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Foulkes, JD, Stratton, G, O Dwyer, MV, Knowles, ZR, Ridgers, ND and Fowweather, LF (2015) Fundamental Movement Skills of Preschool Children in Northwest England. Perceptual and Motor Skills, 121 (1). pp. 260-283. ISSN 1558-688X

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FUNDAMENTAL MOVEMENT SKILLS OF PRESCHOOL CHILDREN IN NORTHWEST
ENGLAND^{1,2,3}

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

³ 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.

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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 a child moves 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 Hombecck, 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 3 and 4) (Williams et al., 2009). The CMSP was selected
220 for the assessment of FMS as its additional performance criteria and alternate scoring methods
221 improved assessment sensitivity (Williams et al., 2009). The CMSP has demonstrated high reliability
222 ($R=0.94$), interobserver reliability ($R=0.94$) and concurrent validity when compared with the TGMD-2
223 ($R=0.98$) (Williams et al., 2009). In the present study all analyses were completed by a single trained
224 assessor (JF) who received 30 hours of training from a member of the research team experienced in
225 conducting video analysis (LF). Inter-rater reliability was established prior to assessment using pre-
226 coded videotapes of 10 children, with 83.9% agreement across the twelve skills (range 72.9-89.3%).
227 Likewise, intra-rater reliability was established using pre-coded videotapes of a further 10 children,
228 with test-retest conducted one week apart, with 91.9% agreement established across the twelve skills
229 (range 89.0-96.0%). Whilst there is no accepted minimum level of percentage agreement, 80-85%
230 agreement has been previously deemed to be acceptable (van der Mars, 1989). If the assessor was
231 unsure whether a child had met a performance criteria then the footage was viewed by both JF and LF,
232 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/m²) 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 BMI z-score. However, differences between adjusted
260 and unadjusted models were negligible and therefore all results are presented unadjusted. Statistical
261 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 low competence levels found overall both locomotor and object-control skills should be
365 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-controls, suggesting that levels of physical activity may also
433 explain sex differences. Whilst boys and girls show competence at differing skills, the low
434 competence levels observed across the sample suggest that future preschool interventions should
435 target a broad array of FMS. Nevertheless, girls may require additional or specific approaches in early
436 childhood (2-4 years) to help them develop object-control skills. The component level analysis
437 provides precise information that can assist with the design of instructional programmes and targeted
438 activities so that both boys and girls can achieve developmentally-appropriate levels of competence.
439 For example, in a session to improve running, boys could be given additional instructions and
440 activities to assist them with keeping their eyes focused forwards, whilst girls worked on moving their
441 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.
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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	0.207
Deprivation Level (IMD)	1.49	1.11	1.38	0.88	0.508
BMI Score	16.67	1.67	16.55	1.63	0.648
BMI-z score	0.71	1.08	0.57	0.93	0.386
Total Score	27.59	7.05	26.74	6.24	0.411
Locomotor Score	15.76	4.0	16.75	3.94	0.108
Object-Control Score	11.84	4.18	9.99	3.32	0.002*

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; *Denotes significant sex
 637 difference ($p \leq 0.05$).

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)	0.049*
Strike	8	3 (2, 4)	3 (2, 4)	0.189
Kick	7	3 (2, 5)	3 (2, 3)	<0.001*
Catch	6	1 (0, 2)	1 (0, 2)	0.690
Roll	6	1 (1, 2)	2 (1, 3)	0.122
Dribble	5	0 (0, 1)	0 (0, 1)	0.909
Run	6	4 (3, 5)	5 (4, 6)	0.046*
Jump	5	2 (1, 3)	2 (1, 3)	0.679
Leap	3	2 (1, 2)	2 (2, 2)	0.727
Hop	6	1 (0, 2)	2 (1, 3)	0.010*
Gallop	7	3 (3, 4)	4 (3, 4)	0.003*
Slide	5	4 (2, 5)	3 (1, 5)	0.250

640 CMSP: Maximum score attainable on the Children's Activity and Movement in Preschool Study

641 Motor Skills Protocol (Williams et al., 2009). IQR: Inter quartile range; * Denotes significant

642 difference ($p \leq 0.05$).

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

Skill Component	Boys (%) <i>n</i> = 91	Girls (%) <i>n</i> = 77	<i>p</i>
Run			
C1. Arms move in opposition to legs, elbows bent ^a	73.6	53.2	0.010*
C2. Brief period of suspension (both feet off the ground) ^a	100.0	100.0	-
C3. Narrow foot placement; lands on heel or toe; not flat footed ^a	90.1	89.6	1.00
C4. Length of stride even; path of movement horizontal ^b	40.7	63.6	0.005**
C5. Nonsupport leg flexed to approximately 90 degrees ^a	79.1	89.6	0.102
C6. Eyes focused forward ^b	31.9	55.8	0.003**
Jump			
C1. Preparatory: flexion of both knees; arms behind body ^a	29.7	23.4	0.457
C2. Arms extend forcefully; forward and upward to full extension above the head ^a	11.0	2.6	0.071
C3. Take-off and landing on both feet simultaneously ^a	67.0	66.2	1.00
C4. Take-off on both feet simultaneously; landing non-simultaneous ^b	1.1	2.6	‡
C5. Arms move downward during landing ^a	44.0	54.5	0.225
C6. Balance maintained on landing ^b	31.9	41.6	0.254
Leap			
C1. Take off on one foot; land on opposite foot ^a	74.7	80.5	0.478
C2. Brief period of suspension (both feet off the ground) ^a	92.3	87.0	0.380

C3. Forward reach with arm opposite the lead foot ^a	2.2	1.3	‡
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Hop

C1. Non-support leg swings forward in pendular motion to assist force production ^a	1.1	6.5	‡
C2. Foot of non-support leg remains behind body ^a	18.7	37.7	0.010*
C3. Arms flexed; swing forward together to produce force ^a	1.1	2.6	‡
C4. Weight received (lands) on ball of foot ^b	23.1	20.8	0.864
C5. Takes off and lands three consecutive times on preferred foot ^a	54.9	74.0	0.016*
C6. Takes off and lands on three consecutive times on non-preferred foot ^a	23.1	27.3	0.655

Gallop

C1. Assumes initial position facing forward ^b	92.3	96.1	‡
C2. Arms (elbows) flexed and at waist level at take off ^a	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 ^a	2.2	3.9	‡
C4. Heel-toe action of lead foot ^b	41.8	58.4	0.045*
C5. Brief period of suspension; both feet off the floor ^a	93.4	97.4	‡
C6. Maintains rhythmic pattern (four consecutive gallops) ^a	8.8	16.9	0.178
C7. Final position facing forward ^b	81.3	90.9	0.121

Slide

C1. Body turned sideways; shoulders aligned with line on floor to initiate ^a	94.5	83.1	0.033*
C2. Steps sideways with lead foot; slides trail foot next to	24.2	28.6	0.639

lead foot^a

C3. Arms used to assist leg action ^b	0.0	0.0	N/A
C4. Body maintained in sideways position moving to right ^b	61.5	55.8	0.555
C5. Body maintained in sideways position moving to left ^b	71.4	55.8	0.053
C6. Minimum of four continuous step-slide cycles to right ^a	59.3	53.2	0.524
C7. Minimum of four continuous step-slide cycles to left ^a	53.8	51.9	0.928

645 ^a Skill component present in both the TGMD-2 (Ulrich, 2000) and CMSP (Williams et al., 2009); ^b
 646 Skill component only present in CMSP; * Denotes significant difference ($p < 0.05$); ** Denotes
 647 significant difference ($p < 0.01$); -: Not applicable as competency for boys/girls = 100%; N/A: Not
 648 applicable as competency for boys/girls = 0%; † Performance criteria did not meet the assumption of
 649 the chi-square test.
 650

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

Skill Component	Boys (%) <i>n</i> = 91	Girls (%) <i>n</i> = 77	<i>p</i> =
Throw			
C1. Wind-up initiated by downward movement of hand/arm ^a	7.7	11.7	0.538
C2. Hip and shoulder rotated so that nonthrowing side faces target ^a	23.1	7.8	0.013*
C3. Steps (weight transferred) onto foot opposite throwing arm ^a	5.5	2.6	‡
C4. Differentiated trunk rotation (2) ^b	0.0	0.0	N/A
C5. Block trunk rotation (1) ^b	46.2	35.1	0.194
C6. Timing of release/flight of ball appropriate (late release = downward flight; early release = upward flight) ^b	23.1	19.5	0.706
C7. Arm follows through beyond release (down and across the body) ^a	13.2	5.2	0.135
Strike			
C1. Dominant hand grips bat just above nondominant hand ^a	36.3	32.5	0.724
C2. Nonpreferred side of body faces imaginary "pitcher"; feet parallel ^b	72.5	51.9	0.009**
C3. Steps (transfers weight) onto foot opposite dominant hand to initiate strike ^a	12.1	5.2	0.197

C4. Differentiated trunk rotation (2) ^b	0.0	0.0	N/A
C5. Block trunk rotation (1) ^a	67.0	59.7	0.413
C6. Arm action/plane of bat movement horizontal ^b	57.1	57.1	1.00
C7. Ball contacts bat ^a	51.6	62.3	0.216
C8. Swings through ball (action does not stop at ball contact) ^b	44.0	31.2	0.123

Kick

C1. Rapid and continuous approach to ball ^a	42.9	9.1	<0.001**
C2. Elongated stride or leap immediately prior to ball contact ^a	58.2	32.5	0.001**
C3. Nonkicking foot placed even with or slightly in back of ball ^a	63.7	54.5	0.293
C4. Leg swing is full; full backswing and forward swing of leg ^b	18.7	11.7	0.301
C5. Backswing coordinated with forward action of non-kicking leg ^b	92.3	71.4	0.001**
C6. Ball contacted with instep of kicking foot (shoe laces) ^a	60.4	51.9	0.342
C7. Kicks through ball; leg action does not stop at ball contact ^b	33.0	24.7	0.314

Catch

C1. Preparatory: hands in front of body; elbows flexed ^a	25.3	23.4	0.916
C2. Arms extend toward ball as it moves closer ^a	45.1	37.7	0.417
C3. Ball caught cleanly with hands/fingers (2) ^a	2.2	0.0	N/A
C4. Ball trapped against body/chest (1) ^b	1.1	0.0	N/A

C5. Ball tracked consistently and close to point of contact ^b	24.2	19.5	0.586
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C6. Doesn't turn head/close eyes as ball approaches ^b	31.9	39.0	0.425
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Roll

C1. Ball arm/hand swings down/back of trunk; chest/head face forward ^a	30.8	40.3	0.262
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C2. Foot opposite ball hand strides forward toward cones ^a	7.7	1.3	‡
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C3. Bends knees; lowers body ^a	30.8	37.7	0.437
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C4. Arm action in vertical plane ^b	65.9	64.9	1.00
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C5. Ball held in fingertips ^b	23.1	33.8	0.172
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C6. Ball released close to floor; bounces less than 4 inches high ^a	4.4	7.8	‡
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Dribble

C1. Arm action independent of trunk ^b	34.1	32.5	0.956
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C2. Ball contacted with one hand at about belt/waist height ^a	2.2	1.3	‡
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C3. Pushes ball with fingertips (does not slap at ball with flat hand) ^b	17.6	11.7	0.394
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C4. Ball contacts surface in front of or to the outside of foot on preferred side ^a	8.8	15.6	0.265
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C5. Controls ball for four consecutive bounces; feet not moved to retrieve ball ^a	3.3	1.3	‡
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653 ^a Skill component present in both the TGMD-2 (Ulrich, 2000) and CMSP (Williams et al., 2009); ^b

654 Skill component only present in CMSP; * Denotes significant difference ($p < 0.05$); ** Denotes

655 significant difference ($p < 0.01$); N/A: Not applicable as competency for boys/girls = 0%; †

656 Performance criteria did not meet the assumption of the chi-square test.

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