FUNDAMENTAL MOVEMENT SKILLS OF PRESCHOOL CHILDREN IN NORTHWEST ENGLAND[1,2,3]

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

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

Physical activity guidelines from the United Kingdom (Department of Health, 2011), Australia (Department of Health and Aging, 2010), and Canada (Tremblay et al., 2012) broadly recommend that preschool children engage in at least 180 minutes of physical activity a day, whilst U.S. guidelines suggest that a minimum of 120 minutes is necessary (National Association for Sport and Physical Education Active Start, 2009). Cross-sectional studies of European (Burgi et al., 2011; Fisher et al., 2005; Foweather et al., 2014; Iivonen et al., 2013), Australian (Cliff, Okely, Smith, & McKeen, 2009) and North American (Williams et al., 2008) preschoolers have found positive associations between FMS competence and objectively measured light-, moderate- to vigorous-intensity and total daily physical activity. Whilst these studies mostly indicate a weak association in young children, the relationship between FMS competence and physical activity is hypothesised to strengthen with age (Stodden et al., 2008) and two systematic reviews have found strong evidence for a positive association between FMS competence and physical activity in children and adolescents (Holfelder & Schott, 2014; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Further, longitudinal evidence suggests that previous levels of FMS competence amongst British primary school children (age 6-11 years) positively predicted pedometer-determined daily physical activity one year later (Bryant, James, Birch, & Duncan, 2014). Likewise, FMS competence during the primary school years has also been shown to positively, albeit weakly, predict self-reported physical activity in adolescents (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009). Notably, recent prospective studies have demonstrated that development of FMS competence may have other tangible benefits for health and development. For example, higher levels of FMS competence have positively predicted cardiorespiratory fitness (Vlahov, Baghurst, & Mwavita, 2014), improved academic performance (Jaakkola, Hillman, Kalaja, & Liukkonen, 2015), and are protective against overweight and obesity (Rodrigues, Stodden, & Lopes, 2015). Together, these studies indicate that improving FMS competence may be a potential mechanism to increase children's physical activity and improve their health.

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

The acquisition of FMS is influenced by a range of bio-psychosocial and environmental factors (Hardy, King, Farrell, et al., 2010; Iivonen et al., 2013). With appropriate encouragement and opportunities for learning and practice, children have the developmental potential to achieve competence at FMS by age six (Gallahue & Donnelly, 2003). Yet previous studies using process-based measures of FMS have indicated low levels of competence among UK (Bryant, Duncan, & Birch, 2013), Canadian (LeGear et al., 2012) and Australian (Okely & Booth, 2004; Van Beurden, Zask, Barnett, & Dietrich, 2002) primary school aged children. The suboptimal levels of FMS competence in older children highlights a need to examine early childhood (2-5 years), which is considered a critical phase for FMS development as a failure to make advancements during this stage may result in children attaining lower competence levels later on in their development (Gallahue & Donnelly, 2003). Moreover, this period sees the rapid growth of the brain and neuromuscular maturation (Malina, Bouchard, & Bar-Or, 2004), which has important implications for motor skill acquisition. Further, early childhood is considered a 'window of opportunity' for FMS development as young children have high levels of perceived competence (LeGear et al., 2012). From a practical perspective, this confidence and fearlessness may encourage engagement and persistence in activities that foster FMS competence (Stodden et al., 2008).

Several studies to date have documented levels of FMS competence among preschool children (Barnett, Ridgers, & Salmon, 2014; Cliff et al., 2009; Goodway, Robinson, & Crowe, 2010; Hardy, King, Farrell, et al., 2010; Robinson, 2011; Ulrich, 2000) and conclude that, as expected in young children, these skills are at the rudimentary stage of development. Ulrich (2000) reported low competency at FMS in a representative sample of 332 US preschool children (ages 3-5) as part of normative data collected for the Test of Gross Motor Development-2 (TGMD-2), a process-based measurement tool that assesses six locomotor skills (run, horizontal jump, slide, gallop, leap, and hop) and six object-control skills (strike, basketball dribble, throw, catch, kick, underhand roll). Hardy, King, Farrell, et al. (2010) assessed eight skills (run, gallop, hop, horizontal .jump; strike, catch, kick, throw) in situ using the TGMD-2 in a sample of 330 four-year-old children from New South Wales, Australia. Although the majority of children were competent at the run, competence levels differed across the remaining seven skills, ranging from low to moderate. Both studies (Hardy, King, Farrell, et al., 2010; Ulrich, 2000) also provide detailed descriptive information on competency at the component level, which is useful for guiding teaching strategies to master individual skill components. Findings broadly indicated that competency was lowest for skills requiring the use of the arms, coordinated trunk movement and the transfer of body weight, and highest for locomotor skills requiring only leg movements (Hardy, King, Farrell, et al., 2010; Ulrich, 2000). Thus whilst descriptive data is available from preschool samples in Australia (Hardy, King, Farrell, et al., 2010; Okely & Booth, 2004) and the USA (Ulrich, 2000), data on FMS competence among European preschool children is lacking (Cools et al., 2009). Such data is important considering that international cultural differences, for example in the educational curriculum or traditional sporting pursuits, may be reflected in levels of FMS competence (Simons & Van Hombeeck, 2003).

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

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

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

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

Method

Participants and settings

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

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

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

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

Measures

Fundamental Movement Skills - Testing followed the protocol laid out in the Test of Gross Motor Development-2 (TGMD-2) (Ulrich, 2000), which is specifically designed and validated for use with children aged 3-10 years (Ulrich, 2000). The TGMD-2 measures the performance of 12 FMS, including six locomotor (run, broad jump, leap, hop, gallop and slide) and six object-control (overarm throw, stationary strike, kick, catch, underhand roll and stationary dribble) skills. Prior to data collection field testers were trained by a senior member of the research team (LF) who has significant experience in administering the TGMD-2, through in-situ observation. Children completed the TGMD-2 in small groups (2-4) led by two field testers, in either school halls or on school playgrounds, dependent on available facilities. The first tester was responsible for recording each trial, using a tripod mounted video camera (Sanyo, Japan), while the second provided a verbal description and single demonstration of the required skill. Children performed each skill twice. If a child did not understand the task correctly (for example, running in the wrong direction) then they were given a further verbal description of the skill and asked to repeat the trial. The twelve skills were completed in a standardised order, taking approximately 35-40 minutes per group.

All video recordings were transferred to DVD for subsequent video analysis. Skill competence was assessed using The Children's Activity and Movement in Preschool Study Motor Skills Protocol (CMSP; (Williams et al., 2009), which was developed using the TGMD-2 (Ulrich, 2000) and has an identical protocol. The CMSP is a process-orientated assessment, evaluating each skill based on the child's demonstration of specific movement components, such as *"arms move in opposition to legs, elbows bent"* (see Tables 3 and 4) (Williams et al., 2009). The CMSP was selected for the assessment of FMS as its additional performance criteria and alternate scoring methods improved assessment sensitivity (Williams et al., 2009). The CMSP has demonstrated high reliability (R=0.94), interobserver reliability (R=0.94) and concurrent validity when compared with the TGMD-2 (R=0.98) (Williams et al., 2009). In the present study all analyses were completed by a single trained assessor (JF) who received 30 hours of training from a member of the research team experienced in conducting video analysis (LF). Inter-rater reliability was established prior to assessment using pre-coded videotapes of 10 children, with 83.9% agreement across the twelve skills (range 72.9-89.3%). Likewise, intra-rater reliability was established using pre-coded videotapes of a further 10 children, with test-retest conducted one week apart, with 91.9% agreement established across the twelve skills (range 89.0-96.0%). Whilst there is no accepted minimum level of percentage agreement, 80-85% agreement has been previously deemed to be acceptable (van der Mars, 1989). If the assessor was unsure whether a child had met a performance criteria then the footage was viewed by both JF and LF, with final scoring agreed upon between the two.

In line with the CMSP's (Williams et al., 2009) assessment criteria, for each skill and during both trials, individual components (ranging from 3 to 8, dependent upon the skills) were marked as being absent (0) or present (1). The only exceptions to this scoring system were components 4 and 5 of the throw and strike, whereby hip/trunk rotation was scored as differentiated (2), block (1) or no rotation (0), whilst the catch identified a successful attempt as having been "*caught cleanly with* *hands/fingers*" (2) or "*trapped against body/chest*" (1). If a skill component was successfully demonstrated in both trials, then it was classed as present. Following the outcome measures of the CMSP (Williams et al., 2009), the number of skill components classed as present were summed to create a total score, whilst locomotor and object-control scores were created by summing the number of components present within each subscale.

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

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

Results

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

Insert Table 1 here

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

Insert Table 2 here

Tables 3 and 4 provide descriptive information on the proportion of boys and girls successfully demonstrating competency at individual skill components. Significant sex differences were observed for seven of the 35 locomotor skill components (see Table 3). Boys were significantly more competent than girls for two components, the first of which required the use of the arms during the run (C1) and the second related to maintaining correct body position during the slide (C2). Four of the components girls were found to be significantly more competent at required correct leg movement/feet placement, during the run (C4), hop (C2 and C5) and gallop (C4), with competency levels ranging between 16.6% and 22.9% higher than boys. Girls were also found to be significantly more competent for an additional criterion of the run (C6). Both boys and girls showed high levels of competence (≥80.0%) for the following components: run (C2 and C3), leap (C2), gallop (C1 and C5) and slide (C1). Conversely, low levels of competence (≤30%) were observed for both sexes for skill components in the jump (C1 and C2), hop (C4 and C6), gallop (C6) and slide (C2), with even lower competency levels (≤5.0%) observed for the jump (C4), leap (C3), hop (C3), gallop (C2 and C3) and slide (C3).

Insert Table 3 here

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

Insert Table 4 here

Discussion

This study examined FMS competency in preschool boys and girls living in a low SES area of North-West England. Low competence levels were found across all skills, with the exception of the run, leap and slide, whilst children performed better at locomotor skills than object-control skills. No significant sex differences were observed for either total or locomotor score, though boys were found to have a significantly higher object-control score than girls. These findings support the study's hypothesis and are consistent with previous research in young children (Barnett et al., 2014; Hardy, King, Farrell, et al., 2010). Furthermore, sex differences were observed for individual skill scores, with boys more competent at the throw and kick and girls more competent at the run, hop and gallop. Whilst at the component level, girls were more proficient at components requiring correct leg movement/feet placement, with boys more proficient at components requiring coordination of the legs and correct trunk movement/body position. These findings are able to add to the limited evidence base that is available on FMS competency among preschool children from low SES areas.

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

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

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

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

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

During the preschool years the physical characteristics of boys and girls are very similar, meaning that physiological differences are unlikely to affect FMS competency, therefore these differences may be due to the influence of socio-cultural or environmental factors. Boys and girls likely participate in differing games and physical activities that may contribute to observed sex differences in competence. For example, Barnett et al. (2013) found an inverse association between participation in dance classes and object-control skill competence amongst preschool girls. Evidence from the wider Active Play research project (Foweather et al., 2014) showed that boys were more active than girls and had higher object-controls, suggesting that levels of physical activity may also explain sex differences. Whilst boys and girls show competence at differing skills, the low competence levels observed across the sample suggest that future preschool interventions should target a broad array of FMS. Nevertheless, girls may require additional or specific approaches in early childhood (2-4 years) to help them develop object-control skills. The component level analysis provides precise information that can assist with the design of instructional programmes and targeted activities so that both boys and girls can achieve developmentally-appropriate levels of competence. For example, in a session to improve running, boys could be given additional instructions and activities to assist them with keeping their eyes focused forwards, whilst girls worked on moving their arms in opposition to the legs, with their elbows bent.

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

With the preschool years being a key developmental stage for the acquisition and development of FMS, the findings of low competence and sex differences in object-control and locomotor skills among the children assessed highlights the need for improvements in competency, especially when improved competence has been associated with a range of health and fitness benefits (Lubans et al., 2010; Rodrigues et al., 2015; Vlahov et al., 2014) and in helping to prevent declines in physical activity (Barnett et al., 2009; Holfelder & Schott, 2014; Stodden et al., 2008). Further research will be beneficial not only to help monitor current levels of competence amongst low SES preschool children, but in helping to develop targeted interventions aimed at increasing overall competence and helping to reduce sex differences in competency.

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

Score	Boys (*n* =91)		Girls (*n* =77)		
	Mean	**SD**	**Mean**	**SD**	***p***
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*

Note. – IMD, Indices of multiple deprivation score; BMI, body mass index; IOTF, International Obesity Task Force age- and sex-specific weight for height z-scores; Maximum scores possible for total, locomotor and object-control skills are 71, 32 and 39, respectively; *Denotes significant sex difference ($p \leqslant 0.05$).

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

Skill	CMSP Score	Boys (n = 91) Median (IQR)	Girls (n = 77) Median (IQR)	p
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

CMSP: Maximum score attainable on the Children's Activity and Movement in Preschool Study Motor Skills Protocol (Williams et al., 2009). IQR: Inter quartile range; * Denotes significant difference ($p \leqslant 0.05$).

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

Skill Component	**Boys (%)** n **= 91**	**Girls (%)** n **= 77**	p
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	‡
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

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

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

Skill Component	Boys (%) *n* = 91	Girls (%) *n* = 77	*p* =
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
C6. Doesn't turn head/close eyes as ball approaches[b]	31.9	39.0	0.425
Roll			
C1. Ball arm/hand swings down/back of trunk; chest/head face forward[a]	30.8	40.3	0.262
C2. Foot opposite ball hand strides forward toward cones[a]	7.7	1.3	‡
C3. Bends knees; lowers body[a]	30.8	37.7	0.437
C4. Arm action in vertical plane[b]	65.9	64.9	1.00
C5. Ball held in fingertips[b]	23.1	33.8	0.172
C6. Ball released close to floor; bounces less than 4 inches high[a]	4.4	7.8	‡
Dribble			
C1. Arm action independent of trunk[b]	34.1	32.5	0.956
C2. Ball contacted with one hand at about belt/waist height[a]	2.2	1.3	‡
C3. Pushes ball with fingertips (does not slap at ball with flat hand)[b]	17.6	11.7	0.394
C4. Ball contacts surface in front of or to the outside of foot on preferred side[a]	8.8	15.6	0.265
C5. Controls ball for four consecutive bounces; feet not moved to retrieve ball[a]	3.3	1.3	‡

[a] Skill component present in both the TGMD-2 (Ulrich, 2000) and CMSP (Williams et al., 2009); [b] Skill component only present in CMSP; * Denotes significant difference ($p < 0.05$); ** Denotes

significant difference ($p < 0.01$); N/A: Not applicable as competency for boys/girls = 0%; ǂ Performance criteria did not meet the assumption of the chi-square test.