1016/j.jadohealth.2008.07.004

480 Booth, M. L., Okely, T., McLellan, L., Phongsavan, P., Macaskill, P., Patterson, J., . . . Holland, B.  
481 (1999). Mastery of fundamental motor skills among New South Wales school students:  
482 prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport*, *2*(2),  
483 93-105.

484 Brown, W. H., Pfeiffer, K. A., McIver, K. L., Dowda, M., Addy, C. L., & Pate, R. R. (2009). Social  
485 and Environmental Factors Associated With Preschoolers' Nonsedentary Physical Activity.  
486 *Child Development*, *80*(1), 45-58. doi: 10.1111/j.1467-8624.2008.01245.x

487 Bryant, E. S., Duncan, M. J., & Birch, S. L. (2014). Fundamental movement skills and weight status  
488 in British primary school children. *European Journal of Sport Science*, 1-7. doi:  
489 10.1080/17461391.2013.870232

- 490 Bryant, E. S., James, R. S., Birch, S. L., & Duncan, M. (2014). Prediction of habitual physical activity  
491 level and weight status from fundamental movement skill level. *Journal of Sports Sciences*,  
492 32(19), 1775-1782. doi: 10.1080/02640414.2014.918644
- 493 Burgi, F., Meyer, U., Granacher, U., Schindler, C., Marques-Vidal, P., Kriemler, S., & Puder, J. J.  
494 (2011). Relationship of physical activity with motor skills, aerobic fitness and body fat in  
495 preschool children: a cross-sectional and longitudinal study (Ballabeina). *Int J Obes*, 35(7),  
496 937-944.
- 497 Butterfield, S. A., Angell, R. M., & Mason, C. A. (2012). Age and sex differences in object control  
498 skills by children ages 5 to 14. *Perceptual and Motor Skills*, 114(1), 261-274. doi:  
499 10.2466/10.11.25.PMS.114.1.261-274
- 500 Cliff, D. P., Okely, A. D., Smith, L. M., & McKeen, K. (2009). Relationships between fundamental  
501 movement skills and objectively measured physical activity in preschool children. *Pediatr*  
502 *Exerc Sci*, 21(4), 436-449.
- 503 Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition  
504 for child overweight and obesity worldwide: international survey. *BMJ*, 320(7244), 1240. doi:  
505 10.1136/bmj.320.7244.1240
- 506 Childrens Schools and Families Committee. (2010). *Sure Start Children's Centres*. London: The  
507 Stationary Office.
- 508 Cools, W., De Martelaer, K., Samaey, C., & Andries, C. (2009). Movement skill assessment of  
509 typically developing preschool children: A review of seven movement skill assessment tools.  
510 *Journal of Sports Science and Medicine*, 8(2), 154-168.
- 511 Cools, W., De Martelaer, K., Samaey, C., & Andries, C. (2011). Fundamental movement skill  
512 performance of preschool children in relation to family context. *Journal of Sports Sciences*,  
513 29(7), 649-660. doi: 10.1080/02640414.2010.551540
- 514 Families, D. f. C. S. a. (2008). *Practice Guidance for the Early Years Foundation Stage*. London.
- 515 Fisher, A., Reilly, J. J., Kelly, L. A., Montgomery, C., Williamson, A., Paton, J. Y., & Grant, S.  
516 (2005). Fundamental movement skills and habitual physical activity in young children. *Med*  
517 *Sci Sports Exerc*, 37(4), 684-688.

- 518 Fowweather, L., Knowles, Z., Ridgers, N. D., O'Dwyer, M. V., Foulkes, J. D., & Stratton, G. (2014).  
519 Fundamental movement skills in relation to weekday and weekend physical activity in  
520 preschool children. *Journal of Science and Medicine in Sport*(0). doi:  
521 <http://dx.doi.org/10.1016/j.jsams.2014.09.014>
- 522 Gallahue, D. L., & Donnelly, F. C. (2003). *Developmental physical education for all children* (4th  
523 ed.). Champaign, IL: Human Kinetics.
- 524 Gallahue, D. L., Ozmun, J. C., & Goodway, J. D. (2011). *Understanding Motor Development: Infants,*  
525 *Children, Adolescents, Adults* (7th ed.). Boston, MA: McGraw Hill.
- 526 Giagazoglou, P. (2013). The Interaction Effect of Gender and Socioeconomic Status on Development  
527 of Preschool-Aged Children in Greece. *Infants & Young Children*, 26(2), 177-186. doi:  
528 10.1097/IYC.0b013e318283bfb8
- 529 Goodway, J. D., Robinson, L. E., & Crowe, H. (2010). Gender Differences in Fundamental Motor  
530 Skill Development in Disadvantaged Preschoolers From Two Geographical Regions.  
531 *Research Quarterly for Exercise and Sport*, 81(1), 17-24. doi:  
532 10.1080/02701367.2010.10599624
- 533 Goodway, J. D., & Smith, D. W. (2005). Keeping all children healthy: challenges to leading an active  
534 lifestyle for preschool children qualifying for at-risk programs. *Family & Community Health*,  
535 28(2), 142-155.
- 536 Department of Communities and Local Government. (2010). *The English Indices of Deprivation:*  
537 *Annual Report*. London: Department of Education.
- 538 Hardy, L. L., King, L., Espinel, P., Cosgrave, C., & Bauman, A. (2010). *NSW schools physical*  
539 *activity and nutrition survey (SPANS) 2010: full report*. Sydney: Centre for Health  
540 Advancement.
- 541 Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills  
542 among Australian preschool children. *Journal of Science and Medicine in Sport*, 13(5), 503-  
543 508. doi: 10.1016/j.jsams.2009.05.010

- 544 Hardy, L. L., Reinten-Reynolds, T., Espinel, P., Zask, A., & Okely, A. D. (2012). Prevalence and  
545 correlates of low fundamental movement skill competency in children. *Pediatrics*, *130*(2),  
546 e390-398. doi: 10.1542/peds.2012-0345
- 547 Department of Health. (2011). *Start Active, Stay Active: A report on physical activity from the four*  
548 *home countries' Chief Medical Officers*. London, UK.
- 549 Holfelder, B., & Schott, N. (2014). Relationship of fundamental movement skills and physical activity  
550 in children and adolescents: A systematic review. *Psychology of Sport and Exercise*, *15*(4),  
551 382-391. doi: <http://dx.doi.org/10.1016/j.psychsport.2014.03.005>
- 552 Iivonen, K. S., Säakslähti, A. K., Mehtälä, A., Villberg, J. J., Tammelin, T. H., Kulmala, J. S., &  
553 Poskiparta, M. (2013). Relationship Between Fundamental Motor Skills And Physical  
554 Activity In 4-year-old Preschool Children. *Perceptual and Motor Skills*, *117*(2), 627-646. doi:  
555 10.2466/10.06.PMS.117x22z7
- 556 Jaakkola, T., Hillman, C., Kalaja, S., & Liukkonen, J. (2015). The associations among fundamental  
557 movement skills, self-reported physical activity and academic performance during junior high  
558 school in Finland. *Journal of Sports Sciences*, 1-11. doi: 10.1080/02640414.2015.1004640
- 559 Kolle, E., Steene-Johannessen, J., Andersen, L., & Anderssen, S. (2009). Seasonal variation in  
560 objectively assessed physical activity among children and adolescents in Norway: a cross-  
561 sectional study. *International Journal of Behavioral Nutrition and Physical Activity*, *6*(1), 36.
- 562 LeGear, M., Greyling, L., Sloan, E., Bell, R., Williams, B.-L., Naylor, P.-J., & Temple, V. (2012). A  
563 window of opportunity? Motor skills and perceptions of competence of children in  
564 Kindergarten. *International Journal of Behavioral Nutrition and Physical Activity*, *9*(1), 29.
- 565 Logan, S. W., Robinson, L. E., Wilson, A. E., & Lucas, W. A. (2012). Getting the fundamentals of  
566 movement: a meta-analysis of the effectiveness of motor skill interventions in children. *Child*  
567 *Care Health Dev*, *38*(3), 305-315. doi: 10.1111/j.1365-2214.2011.01307.x
- 568 Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental  
569 movement skills in children and adolescents: review of associated health benefits. *Sports Med*,  
570 *40*(12), 1019-1035. doi: 10.2165/11536850-000000000-00000



- 571 Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, Maturation, and Physical Activity* (2nd  
572 ed.). Champaign, IL: Human Kinetics.
- 573 Newell, K. M. (1986). Constraints on the development of coordination. In M. G. Wade & H. T. A.  
574 Whiting (Eds.), *Motor Development in Children: Aspects of Coordination and Control* (pp.  
575 341-361). Dordrecht, The Netherlands: Nijhoff.
- 576 O'Brien, W., Issartel, J., & Belton, S. (2013). Evidence for the efficacy of the youth-physical activity  
577 towards health (Y-PATH) intervention. *Advances in Physical Education*, 3(4), 145-153.
- 578 O'Dwyer, M. V., Fairclough, S. J., Ridgers, N. D., Knowles, Z. R., Fowweather, L., & Stratton, G.  
579 (2013). Effect of a school-based active play intervention on sedentary time and physical  
580 activity in preschool children. *Health Education research*, 28(6), 931-942.
- 581 Observatories, A. o. P. H. (2009). Liverpool Health Profile 2009. Retrieved 30/04/2015, 2015, from  
582 [www.apho.org.uk/resource/view.aspx?RID=71192](http://www.apho.org.uk/resource/view.aspx?RID=71192)
- 583 Okely, A. D., & Booth, M. L. (2004). Mastery of fundamental movement skills among children in  
584 New South Wales: prevalence and sociodemographic distribution. *Journal of Science and*  
585 *Medicine in Sport*, 7(3), 358-372. doi: Doi 10.1016/S1440-2440(04)80031-8
- 586 Riethmuller, A. M., Jones, R. A., & Okely, A. D. (2009). Efficacy of interventions to improve motor  
587 development in young children: a systematic review. *Pediatrics*, 124(4), 782-792. doi: doi:  
588 10.1542/peds.2009-0333
- 589 Robinson, L. E. (2011). The relationship between perceived physical competence and fundamental  
590 motor skills in preschool children. *Child Care Health and Development*, 37(4), 589-596. doi:  
591 DOI 10.1111/j.1365-2214.2010.01187.x
- 592 Rodrigues, L. P., Stodden, D. F., & Lopes, V. P. (2015). Developmental pathways of change in fitness  
593 and motor competence are related to overweight and obesity status at the end of primary  
594 school. *Journal of Science and Medicine in Sport*(0). doi:  
595 <http://dx.doi.org/10.1016/j.jsams.2015.01.002>
- 596 Simons, J., & Van Hombeeck, C. (2003). Applicability of the test of gross motor development 2nd ed.  
597 *Kinevaria*, 39(4), 16-21.

- 598 Spessato, B. C., Gabbard, C., Valentini, N., & Rudisill, M. (2012). Gender differences in Brazilian  
599 children's fundamental movement skill performance. *Early Child Development and Care*,  
600 *183*(7), 916-923. doi: 10.1080/03004430.2012.689761
- 601 National Association for Sport and Physical Activity Education. (2009). *A Statement of Physical*  
602 *activity Guidelines for Children from Birth to Age 5*. Sewickly, PA: American Alliance for  
603 Health, Physical Education, Recreation, and Dance.
- 604 Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Robertson, M. A., Rudisill, M. E., Garcia, C., &  
605 Garcia, L. E. (2008). A Developmental Perspective on the Role of Motor Skill Competence in  
606 Physical Activity: An Emergent Relationship. *Quest*, *60*(2), 290-306.
- 607 Tremblay, M. S., LeBlanc, A. G., Carson, V., Choquette, L., Connor Gorber, S., Dillman, C., . . .  
608 Timmons, B. W. (2012). Canadian Physical Activity Guidelines for the Early Years (aged 0–  
609 4 years). *Applied Physiology, Nutrition, and Metabolism*, *37*(2), 345-356. doi:  
610 10.1139/h2012-018
- 611 Ulrich, D. A. (2000). *Test of Gross Motor Development: Examiner's Manual* (2nd ed.). Austin, Texas:  
612 PRO-ED.
- 613 Van Beurden, E., Zask, A., Barnett, L. M., & Dietrich, U. C. (2002). Fundamental movement skills -  
614 how do primary school children perform? The "move it groove it" program in rural Australia.  
615 *Journal of Science and Medicine in Sport*, *5*, 244-252.
- 616 van der Mars, H. (1989). Observer Reliability: Issues and Procedures. In P. W. Darst, D. B. Zakrajsek,  
617 & V. H. Mancini (Eds.), *Analyzing Physical Education and Sport Instruction* (pp. 53-80).  
618 Champaign, IL: Human Kinetics.
- 619 Vlahov, E., Baghurst, T. M., & Mwavita, M. (2014). Preschool motor development predicting high  
620 school health-related physical fitness: a prospective study. *Perceptual and Motor Skills*,  
621 *119*(1), 279-291. doi: 10.2466/10.25.PMS.119c16z8
- 622 Whitehead, M. (2013). The definition of physical literacy (July 2013). Retrieved 21 January 2014,  
623 from <http://www.physical-literacy.org.uk/definitions.php>
- 624 Williams, H. G., Pfeiffer, K. A., Dowda, M., Jeter, C., Jones, S., & Pate, R. R. (2009). A field-based  
625 testing protocol for assessing gross motor skills in preschool children: The CHAMPS motor

- 626 skills protocol (CMSP). *Meas Phys Educ Exerc Sci*, 13(3), 151-165. doi:  
627 10.1080/10913670903048036
- 628 Williams, H. G., Pfeiffer, K. A., O'Neill, J. R., Dowda, M., McIver, K., Brown, W. H., & Pate, R. R.  
629 (2008). Motor skill performance and physical activity in preschool children. *Obesity*, 16, 1421  
630 - 1426.
- 631

632 **Table 1. Mean (SD) Age, Deprivation Level, BMI, BMI-z Score, Total Score, Locomotor Score**  
 633 **and Object-Control Score for boys and girls.**

Score	Boys ( <i>n</i> =91)		Girls ( <i>n</i> =77)		<i>p</i>
	Mean	SD	Mean	SD	
Age	4.70	0.61	4.59	0.53	.21
Deprivation Level (IMD)	1.49	1.11	1.38	0.88	.51
BMI Score	16.67	1.67	16.55	1.63	.65
BMI-z score	0.71	1.08	0.57	0.93	.39
Total Score	27.59	7.05	26.74	6.24	.41
Locomotor Score	15.76	4.0	16.75	3.94	.11
Object-Control Score	11.84	4.18	9.99	3.32	.002*

634 *Note.* – IMD: Indices of multiple deprivation score; BMI: body mass index; IOTF: International  
 635 Obesity Task Force age- and sex-specific weight for height z scores. Maximum scores possible for  
 636 total, locomotor and object-control skills are 71, 32 and 39, respectively; \*Significant sex difference  
 637 ( $p \leq .05$ ).

638

639 **Table 2.** Median (IQR) individual fundamental movement skill scores among boys and girls.

Skill	CMSP	Boys ( <i>n</i> = 91)	Girls ( <i>n</i> = 77)	<i>p</i>
	Score	Median (IQR)	Median (IQR)	
Throw	7	1 (0, 2)	1 (0, 1)	.05*
Strike	8	3 (2, 4)	3 (2, 4)	.19
Kick	7	3 (2, 5)	3 (2, 3)	<.001*
Catch	6	1 (0, 2)	1 (0, 2)	.69
Roll	6	1 (1, 2)	2 (1, 3)	.12
Dribble	5	0 (0, 1)	0 (0, 1)	.91
Run	6	4 (3, 5)	5 (4, 6)	.05*
Jump	5	2 (1, 3)	2 (1, 3)	.68
Leap	3	2 (1, 2)	2 (2, 2)	.73
Hop	6	1 (0, 2)	2 (1, 3)	.01*
Gallop	7	3 (3, 4)	4 (3, 4)	.003*
Slide	5	4 (2, 5)	3 (1, 5)	.25

640 *Note.* — CMSP: Maximum score attainable on the Children's Activity and Movement in Preschool

641 Study Motor Skills Protocol (Williams, et al., 2009); IQR: Inter-quartile range; \* Significant

642 difference ( $p \leq .05$ ).

643

644 **Table 3.** Proportion (%) of boys and girls demonstrating competency of skill components for  
 645 locomotor skills.

Skill Component	Boys (%) <i>n</i> = 91	Girls (%) <i>n</i> = 77	<i>p</i>
<b>Run</b>			
C1. Arms move in opposition to legs, elbows bent <sup>a</sup>	73.6	53.2	.01*
C2. Brief period of suspension (both feet off the ground) <sup>a</sup>	100.0	100.0	+
C3. Narrow foot placement; lands on heel or toe; not flat footed <sup>a</sup>	90.1	89.6	1.00
C4. Length of stride even; path of movement horizontal <sup>b</sup>	40.7	63.6	.01†
C5. Nonsupport leg flexed to approximately 90 degrees <sup>a</sup>	79.1	89.6	.10
C6. Eyes focused forward <sup>b</sup>	31.9	55.8	.003†
<b>Jump</b>			
C1. Preparatory: flexion of both knees; arms behind body <sup>a</sup>	29.7	23.4	.46
C2. Arms extend forcefully; forward and upward to full extension above the head <sup>a</sup>	11.0	2.6	.07
C3. Take-off and landing on both feet simultaneously <sup>a</sup>	67.0	66.2	1.00
C4. Take-off on both feet simultaneously; landing non-simultaneous <sup>b</sup>	1.1	2.6	‡
C5. Arms move downward during landing <sup>a</sup>	44.0	54.5	.23
C6. Balance maintained on landing <sup>b</sup>	31.9	41.6	.25
<b>Leap</b>			
C1. Take off on one foot; land on opposite foot <sup>a</sup>	74.7	80.5	.48
C2. Brief period of suspension (both feet off the ground) <sup>a</sup>	92.3	87.0	.38

C3. Forward reach with arm opposite the lead foot <sup>a</sup>	2.2	1.3	‡
----------------------------------------------------------------	-----	-----	---

### Hop

C1. Non-support leg swings forward in pendular motion to assist force production <sup>a</sup>	1.1	6.5	‡
C2. Foot of non-support leg remains behind body <sup>a</sup>	18.7	37.7	.01*
C3. Arms flexed; swing forward together to produce force <sup>a</sup>	1.1	2.6	‡
C4. Weight received (lands) on ball of foot <sup>b</sup>	23.1	20.8	.86
C5. Takes off and lands three consecutive times on preferred foot <sup>a</sup>	54.9	74.0	.02*
C6. Takes off and lands on three consecutive times on non-preferred foot <sup>a</sup>	23.1	27.3	.66

### Gallop

C1. Assumes initial position facing forward <sup>b</sup>	92.3	96.1	‡
C2. Arms (elbows) flexed and at waist level at take off <sup>a</sup>	0.0	2.6	N/A
C3. Step forward with lead foot; step with trail foot to a position adjacent to or behind lead foot <sup>a</sup>	2.2	3.9	‡
C4. Heel-toe action of lead foot <sup>b</sup>	41.8	58.4	.05*
C5. Brief period of suspension; both feet off the floor <sup>a</sup>	93.4	97.4	‡
C6. Maintains rhythmic pattern (four consecutive gallops) <sup>a</sup>	8.8	16.9	.18
C7. Final position facing forward <sup>b</sup>	81.3	90.9	0.12

### Slide

C1. Body turned sideways; shoulders aligned with line on floor to initiate <sup>a</sup>	94.5	83.1	.03*
C2. Steps sideways with lead foot; slides trail foot next to	24.2	28.6	.64

lead foot<sup>a</sup>

C3. Arms used to assist leg action <sup>b</sup>	0.0	0.0	N/A
C4. Body maintained in sideways position moving to right <sup>b</sup>	61.5	55.8	.56
C5. Body maintained in sideways position moving to left <sup>b</sup>	71.4	55.8	.05
C6. Minimum of four continuous step-slide cycles to right <sup>a</sup>	59.3	53.2	.52
C7. Minimum of four continuous step-slide cycles to left <sup>a</sup>	53.8	51.9	.93

646 *Note* .— a Skill component present in both the TGMD–2 (Ulrich, 2000) and CMSP (Williams, *et*  
 647 *al.*, 2009). b Skill component only present in CMSP. \*Significant difference ( $p < .05$ ). †Significant  
 648 difference ( $p < .01$ ). ‡Performance criteria did not meet the assumption of the chi-squared test. + Not  
 649 applicable as competency for boys/girls = 100%. N/A: Not applicable as competency for boys/girls =  
 650 0%.

651



652 **Table 4.** Proportion (%) of boys and girls demonstrating competency of skill components for object-  
 653 control skills.

Skill Component	Boys (%) <i>n</i> = 91	Girls (%) <i>n</i> = 77	<i>p</i> =
<b>Throw</b>			
C1. Wind-up initiated by downward movement of hand/arm <sup>a</sup>	7.7	11.7	.54
C2. Hip and shoulder rotated so that nonthrowing side faces target <sup>a</sup>	23.1	7.8	.01*
C3. Steps (weight transferred) onto foot opposite throwing arm <sup>a</sup>	5.5	2.6	‡
C4. Differentiated trunk rotation (2) <sup>b</sup>	0.0	0.0	N/A
C5. Block trunk rotation (1) <sup>b</sup>	46.2	35.1	.19
C6. Timing of release/flight of ball appropriate (late release = downward flight; early release = upward flight) <sup>b</sup>	23.1	19.5	.71
C7. Arm follows through beyond release (down and across the body) <sup>a</sup>	13.2	5.2	.14
<b>Strike</b>			
C1. Dominant hand grips bat just above nondominant hand <sup>a</sup>	36.3	32.5	.72
C2. Nonpreferred side of body faces imaginary "pitcher"; feet parallel <sup>b</sup>	72.5	51.9	.01*
C3. Steps (transfers weight) onto foot opposite dominant hand to initiate strike <sup>a</sup>	12.1	5.2	.20

C4. Differentiated trunk rotation (2) <sup>b</sup>	0.0	0.0	N/A
C5. Block trunk rotation (1) <sup>a</sup>	67.0	59.7	.41
C6. Arm action/plane of bat movement horizontal <sup>b</sup>	57.1	57.1	1.00
C7. Ball contacts bat <sup>a</sup>	51.6	62.3	.22
C8. Swings through ball (action does not stop at ball contact) <sup>b</sup>	44.0	31.2	.12

### Kick

C1. Rapid and continuous approach to ball <sup>a</sup>	42.9	9.1	<.001†
C2. Elongated stride or leap immediately prior to ball contact <sup>a</sup>	58.2	32.5	.001†
C3. Nonkicking foot placed even with or slightly in back of ball <sup>a</sup>	63.7	54.5	.29
C4. Leg swing is full; full backswing and forward swing of leg <sup>b</sup>	18.7	11.7	.30
C5. Backswing coordinated with forward action of non-kicking leg <sup>b</sup>	92.3	71.4	0.001†
C6. Ball contacted with instep of kicking foot (shoe laces) <sup>a</sup>	60.4	51.9	.34
C7. Kicks through ball; leg action does not stop at ball contact <sup>b</sup>	33.0	24.7	.31

### Catch

C1. Preparatory: hands in front of body; elbows flexed <sup>a</sup>	25.3	23.4	.92
C2. Arms extend toward ball as it moves closer <sup>a</sup>	45.1	37.7	.42
C3. Ball caught cleanly with hands/fingers (2) <sup>a</sup>	2.2	0.0	N/A
C4. Ball trapped against body/chest (1) <sup>b</sup>	1.1	0.0	N/A

C5. Ball tracked consistently and close to point of contact <sup>b</sup>	24.2	19.5	.59
--------------------------------------------------------------------------	------	------	-----

C6. Doesn't turn head/close eyes as ball approaches <sup>b</sup>	31.9	39.0	.43
------------------------------------------------------------------	------	------	-----

**Roll**

C1. Ball arm/hand swings down/back of trunk; chest/head face forward <sup>a</sup>	30.8	40.3	.26
-----------------------------------------------------------------------------------	------	------	-----

C2. Foot opposite ball hand strides forward toward cones <sup>a</sup>	7.7	1.3	‡
-----------------------------------------------------------------------	-----	-----	---

C3. Bends knees; lowers body <sup>a</sup>	30.8	37.7	.44
-------------------------------------------	------	------	-----

C4. Arm action in vertical plane <sup>b</sup>	65.9	64.9	1.00
-----------------------------------------------	------	------	------

C5. Ball held in fingertips <sup>b</sup>	23.1	33.8	.17
------------------------------------------	------	------	-----

C6. Ball released close to floor; bounces less than 4 inches high <sup>a</sup>	4.4	7.8	‡
--------------------------------------------------------------------------------	-----	-----	---

**Dribble**

C1. Arm action independent of trunk <sup>b</sup>	34.1	32.5	.96
--------------------------------------------------	------	------	-----

C2. Ball contacted with one hand at about belt/waist height <sup>a</sup>	2.2	1.3	‡
--------------------------------------------------------------------------	-----	-----	---

C3. Pushes ball with fingertips (does not slap at ball with flat hand) <sup>b</sup>	17.6	11.7	.39
-------------------------------------------------------------------------------------	------	------	-----

C4. Ball contacts surface in front of or to the outside of foot on preferred side <sup>a</sup>	8.8	15.6	.27
------------------------------------------------------------------------------------------------	-----	------	-----

C5. Controls ball for four consecutive bounces; feet not moved to retrieve ball <sup>a</sup>	3.3	1.3	‡
----------------------------------------------------------------------------------------------	-----	-----	---

---

654 *Note* .— a Skill component present in both the TGMD–2 ( Ulrich, 2000 ) and CMSP ( Williams,  
655 *et al.* , 2009 ). b Skill component only present in CMSP. N/A: Not applicable as competency for  
656 boys/girls = 0%. \*Significant difference (  $p < .05$  ). †Significant difference (  $p < .01$  ). ‡Performance

657 criteria did not meet the assumption of the chi-squared test.