

Physical Activity and Fundamental Movement Skills of 3- to 5-Year-Old Children in Irish Preschool Services

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The aim of this study was to quantify levels of physical activity (PA) and fundamental movement skills (FMS) of children aged 3 to 5 years in Irish preschool services during care hours, and investigate the relationship between these two variables. Data were collected from 141 children (50.3% boys, age $M = 3.9 \pm 0.5$ years) across 9 preschool services. Measurements included PA via accelerometry, and proficiency in four FMS (run, vertical jump, throw and catch). The recommended guideline of 15 minutes of PA per hour (min PA/hour) was met by 35% of children ($M = 13.6$ min PA/hour). Significant differences in mean PA per hour were found by gender, with boys (14.2 min PA/hour) more active than girls (13.0 min PA/hour), and age, with younger children (14.2 min PA/hour) more active than older (12.6 minutes PA/hour). Percentage of children proficient in the run was high (88.4%), but low across the other skills (4.9%–18.5%). Significant differences were identified by gender for vertical jump with girls scoring higher than boys. No significant relationship was found between FMS and total PA. Low levels of PA and FMS proficiency highlight need for intervention in early years settings to ensure children develop skills to participate in PA.

Keywords: childcare, early childhood, Ireland

Physical activity (PA), defined as any bodily movement produced by skeletal muscle requiring greater energy expenditure than resting (Caspersen, Powell, & Christenson, 1985), is important at all stages of life for physical (Poitras et al., 2016; Warburton & Bredin, 2017) and mental health (Ahn & Fedewa, 2011; Lubans et al., 2016). Particularly for young children, PA through active play contributes to the development of cognitive function (Tandon et al., 2016), social

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skills (Gehris, Gooze, & Whitaker, 2015), and physical self-concept (Babic et al., 2014), alongside benefiting a range of physical health outcomes (Ghazi et al., 2016; Timmons et al., 2012; Vale, Trost, Rego, Abreu, & Mota, 2015).

In Ireland, the PA recommendation for children under 6 years old is encompassed by the guidelines for children and young people, which recommends that those aged 2 to 18 years achieve a total of 60 minutes of moderate to vigorous PA (MVPA) throughout the day every day (Department of Health and Children, 2009). There have been a number of recent international developments regarding guidelines for this age group. Between 2010 and 2012, the UK, Australia and Canada published guidelines recommending that children under six participate in 180 minutes of PA at any intensity, spread across the day during their early years (Chief Medical Officers, 2011; Department of Health and Ageing, Commonwealth of Australia, 2010; Tremblay et al., 2012). For time spent in childcare, this has been extrapolated across a 12-hour day, with the Institute of Medicine (IOM) recommending 15 minutes per hour (mins/hr) of PA at any intensity for all hours that children are in childcare (Institute of Medicine, 2011). More recently however, it has been recognized that PA is only one aspect of movement that impacts health, and with this has come a shift towards integrating PA, sedentary behavior (SB), and sleep into one overall guideline balancing movement behaviors throughout the whole day (Chaput, Carson, Gray, & Tremblay, 2014). Canada (Tremblay et al., 2017), Australia (Okely et al., 2017), and South Africa (Laureus Sport for Good Foundation, 2018) have now published 24-hour movement guidelines from birth to age 4 or 5, recommending the optimal balance of PA, SB, and sleep for infants, toddlers, and preschool children. These guidelines all recommend at least 180 minutes of PA for preschool children, with at least 60 minutes of 'energetic play' (operationalized as MVPA), less than one hour at a time of SB and 10–13 hours of quality sleep.

Learning to move is a necessary skill underlying PA participation (Stodden et al., 2008; Jaakkola, Yli-Piipari, Huotari, Watt, & Liukkonen, 2016), and as well as myriad physical health and developmental benefits, PA provides an opportunity for young children to experience and develop essential gross motor skills (Pica, 2011; Laukkanen, Pesola, Havu, Sääkslahti, & Finni, 2014; Lin, Cherng, & Chen, 2017). In particular, a specific group of basic movement patterns called fundamental movement skills (FMS) have been shown to play a crucial role in PA participation throughout the lifespan. These skills are often described as the 'ABCs' or 'building blocks' of movement (Clark & Metcalfe, 2002; Goodway & Robinson, 2006) and are precursors to more specialized movement patterns used in sport, recreation, and play activities such as running, jumping, and throwing. It has been suggested that children have the capacity to develop most of these skills by the age of 6 years old (Gallahue & Ozmun, 2006), but while there is a prevalent belief that children develop these skills naturally over time, achieving mastery in FMS requires both teaching and practice (Clark, 2007; Liong, Ridgers, & Barnett, 2015; Barnett, Salmon, & Hesketh, 2016). Most recent research suggests that failure to reach a sufficient level of proficiency in FMS during childhood can impact negatively on PA participation throughout the lifespan (Robinson et al., 2015).

The preschool years (ages 3 to 5) are emphasized as an essential period for children to practice and learn specific movement patterns through PA (Colella & Morano, 2011; LeGear et al., 2012). This period has been described as a 'window of opportunity' for development of FMS and positive PA behaviors, specifically

due to an optimum combination of malleable health behavior (Skouteris et al., 2012), neural development (Fischer & Rose, 1998; Haywood & Getchell, 2009), and propensity to attempt and persist with activities at this stage of life (LeGear et al., 2012). As such, the important role of early childhood care and education services has been highlighted, with this context ideally positioned to both teach and encourage PA and FMS from an early age (Goldfield, Harvey, Grattan, & Adamo, 2012; Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016; Lindsay, Greaney, Wallington, Mesa, & Salas, 2017; Tucker & Irwin, 2010).

In Ireland, there is a paucity of data regarding PA and FMS levels of children in the preschool years, as available research to date has focused on school-aged children (Harrington et al., 2016). Low levels of PA have been identified for Irish children and young people, with research suggesting that only 19% of primary school children, and 12% of post-primary school children are meeting the national guideline for children and youth of 60 minutes MVPA per day (Woods, Tannehill, Quinlan, Moyna, & Walsh, 2010). Similarly, markedly low levels of FMS proficiency have been identified in Irish primary school children (Bolger et al., 2017) and youth, with a recent study highlighting that only 0.5% of a sample of 256 11- to 12-year-olds achieved mastery, and 11% achieved near mastery in the nine FMS tested (Belton, O' Brien, Meegan, Woods, & Issartel, 2014). As PA and FMS levels tend to track from early childhood (EC) through to middle childhood and adolescence (Jones, Hinkley, Okely, & Salmon, 2013; McKenzie et al., 2002; Telama et al., 2014), this would suggest that children in Ireland are not developing FMS proficiency and establishing positive PA behaviors from a young age.

Since September 2016, the state-funded Early Childhood Care and Education (ECCE) scheme has offered two years of free ECCE for preschool-aged children, with approximately 95% of eligible children participating in the scheme (Pobal, 2016). As such, the potential for ECCE services to positively influence PA and FMS behaviors through the teaching, facilitation and encouragement of active play and associated skills is pivotal. This paper aims to fill a gap in current knowledge by investigating levels of PA and FMS of children in preschool services in Ireland and exploring the relationship between these two variables. It will also compare these levels with those of preschool children internationally.

Methods

Participant Recruitment

This study presents cross-sectional data, taken at baseline, from a larger intervention study called 'Kids Active'. Ethical approval for the study was obtained from the Dublin City University Research Ethics Committee (DCU/REC/2016/013).

Services offering the ECCE scheme in Dublin were recruited to take part in the physical data element (measurement of height, weight, PA, and FMS) of the Kids Active program through Early Childhood Ireland, a membership-based organization representing the early childhood care and education sector in Ireland. Services that offered the ECCE scheme and were current members of Early Childhood Ireland were invited to fill out an expression of interest form on the Early Childhood Ireland website in January 2016, which was publicized through their member newsletters and social media. A total of 40 expressions of interest were received, from which 10

were randomly chosen for inclusion in the study. One of the chosen services was unable to take part in all elements of the data collection and was subsequently excluded from the study. As required for inclusion in the ECCE scheme, all services utilized the Aistear national early years curriculum framework (National Council for Curriculum and Assessment, 2009) which ensured that despite different ethos or approaches, all services followed the same curriculum framework. Informed Consent was received from parents or guardians of children participating in the study, along with verbal assent from the children themselves on the day of testing.

Measures

Data were collected on-site at each service by two trained postgraduate researchers during ECCE hours. Each testing session lasted approximately two hours for height, weight, and FMS measurement, with accelerometers distributed at the end of the testing session for wear over the following two weeks.

Anthropometrics. Weight status was assessed through measurement of standing height (measured with Leicester Height Measure to the nearest 0.1 cm) and weight (measured with Seca mechanical weighing scales to the nearest 0.1 kg). Both measures were taken without shoes. Body Mass Index (BMI) was calculated as weight in kilograms divided by the square of the height in meters (kg/m^2).

Physical Activity. PA and SB were measured using ActiGraph GT1M or GT3X accelerometers, both of which have been validated for use with young children (Costa, Barber, Cameron, & Clemes, 2014; Pate, O'Neill, & Mitchell, 2010; Van Cauwenberghe, Gubbels, Bourdeauduij, & Cardon, 2011). Accelerometers were set to record at 10-second epochs in order to capture the short sporadic bursts of PA, characteristic of preschool children (Dwyer, Baur, & Hardy, 2009). The device was worn on the right hip using an elasticated belt for the duration of the ECCE day at the service. Educators were asked to put an accelerometer belt on each child (with each monitor labelled for each individual child) as they arrived in the morning and remove it before they went home for a total of five days over a two-week period.

Fundamental Movement Skills. Four FMS were assessed consisting of two locomotor skills (run and vertical jump) and two object control skills (catch and overhand throw). Skills were assessed using the guidelines from the Test of Gross Motor Development-2 (Ulrich, 2000) for run, catch, and overhand throw, and the Victorian Fundamental Motor Skills Manual (Department of Education Victoria, 1996) for vertical jump. The TGMD-2 provides good test-retest reliability in EC ($r = .88$) (Valentini, 2012), with high internal consistency (Cronbach's alpha .85 to .91) (Cools, Martelaer, Samaey, & Andries, 2009). Collection of FMS data followed the protocol previously established for a study investigating FMS in Irish children (Belton et al., 2014; O'Brien, Issartel, & Belton, 2013). For each testing session, children were divided into groups of 5 (± 1). For each skill, children received a demonstration and a description of the skill to be performed. Participants performed each skill three times which included one practice and two performance trials. Video cameras recorded each participant's performance, for which scoring was completed at a later date. In accordance with the TGMD-2 and Victorian Fundamental Motor Skills Manual (Department of Education Victoria, 1996; Ulrich, 2000), each skill consisted of qualitative performance criteria to describe

the movement pattern of the skill. If a child performed a skill component correctly, a score of one was recorded, and if performed incorrectly, the score was recorded as zero. This scoring was performed by trained researchers, who achieved 95% inter-rater agreement with an expert scorer. Raw scores of each FMS were obtained by summing the scores of the criterion of the two performance trials (run, vertical jump, catch, and overhand throw; maximum scores of 8, 12, 6, and 8, respectively, total FMS; maximum score of 34).

Data Processing

BMI percentiles were calculated relative to gender and age using the Centers for Disease Control and Prevention (CDC) Children's BMI tool based on CDC growth charts (Kuczmarski et al., 2002). Weight status was classified according to percentile as underweight (<5th percentile), normal weight (5th–85th percentile), or overweight or obese ($\geq$ 85th percentile) (Center for Disease Control and Prevention, 2000; Kuczmarski et al., 2002). Results indicated that only two children were classified as 'underweight'; therefore, weight status was collapsed into a binary variable of 'not overweight or obese' and 'overweight or obese'. Similarly, the sample contained only two 5-year-olds (representing 1.2% of the sample; aged 5.1 and 5.3 years), and as a result, age categories were classified as children under 4 years of age and children 4 years of age or older for analysis (<4 or $\geq$ 4).

Accelerometer data were processed using ActiLife software version 6.13.3. Only data from the y-axis across both accelerometer models (GT1M and GT3X) were used in the study, as this has been shown to be comparable across monitors (Sasaki, John, & Freedson, 2011). Minimum wear time for inclusion in analysis was set at $\geq$ 150 minutes (2.5 hours out of the 3-hour ECCE preschool day, allowing for time to put on and remove the belts) for a minimum of three days. Periods of 60 minutes or more of continuous zeros were considered non-wear time, and excluded from analysis (Colley et al., 2013; Pfeiffer et al., 2013). Cut points developed for preschool children by Pate and colleagues (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Pate et al., 2015) were chosen for comparability with previous studies, as they have been most frequently used to assess PA of preschool children in the childcare setting (O'Brien, Vanderloo, Bruijns, Truelove, & Tucker, 2018). The Pate cut points were applied to determine minutes of Sedentary (Sed) and PA of intensities light (LPA), moderate (MPA), and vigorous (VPA), with intensities also combined to give an overview of total time in higher intensity activity (MPA + VPA = MVPA) and total PA at any intensity (LPA + MPA + VPA = LMVPA). To account for the different lengths of time that children spent in ECCE, average daily minutes per hour (mins/hr) at each intensity were calculated for each participant (Vanderloo & Tucker, 2015). The proportion of children meeting the IOM guideline of 15 mins/hr (Institute of Medicine, 2011) was calculated based on mean hourly LMVPA (O'Neill, Pfeiffer, Dowda, & Pate, 2016). While MVPA and SB are included in the 24-hour movement guidelines, no hourly or childcare-specific recommendations have been extrapolated from this and therefore MVPA and Sed are presented only as mean mins/hr.

A binary variable called 'mastery or near mastery' (MNM) was also created for each of the four FMS. MNM for each skill represents children who had

achieved mastery (defined as correct performance of each skill component on both trials) and near mastery (defined as correct performance of all but one of the skill components on both trials), in line with previous studies (O'Brien et al., 2013; Van Beurden et al., 2003), to assess the proportion of children proficient in each skill.

Statistical Analysis

All data were analyzed using IBM SPSS Statistics 23, with alpha set at $p < .05$. Main outcome variables analyzed were mean PA mins/hr at each intensity, and FMS proficiency (for each of the four skills individually and for the four skills combined). Independent-samples *t*-tests were conducted to assess the impact of weight status on both mean PA mins/hr and FMS raw scores.

Two-way between-groups ANOVA were computed to explore the impact of the independent variables gender and age on both mean PA mins/hr and FMS proficiency scores. To estimate the ANOVA effect sizes, partial eta squared (η^2) were additionally computed and interpreted according to guidelines by Cohen (1988) of .01 = small, .06 = moderate, and .14 or above = large.

Additionally, categorical dependent variables were analyzed which included the proportion of children meeting the IOM guidelines and proportion of children achieving MNM for each of the four skills. Chi-square tests for independence were used to examine whether differences existed by independent variables age and gender for percentage of children meeting the IOM guideline, or achieving MNM for each of the four individual FMS.

Pearson correlations were used to test for associations between each of the FMS variables (raw skill scores individually and total FMS gross score) and mins/hr PA at different intensities. This was repeated for the sample overall, then split by each variable of age, gender and weight status. Associations between raw BMI score, PA mins/hr, and FMS proficiency scores were also investigated using Pearson correlations overall, by age and by gender. Strength of any significant correlations were classified according to Evans (1996), as very weak ($r = .00-.19$), weak ($r = .20-.39$), moderate ($r = .40-.59$), strong ($r = .60-.79$), or very strong ($r = .80-1.0$)

Results

A total of 141 participated in the Kids Active research (50.3% boys). Due to the age of the children, some participants did not want to take part in all elements of the testing, with numbers included in each analysis varying (anthropometric data $n = 141$; PA data $n = 126$; and total FMS data $n = 124$). A total of 19.1% of the sample were classified as overweight or obese. Average wear time for accelerometers was 5.1 ± 2 hours per day. Independent-samples *t*-tests indicated no significant differences between children who were overweight or obese, and children who were not overweight or obese for any of the PA or FMS variables. Participant characteristics are presented in Table 1.

The mean minutes per hour of PA at each intensity, and the percentage of children who met the IOM guideline of 15 mins LMVPA/hr during standard ECCE hours are presented in Table 2, with results of the two-way ANOVA and chi-square test for independence.

Table 1 Characteristics of the Study Sample (Mean ± SD) (N = 141)

	Total (141)	Boys (71)	Girls (70)
Age (years)	3.9 (.47)	3.9 (.48)	4.0 (.48)
Height (m)	1.02 (.05)	1.03 (.05)	1.01 (.05)
Weight (kg)	16.7 (2.4)	17.3 (2.6)	16.1 (2.2)
BMI (kg·m ⁻²)	15.9 (1.6)	16.2 (1.9)	15.7 (1.2)
Not overweight or obese	80.9%	76.1%	85.7%
Overweight or obese	19.1%	23.9%	14.3%

Table 2 Mean (±SD) Hourly Minutes of PA and Percentage of Children Meeting the Guideline (n = 126)

Age	Boys		Girls		Sig.	Effect Size
	<4	≥4	<4	≥4		
n	n = 32	n = 27	n = 33	n = 34	p	η ²
Min/hr Sed	45.1 (2.9)	46.5 (3.0)	46.5 (3.3)	47.7 (3.7)	(age) .029* (gen) .030*	.039 .038
Min/hr LPA	6.3 (1.0)	5.8 (1.0)	5.9 (1.3)	5.4 (1.1)	(age) .016*	.046
Min/hr MPA	5.4 (1.2)	4.8 (1.2)	4.9 (1.3)	4.3 (1.4)	(gen) .031* (age) .013*	.037 .050
Min/hr VPA	3.3 (1.0)	2.9 (1.1)	2.7 (1.0)	2.6 (1.6)	(gen) .044*	.033
Min/hr MVPA	8.6 (2.1)	7.7 (2.1)	7.6 (2.2)	6.9 (2.7)	(gen) .028*	.039
Min/hr LMVPA	14.9 (2.9)	13.5 (3.0)	13.5 (3.3)	12.4 (3.7)	(gen) .030* (age) .029*	.038 .039
Meeting 15 min/hr guideline	46.9%	29.6%	36.4%	26.5%	.328	

Note. Sed = sedentary; LPA = light physical activity; MPA = moderate physical activity; VPA = vigorous physical activity; MVPA = MPA+VPA; LMVPA = LPA+MPA+VPA; gen = main effect for gender; age = main effect for age.

**p* < .05.

Results of the two-way between-groups ANOVA exploring the impact of gender and age on mins/hr of PA indicated no significant interaction effect at any intensity. Significant main effects were found for age at Sed [*F* (1, 122) = 4.9, *p* = .029], LPA [*F* (1, 122) = 5.9, *p* = .016], MPA [*F* (1, 122) = 6.4, *p* = .013], and LMVPA [*F* (1, 122) = 4.9, *p* = .029] with small effect sizes of η² between .039 and .050. Overall, children in the younger age group were generally less sedentary, and more active than those in the older group for LPA, MPA, and LMVPA, but not VPA or MVPA.

Statistically significant main effects were also found for gender, with girls accumulating less PA and more SB than boys in all cases, at Sed [*F* (1, 122) = 4.8, *p* = .030], MPA [*F* (1, 122) = 4.8, *p* = .031], VPA [*F* (1, 122) = 4.1, *p* = .044],

LMVPA [$F(1, 122) = 4.8, p = .030$], and MVPA [$F(1, 122) = 5.0, p = .028$] with small effect sizes of η^2 between .033 and .039.

In terms of meeting the 15 mins/hr guideline, boys in the younger age category were the most active, with 46.9% meeting the PA guideline, compared to only 26.5% of girls in the older age group. Despite this, chi-square tests revealed no significant association between meeting the PA guideline by age and gender [$\chi^2(1, n = 126) p = .328, \phi = .165$].

Fundamental Movement Skills

Mean FMS raw scores ($\pm$ SD) and percentage of children achieving MNM for each of the four skills by age and gender are presented in Table 3. Results of the two-way ANOVA exploring impact of gender and age on FMS raw score indicated no significant interaction effects for any of the skills individually or combined. There was a significant main effect for gender for the skill of vertical jump [$F(1, 120) = 6.7, p = .011$] with a small effect size ($\eta^2 = .53$). In this case, when not classified by age group, girls achieved a higher raw score for vertical jump (7.6) than boys (6.7).

Chi-squared tests for independence indicated no significant association between MNM by age or gender for any of the four skills.

Relationship Between Fundamental Movement Skills and Physical Activity

Significant weak negative correlations were found between total FMS score and both MPA ($p = .041, r^2 = .042$) and LPA ($p = .030, r^2 = .047$) for the overall sample. Significant weak negative correlations were also found for boys between catch and LPA ($p = .034, r^2 = .085$), and for 3-year-olds between total FMS score and both LPA ($p = .028, r^2 = .087$) and LMV ($p = .035, r^2 = .079$), with weak positive correlation for total FMS score and Sed ($p = .035, r^2 = .079$).

Discussion

Overall, only 35% of children met the guideline of 15 mins/hr LMVPA during ECCE hours. In contrast to this, a recent study in the UK (Hinkley et al., 2016) indicated that 99.1% of a sample of 731 children met the guidelines on an average day during care hours. In this study, Hinkley and colleagues objectively measured PA with ActiGraph accelerometers, but a cut point of 100 CPM was utilized to distinguish SB from PA. This is a significantly lower threshold than the ≤ 799 CPM used to classify SB in the current study, indicating that SB may have been underestimated, in comparison with our results.

The absence of differences in PA behavior by weight status reported in this sample is similar to a Canadian study in which no differences for PA during preschool hours were found between overweight and non-overweight children in a sample of 216 children (Tucker, Maltby, Burke, Vanderloo, & Irwin, 2016). In contrast with this, Trost, Sirard, Dowda, Pfeiffer, and Pate (2003) in the USA identified significant differences in PA by weight status for 3- to 5-year-old boys only, with overweight boys significantly less active than their normal weight peers. This, however, was

Table 3 Mean ($\pm$ SD) Raw FMS Scores and Percentage of Children Achieving Master and Near Mastery (MNM)

	Boys		Girls		Sig.	Effect size η^2
	<4 years old (<i>n</i> = 41)	$\geq$ 4 years old (<i>n</i> = 30)	<4 years old (<i>n</i> = 39)	$\geq$ 4 years old (<i>n</i> = 28)		
Run raw score (maximum score 8)	6.9 (1.0)	7.1 (1.0)	7.0 (1.3)	6.6 (1.3)	.169	
Run MNM <i>n</i>	82.9% 41	93.3% 30	89.7% 41	89.3% 29	.572	
Jump raw score (maximum score 12)	6.7 (1.8)	6.7 (1.9)	7.1 (1.8)	8.0 (1.4)	(gen) .011*	.053
Jump MNM <i>n</i>	7.3% 40	3.3% 29	2.4% 43	10.3% 32	.476	
Throw raw score (maximum score 8)	2.6 (1.6)	2.7 (1.7)	2.6 (2.1)	2.7 (1.9)	.884	
Throw MNM <i>n</i>	2.5% 42	3.4% 29	7% 42	6.3% 32	.763	
Catch raw score (maximum score 6)	2.1 (1.3)	2.6 (1.4)	2.1 (1.3)	1.9 (1.4)	.888	
Catch MNM <i>n</i>	22% 38	15.6% 25	16.7% 38	19.4% 23	.893	
Total raw score (maximum score 34)	18.6 (3)	18.8 (3.5)	19.0 (3.9)	18.8 (2.3)	.774	

Note. gen = main effect for gender.
**p* < .05.

before the introduction of the 180 minutes LMVPA guideline specifically for early years, and as such PA was defined as MVPA with no analysis of LMVPA.

The results of this study indicate differences in PA behavior by gender, with boys appearing to be significantly more active than girls. Similar results have been found in numerous studies of children aged 3 to 5 years old, with boys participating in significantly more LMVPA (Caldwell et al., 2016; Hesketh et al., 2014; Rice & Trost, 2014) and MVPA (Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012; Rice & Trost, 2014; Vale, Silva, Santos, Soares-Miranda, & Mota, 2010) than girls. Interestingly, a study in the UK (Hesketh, Griffin, & van Sluijs, 2015) found that objectively measured PA was comparable between boys and girls during time at home, but boys were significantly more active than girls during time in the preschool setting. Hesketh and colleagues (2015) suggest that this is indicative of children's innate preferences for different types of activities, as the regulatory standards for preschool services in the UK emphasize a child-led approach and children are encouraged to self-select activities. Evidence suggests that boys tend to engage in more high intensity activities like rough-and-tumble play, and girls tend to favor light intensity activities like playing with dolls (Barbu, Cabanes, & le Maner-Idrissi, 2011; Pellegrini & Smith, 1998). As these tendencies are most likely influenced by inadvertent stereotyping of activities (Hesketh et al., 2015; Hinkley et al., 2012; Morley, Till, Ogilvie, & Turner, 2015), the important role of parents and carers in addressing this trend is emphasized to ensure that all children are encouraged to partake in different types of active play regardless of gender.

In terms of age, previous evidence (Rice & Trost, 2014) has pointed to older preschool children being more active than younger children. Results of this study, however, show that younger children were significantly more active than older children overall, which was influenced by the difference between ages for LPA and MPA, with no differences in the higher intensities of VPA or MVPA. Research has shown that high intensity activity accounts for only a small proportion of preschool children's activity, with as little as 1.8% of time in VPA, and 5.5% of daily activity in MVPA. (Bornstein, Beets, Byun, & McIver, 2011; Pate, Mciver, Dowda, Brown, & Addy, 2008). The present results concur with these findings, as the data suggests that younger children may engage in more PA overall through lighter intensity activities. While MVPA is highlighted as the target intensity for school-age children, adolescents, and adults, PA at any intensity is beneficial for children of this age, in line with previous guidelines for early years PA (Chief Medical Officers, 2011). It is suggested that future studies investigating PA of children in ECCE should compare PA levels of 3-, 4-, and 5-year-olds to explore if this finding of PA decreasing for older preschool children extends to other studies or is unique to this sample.

Previous research has highlighted differences in FMS by gender, with studies utilizing the TGDM-2 for preschool children in Australia indicating that girls tend to outperform boys in locomotor skills (Cliff, Okely, Smith, & McKeen, 2009; Hardy, King, Farrell, Macniven, & Howlett, 2010) and boys tend to score significantly higher than girls in object control skills (Hardy et al., 2010). While differences were not found for gender overall in the current study, the finding that girls scored significantly higher in the vertical jump is in keeping with the literature, even if the magnitude of this difference was not enough to influence overall locomotor differences. The fact that only one of the four FMS tested

showed significant differences by gender may more strongly reflect societal expectations than physical abilities, as it has been suggested that biological differences between genders that may impact on skill performance are not prominent before puberty (Malina, Bouchard, & Bar-Or, 2004). Therefore a child's FMS development may depend on societal and environmental factors such as gender stereotyped games and social expectations which may not be ingrained at this early age (Saraiva, Rodrigues, Cordovil, & Barreiros, 2013).

When analyzed by age, these FMS results indicate no significant differences for any of the four FMS tested, contrary to the research that older children achieve higher proficiency in FMS than their younger counterparts (Yang, Lin, & Tsai, 2015).

These findings are concerning, as it highlights that preschool children in this setting are not improving in their FMS during the years that are considered the 'window of opportunity'. In order to reach sufficient proficiency in FMS to allow children to take part in, and enjoy PA throughout their lives, interventions at this age are warranted, while this 'window' is still metaphorically open (LeGear et al., 2012). Compared to the other skills, a high proficiency level was identified for the run, reflective perhaps of this being a skill that children get more opportunities to engage in, and practice through active play.

In comparing raw FMS scores to those presented for preschool children internationally, the current sample achieved similar results for throw (raw score 2.7) to a sample of 41 children in Switzerland (raw score 2.8) (Donath, Faude, Hagmann, Roth, & Zahner, 2015), though lower on the catch (Irish sample scored 2.2 while the Swiss sample scored 3.4). Mean raw score for run (6.9) was also slightly above results of a study in the USA, in a sample of 71 children who achieved a mean raw score of 6.3 (Alhassan et al., 2012), but were lower than an Australian sample of 425 4-year-olds who achieved a mean score of 7.4 (Hardy et al., 2010). Results from the research by Hardy and colleagues (2010) also indicates higher mean scores than the Irish sample for throw (3.5 vs 2.7) and catch (4.0 vs 2.2), while girls in the Irish sample scored higher in the throw than a sample of 54 girls in the USA (2.6 vs 0.32) and slightly lower results for catch (2.0 vs 2.5) (Veldman, Palmer, Okely, & Robinson, 2017). This shows that there is a need for targeted intervention in the early years, as Irish children are already falling behind their international counterparts in FMS proficiency. The availability of two free ECCE years in Ireland means that FMS intervention programs at this level could potentially reach all children in Ireland.

Previous studies investigating the relationship between PA and FMS for preschool children have shown mixed results, with some evidence of a link between higher intensity (MVPA) activities and object control skills (Cook, 2012), locomotor skills (Williams et al., 2008) and FMS overall (Williams et al., 2008). In the current sample, some significant correlations were found indicating that higher FMS proficiency may be weakly associated with less time in LPA and MPA, though no corresponding relationship between FMS and higher intensity activity was identified. The proposed nature of this relationship is captured in a study by Barnett and colleagues (Barnett, Salmon, & Hesketh, 2016), in which children's PA and FMS data were measured at ages 19 months, 3.5 years, and 5 years. In this case, MVPA at 3.5 was associated with locomotor skills at age 5, with the conclusion that previous time in PA may be more important to current skill level than current PA. Similarly, in a systematic review of literature investigating this relationship, stronger relationships

were identified between FMS and PA in middle childhood than in early childhood or adolescence (Logan, Kipling Webster, Getchell, Pfeiffer, & Robinson, 2015). Stodden and colleagues (2008) hypothesize that FMS and PA are weakly related in early childhood, and the strength of the relationship between these two variables increases as children age and develop, with research indicating that FMS developed in childhood are important for participation in PA in adolescence (Robinson et al., 2015). While a reciprocal relationship between PA and FMS are proposed, the uni-directional relationship (increased PA leading to the development of FMS) may be a more important focus for young children, as PA provides the context and opportunity to practice and increase proficiency in FMS (Colella & Morano, 2011). It is expected that the relationship in the other direction (higher FMS proficiency enabling greater participation in PA) would strengthen in middle childhood, and beyond (Logan et al., 2015). This is an important consideration, as it indicates that while proficiency in FMS may facilitate participation in PA in later years (Robinson et al., 2015), participation in PA in the early years is essential for practicing and refining these FMS (Lopes, Rodrigues, Maia, & Malina, 2011). That is to say, although there is no clear relationship between PA and FMS for the current sample at this timepoint, high levels of PA at this age may be associated with greater FMS proficiency in later years, due to increased opportunities to learn and use these skills (Goodway, Famelia, & Bakhtiar, 2014; Loprinzi, Davis, & Fu, 2015). Mutually, higher proficiency in FMS at this timepoint could be associated with greater PA participation in later years, as evidenced by longitudinal studies exploring this relationship (Lopes, Rodrigues, Maia, & Malina, 2011; Larsen, Kristensen, Junge, Rexen, & Wedderkopp, 2015). Interventions targeting both PA and FMS simultaneously would be worthwhile for this population to ensure that all children get the opportunity to reach their physical potential. While a focus on PA mainly would be justified based on these findings, it is suggested that FMS is also incorporated into the preschool learning environment to ensure that learning of FMS is supported.

Limitations

A number of limitations of the current study must be acknowledged. For the PA data, only time within the ECCE service was measured, which accounts for only a small portion of PA within the day. As many children only attended the service for the government-funded 3-hour ECCE session, the wear time criteria was low. Additionally, the myriad of different cut points utilized in previous research for this age group makes international comparison difficult. The small number of skills tested provides limited information on the FMS of children in the ECCE setting in Ireland and may not capture differences by gender or age that may exist overall, or for specific skills, within this population.

Conclusion

The low proportion of children meeting the guidelines for PA during ECCE hours and low FMS proficiency for selected FMS indicates that children, in the ECCE setting in Ireland, may be insufficiently active for health, movement, and developmental benefits. As research indicates that FMS do not emerge naturally,

teaching, feedback, and opportunities to practice are essential to achieve mastery in these skills. Intervention is warranted in this population to ensure that children achieve proficiency in FMS through PA in the form of active play, while they are still in the prime stage of life to develop these skills. Given the paucity of PA research for this population in Ireland, and the recent increase in evidence-based 24-hour movement guidelines as a benchmark for comparison, more extensive research involving full-day accelerometer wear is warranted. Coupled with a complete battery of FMS tests, this would allow for international comparison and make longitudinal research possible to explore the relationship between PA and FMS at different timepoints across the lifespan.

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