Does fundamental movement skill proficiency vary by sex, class group or weight status? Evidence from an Irish primary school setting

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This study examined fundamental movement skill (FMS) proficiency among male (N=216) and female (N=198) Irish primary school pupils from Year 2 to Year 7 (9.0 ± 1.7 years). Following anthropometric measurements, participants were video-recorded performing 15 FMS and scored using the TGMD-3, Victorian Fundamental Movement skills Manual and the Get skilled: Get active guidelines. Percentage mastery ranged between 1.4% (gallop) and 35.7% (slide). A two-way ANOVA evaluated the effect of sex (male/female) and class group (Year 2/3/4/5/6/7) on individual skills, locomotor subtest, object-control subtest and total TGMD-3 (GMQ) scores. No significant sex × class interaction effects were found. Large effect sizes were reported for male superiority in object-control subtest (η_p^2=0.26) and GMQ (η_p^2=0.16) scores (both $p<0.001$). Older classes had higher object-control subtest scores than younger classes, but scores plateaued after Year 5. Furthermore, overweight participants had significantly lower locomotor subtest ($p<0.001$, d=0.7), object-control subtest ($p=0.03$, d=0.3) and GMQ scores ($p<0.001$, d=0.5) than non-overweight participants. This study highlights very poor levels of FMS mastery among Irish schoolchildren and stresses the need for developmentally appropriate, FMS intervention programmes that are inclusive regardless of age, sex or weight status.

Keywords: FMS, motor competence, physical activity, physical education, TGMD-3

Introduction

Fundamental movement skills (FMS) are the basic observable patterns of movement that create a foundation for the development of more advanced skills required for activities of daily living and both recreational and competitive forms of physical activity (PA) (Gallahue, Ozmun & Goodway, 2012). FMS include locomotor (e.g. run, hop), object-control (e.g. throw, catch) and stability (e.g. single leg stance, roll) skills (Gallahue et al., 2012), which children acquire at different rates depending on environmental and individual factors. Opportunities to be physically active must be provided to children for FMS to be developed to a proficient level, however, technological advances and safety concerns have led to sedentary lifestyle behaviours in favour of outdoor free-play activities. Children who fail to acquire a proficient level of FMS often lack the confidence and motivation to engage in PA (Whitehead, 2010; Stodden et al., 2008; Seefedlt, 1980) and are more likely to drop out of organised sport during adolescence (Woods, Tannehill, Quinlan, Moyna, & Walsh, 2010).

The literature reports that only 19% and 12% of Irish primary and secondary level students meet the recommended guidelines of 60 minutes of moderate-to-vigorous PA per day respectively (Woods et al., 2010). Furthermore, Ireland is predicted to become one of the most inactive and obese European nations by 2025 (NCD risk factor collaboration, 2016). At present, preventable diseases such as type 2 diabetes, heart disease and cancers cost the Irish healthcare system up to €1.16 billion each year (Dee et al., 2015). These diseases often manifest during childhood. Early childhood interventions, are therefore essential to foster the maintenance of lifelong health and wellbeing. Children with high motor competence are reported to be 2.46 times more likely to achieve the recommended levels of daily moderate-to-vigorous PA than children with low motor competence (De Meester et al., 2018). Therefore identifying FMS proficiency levels among schoolchildren can provide essential information for the development of targeted intervention programmes aimed at increasing the necessary confidence and competence for lifelong PA participation.

Nationally (Bolger et al., 2017) and internationally, (Bryant, Duncan & Birch, 2014; Van Beurden, Zask, Barnett & Dietrich, 2002; Hume et al., 2008; Bardid et al., 2016; Mukherjee, Jamie & Hin Fong, 2017) the proportion of schoolchildren achieving advanced skill proficiency is frequently less than 50% for most FMS. Furthermore, sociocultural influences (Garcia, 1994; Thomas and French, 1985) have likely contributed to males often outperforming females in object-control skills (Bolger et al., 2017; Foulkes et al., 2015; Hardy, King, Farrell, Macniven & Howlett, 2010). Although female superiority is sometimes observed for balance and skipping skills (Hardy et al., 2010; van Beurden et al., 2002; O'Brien, Belton & Issartel, 2015), overall locomotor skill performance is often similar for males and females (Goodway, Robinson and Crowe, 2010; O'Brien et al., 2015; Bardid et al., 2016).

FMS assessments focusing on movement quality are useful when comparing sex and age differences, as size and strength do not influence the results. The Test of Gross Motor Development, currently in its third edition (TGMD-3), is a valid and reliable tool for assessing 13 FMS (6 locomotor and 7 object-control skills) among children aged three to ten years-old (Valentini, Zanell & Webster 2016; Rintala, Sääkslahti & Iivonen, 2017; Temple & Foley, 2016), while the TGMD-2 has shown adequate reliability and validity among adolescents (Mean age: 12.03±0.49) (Issartel et al., 2017). Although balance is a prerequisite skill for performing most locomotor skills, it is not assessed individually in the TGMD-3. Therefore, the single leg stance was assessed using the 'Get Skilled: Get Active' protocol (NSW Department of Education and Training, 2000). The vertical jump is a key FMS for the Irish sports of Gaelic football and hurling and therefore assessed using performance criteria outlined in the ‘Victorian Fundamental Motor Skills Manual’ (Department of Education Victoria, 1996). Scores are assigned based on the presence or absence of 3-5 performance criteria. Ideally, all children should be achieving maximum scores in each skill by the age of ten (Ulrich, 2000).

Although children have the potential to master most FMS by age 6, the rate of development is highly individual and depends on exposure and practice opportunities. The optimal learning period is proposed to be between 3 and 8 years old (Gallahue et al., 2012), highlighting the need for research to be conducted among primary school children. To date, only two studies have investigated FMS proficiency levels among Irish primary school children and the proportion of children achieving mastery in most FMS is less than 50% (Bolger et al., 2017; Farmer, Belton & O’Brien 2017). However, Bolger et al. (2017) only included participants in Year 2 and 5 of primary school, therefore lacking information on whether a plateau in FMS proficiency occurs between those years and Farmer et al., (2017) only included 8 to 12 year-old females, at which point children should have already mastered most FMS. Therefore, the aim of this study was to identify proficiency levels of Irish schoolchildren in Year 2 (6-7 years-old) through to Year 7 (11-12 years-old) inclusive, across 15 FMS. Differences according to class group, sex and weight status were also investigated.

Methods

Participants

A convenience sample of 414 schoolchildren (age: 6-12) attending three mixed-sex, midland-based primary schools were recruited. Pupils in Years 2 to 7 inclusive, were included. A sample size calculation was completed using previous research by Wai-Yin Pang and Tik-Pui Fong (2009) which tested a comparable age group (6-9 years) and applied similar testing methods (TGMD-2). With α=0.05, power=0.8, detectable difference=1 and standard deviation=4.4, the projected sample size required was 310. Parental consent and participant assent was obtained prior to data collection. The Institute Research Ethics Board granted ethical approval.

Data collection

FMS proficiency was examined on 15 skills. Performance criteria for 13 skills were outlined in the TGMD-3 (Ulrich & Webster, 2015). These skills were: run, gallop, hop, skip, horizontal jump and slide in the locomotor subtest and two-hand strike of a stationary ball, one-hand forehand strike of a self-bounced ball, one-hand stationary dribble, two-hand catch, kick a stationary ball, overhand throw and underhand throw in the object-control subtest. The vertical jump and single leg stance were assessed using the performance criteria outlined in the 'Victorian Fundamental Motor Skills Manual' (Department of Education Victoria, 1996) and the 'Get Skilled: Get Active' protocols (NSW Department of Education and Training, 2000) respectively.

Class groups were tested in the school hall during a 90-minute time period. Height (measured to the nearest 0.1 cm) using a portable height stadiometer (SECA 217, SECA ltd., Leicester, UK) and body mass (measured to the nearest 0.1 kg) using a portable SECA heavy-duty scale (SECA colorata 760, SECA ltd., Leicester, UK) were measured and recorded under assigned ID numbers. BMI was derived using the equation: body mass (kg)/ height (m^2). Participants were categorised as either overweight/obese or non-overweight according to the age- and gender-specific International Obesity Task Force cut-off points (Cole et al., 2000). The participants were then guided through a dynamic warm-up (Faigenbaum & McFarland, 2007), divided into three groups and assigned to one of the three testing stations. Five skills were tested and video-recorded (Panasonic V260 full HD camcorder, hc-v260eb-k, Panasonic, UK) at each station, which were facilitated by two trained testers. One tester performed a demonstration of the skills and instructed participants to perform one practice and two test trials of each, which were video-recorded by the second tester. Participants moved in a clockwise direction to the next station until all three stations were complete.

Scoring protocol

Intra-rater reliability was established prior to scoring skill performances with ICC values ranging between 0.79-0.94. Each skill was scored based on the presence or absence of predefined performance criteria. A score of 1 was given for each performance criterion correctly performed and 0 for any absent or incorrectly performed criterion. Scores for two trials of each skill were summed to give individual skill scores. The maximum score possible for each skill depended on its number of performance criteria which was either 3, 4, 5 or 6. For example, the dribble was divided into three performance criteria (1. Contacts ball with one hand at about waist level, 2. Pushes the ball with fingertips (not slapping the ball), 3. Maintains control of the ball for at least four consecutive bounces without moving the feet to retrieve the ball), allowing a maximum possible score of 6. The locomotor and object-control skill subtest scores were calculated by adding together the scores for each of the six locomotor skills (maximum possible score=46) and seven object-control skills (maximum possible score=54) included in the TGMD-3 protocol respectively. The subtest scores were then summed to give an overall gross motor quotient (GMQ) score (maximum possible score=100). Mastery was defined as the correct performance of all criteria over two trials (e.g. score of 6 for the dribble). Near mastery was defined as the correct performance of all but one performance criteria over two trials which for the dribble was assigned for a score of 5. A score of 4 would also be classified as near mastery if only one criterion was absent over two trials, however, where two different criteria were absent, poor mastery was assigned. Poor mastery was defined as the incorrect performance/absence of more than one performance criteria over two trials. This classification of mastery levels is often used both nationally (O'Brien et al., 2015; Belton et al., 2014) and internationally (Van Beurden et al., 2003).

Data analysis

FMS data were analysed using SPSS version 24 and statistical significance was set at $p<0.05$. Descriptive statistics and frequencies were used to present mean scores and percentage mastery for each skill. Differences in individual skill, locomotor subtest, object-control subtest and GMQ scores with respect to sex (male/female) and class group (Year 2/3/4/5/6/7) were established using a two-way ANOVA with Tukeys post-hoc test used to identify the specific significant differences across class groups. Partial eta squared values (η_p^2) of 0.01, 0.06 or 0.14, represented small, medium and large effect sizes respectively (Cohen, 1988). Differences in skill performance between overweight/obese and non-overweight participants were detected using independent samples t-tests. Effect sizes were calculated using

Cohen's d where d=0.2, 0.5 and 0.8 represented small, medium and large effect sizes respectively (Cohen, 1988).

Results

Participant information

Participant demographics categorised by class group and sex for 216 males and 198 females aged 6-12 years are summarised in Table 1.

****Insert Table 1 near here****

Mastery levels

Overall, participants demonstrated low levels of mastery across all fifteen skills ranging from 1.4% (gallop) to 35.7% (slide) (Figure 1). Over 50% of participants had poor mastery in nine of the fifteen skills including two hand strike (78%), vertical jump (77.8%), hop (72.5%), one-hand forehand strike (65.5%), gallop (62.8%), kick a stationary ball (62.1%), run (57.3%) and overhand throw (55.1%). The slide, two-hand catch and skip were the best performed with 80.9%, 75.6% and 73.2% classified as having mastery/near mastery respectively.

**** Insert Figure 1 near here ****

Sex and class group differences in FMS proficiency

Results of the two-way ANOVA investigating the impact of sex (male/female) and class group (Year 2/3/4/5/6/7) on individual skill, locomotor subtest, object-control subtest and GMQ scores are summarised in Table 2. No interaction effects were present ($p>0.05$), suggesting that the effect of class group on FMS proficiency was similar for both males and females and the effect of sex on FMS proficiency was similar across class groups.

A significant, large effect size was reported for male superiority in the object-control subtest ($p<0.001$, $\eta_p^2=0.26$) and GMQ scores ($p<0.001$, $\eta_p^2=0.14$). Although males were better than females in the slide and females were better than males in the skip (both $p<0.001$, $\eta_p^2=0.03$), effect sizes were small and sex did not significantly affect overall locomotor subtest scores ($p>0.05$, $\eta_p^2=0.00$). Significant differences were reported across class groups for 11 of the 15 skills and for the object-control subtest ($p<0.001$, $\eta_p^2=0.27$) and GMQ ($p<0.001$, $\eta_p^2=0.16$) scores, but locomotor subtest scores were similar across all class groups ($p>0.05$; $\eta_p^2=0.02$). Participants in Year 2 had significantly lower scores than all other class groups for each object-control skill, and were significantly poorer than Year 7 pupils for only one locomotor skill (skip). Improvements in object-control subtest scores peaked at Year 5 after which a plateau/slight decline was observed.

**** Insert Table 2 near here****

Differences according to weight status

Table 3 summarises the differences in mean scores for each skill, locomotor subtest, object-control subtest and GMQ between overweight/obese (n=95/23%) and non-overweight (n=319/77%) participants. Non-overweight participants performed significantly better than overweight participants in the locomotor subtest ($p<0.001$, $d=0.7$), object-control subtest ($p=0.03$, $d=0.3$) and GMQ score ($p<0.001$, $d=0.5$). Non-overweight participants were significantly better than overweight participants in 7 skills with medium effect sizes for the run ($p<0.001$, $d=0.7$) and horizontal jump ($p<0.001$, $d=0.5$), and small effect sizes for the hop ($p=0.01$, $d=0.3$), slide ($p=0.004$, $d=0.3$), vertical jump ($p=0.002$, $d=0.4$), kick ($p=0.009$, $d=0.3$) and two-hand strike ($p=0.003$, $d=0.3$).

**** Insert Table 3 near here ****

Discussion

The current study offers a more comprehensive and up-to-date analysis of the status of FMS proficiency in Irish children in recent years by evaluating a broader range of FMS, including participants across a longer age span and assessing FMS proficiency according to weight status. The low percentage of Irish primary school children achieving mastery in this study is similar to previous national (Bolger et al., 2017) and international investigations (Bardid et al., 2016; Bryant et al., 2014; van Beurden et al., 2002). The largest improvements in FMS mean scores occurred between Year 2 (age 6-7) and Year 3 (age 7-8), after which scores began to plateau and decline slightly, especially after Year 5 (age 9-10). In addition, males were significantly better than females in the object-control subtest and non-overweight participants had significantly better locomotor and object-control subtest scores than their overweight/obese counterparts.

The proportion of participants who achieved mastery (i.e. maximum score for a skill) across 15 FMS ranged from 1.4% (gallop) to 35.7% (slide). These scores are lower than Bolger et al. (2017), where the proportion of Year 2 and Year 6 Irish schoolchildren achieving mastery was between 12.3% (horizontal jump) and 79.4% (run). Bolger et al. (2017) reported higher mastery levels in the run (13% vs 79.4%), gallop (1.4% vs 53.1%), kick (20% vs 59%) and hop (2.4% vs 28.4%) but a similar proportion of participants achieved mastery in the horizontal jump, catch and overhand throw. The differences may be because the current sample had a higher percentage of overweight/obese participants (23% vs 13.8%). Some evidence exists for an inverse correlation between PA levels and weight status (Slotte et al., 2017), which might indicate lower levels of PA among the current sample and hence a reduced likelihood of attaining FMS mastery. PA levels were not recorded as part of this study, therefore, can only be considered as one of many potential influencing factors for poor FMS mastery. Other factors include socioeconomic status, education, family behaviours and cultural beliefs (Venetsanou and Kambas, 2010). Future investigations should aim to understand the reasons why FMS mastery is not being attained.

These poor mastery levels are consistent with international investigations where less than 50% of English (Bryant et al., 2014), Australian (van Beurden et al., 2002; Hume et al., 2008; Hardy et al., 2013), US (Butterfield et al., 2012), Singaporean (Mukherjee et al., 2017), Brazilian (Valentini et al., 2007; Spessato et al., 2013), South African (Pienaar, Vidagie, & Leonard, 2015) and Belgian (Bardid et al., 2016) schoolchildren between 6 and 12 years old achieved mastery across a broad range of FMS. It is speculated that PA and FMS competence are reciprocally related (Stodden et al., 2008). Young children who do not partake in regular PA are limiting their opportunities to practice and learn FMS and therefore more likely to have poor FMS competence. Consequently, as children get older, poor FMS competence is likely to reduce confidence and motivation to willingly participate in regular PA (Stodden et al., 2008). If Irish schoolchildren are provided more opportunities to improve their FMS proficiency, the likelihood is that PA levels will increase which may enhance physical and psychological wellbeing and reduce the incidence of obesity-related diseases.

Bolger et al, (2017) reported that Irish schoolchildren in Year 6 (age 10) demonstrated higher locomotor and object-control subtest scores than those in Year 2 (age 6), therefore it was expected that FMS proficiency levels of older children would be better than younger children. However, no significant differences were reported across any class group from Year 2 (age 6) to 7 (age 12) for the locomotor subtest score but object-control subtest scores significantly improved between Year 2 and 5 (age 9), and plateaued thereafter. Similarly, Belgian (Bardid et al., 2016) and Brazilian (Valentini et al., 2016) schoolchildren aged 3-8 and 3-10 years respectively, showed no significant improvements in locomotor subtest scores after age 6 (Bardid et al., 2016) and Brazilian schoolchildren's object-control subtest scores began to plateau by age 8 (Valentini et al., 2016). Bardid et al. (2016). Since Bardid et al. (2016) only included children up to age 8, it is unknown if a similar plateau would have occurred had older children been included in that study. This plateauing effect was not the result of children achieving maximum scores for each skill. Failure to improve locomotor skills beyond age 6 and object-control skills beyond age 9 may be influenced by experience and practice opportunities. For example, children experience and practice locomotor skills before starting primary school and have therefore developed some level of proficiency. In contrast, for many children, their first opportunity to practice and learn object-control skills is during primary school PE lessons and therefore take longer to develop. Irish primary school teachers receive limited training on teaching PE, and often lack the confidence and motivation to successfully teach FMS within the curriculum (Fletcher and Mandigo, 2012). Exposure to new skills during PE provides an opportunity for children to acquire an elementary level of skill, but more specialised teacher-training programmes may be required to ensure teachers can facilitate the development of FMS to mastery level.

Males were significantly better than females in the object-control skills category ($p<0.001$, $\eta_p^2=0.27$) which is supported by previous research (Bolger et al., 2017; Bardid et al., 2016; van Beurden et al., 2002). As pre-pubescent males and females are biologically similar, this divide is likely influenced by socio-cultural factors (Garcia, 1994; Thomas & French, 1985). Highly competitive invasion games are reportedly the most dominant activity in Irish primary PE lessons (Woods et al., 2010). However, females are more likely to disengage from these highly competitive activities due to the issues of perceived sex roles and the idea that they should act in a more caring, less competitive manner (Spencer, Rehman & Kirk, 2015). Therefore, while games are essential to the development of object-control skills, they must be organised in a manner that allows all children to fully engage with the activity to facilitate object-control skill development for both males and females.

Evidence for sex differences in locomotor skill proficiency is less consistent with some studies reporting female superiority (Bolger et al., 2017; Hardy et al., 2010), and others supporting the current findings of no significant differences between males and females (O'Connor et al., 2018; O'Brien et al., 2015; Foulkes et al., 2015; Bardid et al., 2016; Goodway et al., 2010). These variations may be influenced by the amount and type of locomotor skills assessed in a study, as females are more often significantly better at balance and skipping skills (Okely and Booth, 2004), potentially due to greater female engagement in activities such as dance and gymnastics (Garcia 1994; Thomas & French, 1985; Woods et al., 2010; Blachford et al., 2003). However, regardless of sex, less than 50% of participants achieved mastery or near-mastery in the majority of skills, and so these findings merely highlight the need to accommodate inter-individual variability within intervention programmes.

Non-overweight participants had higher locomotor subtest scores than overweight participants, which supports previous research that noted a 2-4 times higher chance of this occurring (Okely and Booth, 2004). The largest difference was observed for the run, a skill which overweight children are consistently less competent at (Bryant et al., 2014; Hume et al., 2008). Children with higher BMI are more likely to have excess adipose tissue surrounding joints, thus making it more difficult to physically move body limbs or to achieve full range of motion (Bryant et al., 2016). The criteria ‘non-support leg bent to 90 degrees’ for the run is an example of one component that may be largely affected by higher BMI and adipose tissue. Apart from the kick, the object-control skills investigated in the current study did not require whole-body locomotion and therefore might explain why less of a difference was observed between overweight and non-overweight participants for object-control skill performance, compared to locomotor skill performance.

Lower levels of FMS proficiency among overweight children may put them at increased risk of demotivation and PA avoidance and therefore further weight gain (Stodden et al., 2008). Thus, tackling this issue in primary school is essential to ensure feelings of embarrassment and incompetence, which overweight children commonly report as a major barrier to PA participation, are avoided (Stodden et al., 2008). Primary schools provide an ideal setting to educate all children on the importance of PA and focusing on FMS development may increase their confidence and motivation to become more physically active both within and outside school.

The strengths of this study are the large sample size and the inclusion of children across a broad age range. Generalisability of findings are limited due to the inclusion of only three primary schools (a large urban school, small village school and a rural school). Socioeconomic status and ethnicity can significantly influence FMS proficiency (Adeyemi-Walker et al., 2018). A separate analysis examining the differences in FMS proficiency between each of the three schools found that participants in the large urban school had significantly lower mean GMQ scores than the rural and village school. Large urban schools in Ireland tend to be more ethnically diverse compared to the rural and village schools and this may explain the lower FMS scores. In addition, children who grow up in rural Ireland often have greater access to green space and more freedom to explore the outdoors compared to urban-based children. This may provide rurally-based children with more opportunities to develop their FMS. Future studies should therefore aim to include a larger representative sample with participants from varied ethnic, cultural and socioeconomic backgrounds. Furthermore, comparing FMS proficiency across class groups is limited by the cross-sectional design, while weight classification is limited by using only BMI. A longitudinal study could more accurately determine whether children improve their FMS competence throughout the primary school years. Having excess adipose tissue explains why overweight children are less proficient at locomotor skills than non-overweight children, however, BMI does not differentiate between lean mass and fat mass. Future investigations should therefore aim to include more accurate measurements of body composition such as DEXA, waist-hip circumference and skin-fold measurements. Finally, the expectation is that improving FMS competence will facilitate higher levels of PA engagement. Unfortunately, measuring PA levels was beyond the scope of this investigation and should be considered in future studies.

Conclusion

The current study highlights the inadequate FMS proficiency levels among Irish schoolchildren, with new insights uncovered regarding age and weight-related differences. Males were more proficient than females in the object-control subtest and non-overweight children were more proficient than overweight children in the locomotor subtest. Thus, future intervention programmes should be tailored to the specific needs of the child, particularly at an age when teaching and practicing FMS is optimal for learning. Although some improvement in skill performance was observed throughout the early years, this plateaued or slightly declined after Year 5. Given that primary school offers an ideal setting for FMS development, future research should aim to understand how all children can be facilitated in acquiring a proficient level of FMS, regardless of sex, age or weight-status.

Disclosure Statement

The authors report no conflict of interest.

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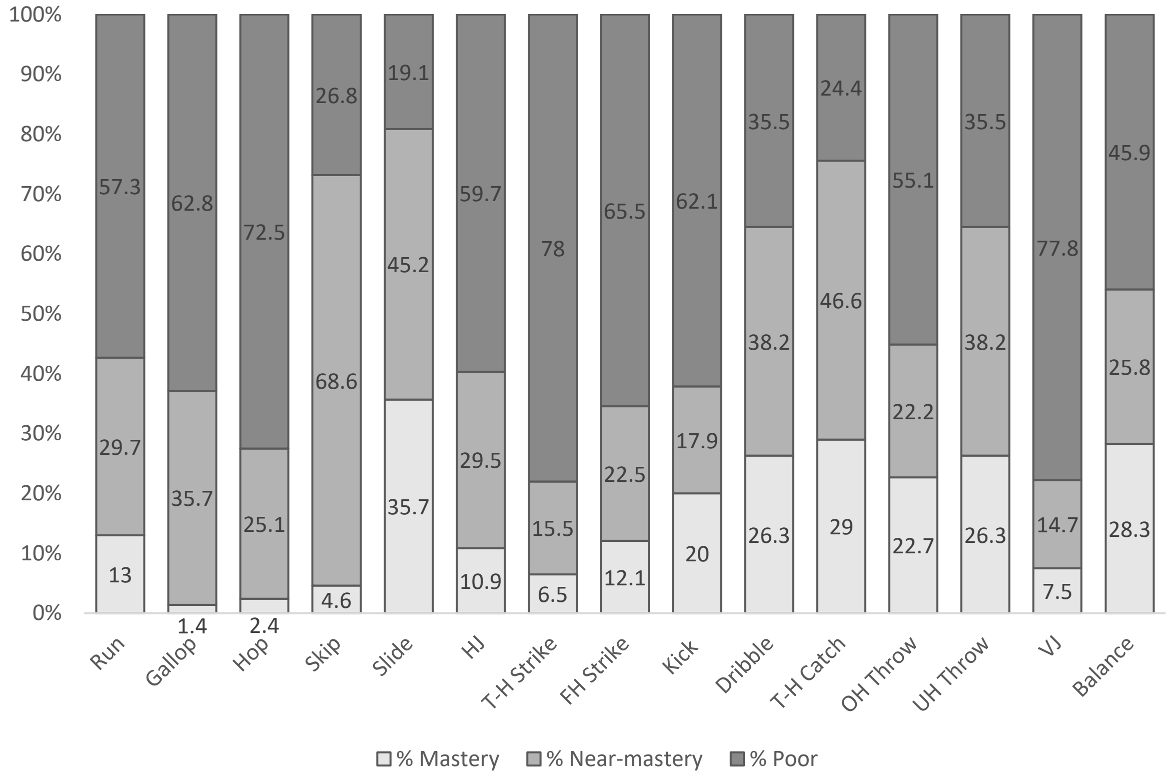

Figure 1. Percentage of participants (n = 414) achieving mastery, near-mastery and poor in each skill

Note: HJ = Horizontal jump, T-H Strike = Two-hand strike, FH Strike = Forehand strike, OH Throw = Overhand throw, UH throw = Underhand throw, T-H Catch = Two-hand catch, VJ = Vertical jump

Table 1. Participant information classified according to class group and sex

Class	Sex	n	Age (yr.) ± SD	Weight (kg) ± SD	Height (cm) ± SD
Year 2	M	25	6.6 ± 0.4	23.6 ± 4.1	121.6 ± 5.0
	F	36	6.4 ± 0.4	22.2 ± 3.4	118.9 ± 4.5
Year 3	M	51	7.8 ± 0.4	26.7 ± 5.1	128.0 ± 5.4
	F	43	7.7 ± 0.5	27.6 ± 6.4	128.8 ± 4.6
Year 4	M	23	8.6 ± 0.4	30.0 ± 5.9	132.6 ± 5.7
	F	32	8.5 ± 0.5	31.2 ± 12.1	131.7 ± 8.1
Year 5	M	43	9.5 ± 0.4	32.9 ± 5.4	137.1 ± 4.9
	F	27	9.5 ± 0.4	33.2 ± 6.9	134.7 ± 6.4
Year 6	M	36	10.5 ± 0.4	36.7 ± 10.7	144.4 ± 7.4
	F	30	10.5 ± 0.5	39.4 ± 12.6	144.1 ± 8.2
Year 7	M	38	11.6 ± 0.4	42.2 ± 11.9	148.9 ± 8.9
	F	30	11.5 ± 0.4	45.4 ± 9.5	149.2 ± 6.5
Total	M	216	9.2 ± 1.7	32.8 ± 10.2	136.0 ± 11.1
	F	198	8.9 ± 1.8	32.4 ± 11.6	133.7 ± 12.0

Note: M = male, F = female, n = number of participants, SD = standard deviation

Table 2. Two-way ANOVA for the effect of class group and sex on FMS proficiency levels

			Mean (raw score) ± SD							Sex		Class		
	Skill	**S**	**Year 2 (6 yrs.)**	**Year 3 (7 yrs.)**	**Year 4 (8 yrs.)**	**Year 5 (9 yrs.)**	**Year 6 (10 yrs.)**	**Year 7 (11 yrs.)**	**Total**	**p**	**η_p^2**	**p**	**η_p^2**	**Post hoc**
TGMD-3 LM skills	Run	M	5.6 ± 1.8	5.1 ± 1.7	5.4 ± 1.6	4.7 ± 1.7	5.0 ± 1.7	5.6 ± 1.9	5.2 ± 1.7	0.12	0.01	0.09	0.02	NA
	MS = 8	F	5.2 ± 1.6	5.3 ± 1.5	5.9 ± 1.6	4.5 ± 1.4	4.9 ± 1.8	5.1 ± 1.8	5.0 ± 1.6					
		T	5.4 ± 1.7	5.2 ± 1.6	5.1 ± 1.6	4.7 ± 1.6	4.9 ± 1.7	5.4 ± 1.9	5.1 ± 1.7					
	Gallop	M	4.5 ± 1.8	4.8 ± 1.6	5.5 ± 1.3	4.2 ± 1.8	4.3 ± 1.9	4.7 ± 1.6	4.6 ± 1.7	0.53	0.00	**0.001 ****	0.05	Y4>Y5+Y7
	MS = 8	F	4.7 ± 1.4	5.1 ± 1.1	5.2 ± 1.1	4.2 ± 1.8	5.0 ± 0.8	4.4 ± 1.7	4.8 ± 1.4					
		T	4.6 ± 1.6	4.9 ± 1.4	5.4 ± 1.2	4.2 ± 1.8	4.6 ± 1.5	4.5 ± 1.7	4.7 ± 1.6					
	Hop	M	4.7 ± 1.6	4.4 ± 1.8	5.0 ± 1.5	4.1 ± 1.3	4.6 ± 1.5	4.3 ± 1.3	4.4 ± 1.5	0.62	0.00	0.48	0.01	NA
	MS = 8	F	4.0 ± 1.7	4.7 ± 1.8	4.5 ± 1.5	4.3 ± 1.3	4.5 ± 1.3	4.6 ± 1.4	4.4 ± 1.5					
		T	4.3 ± 1.7	4.5 ± 1.8	4.7 ± 1.5	4.2 ± 1.3	4.5 ± 1.4	4.4 ± 1.3	4.4 ± 1.5					
	Skip	M	2.8 ± 1.8	3.3 ± 1.5	2.9 ± 1.8	3.2 ± 1.7	3.4 ± 1.5	4.0 ± 1.4	3.3 ± 1.6	**0.001 ****	0.03	**0.004 ****	0.04	Y2<Y7/ Y4<Y7
	MS = 6	F	3.5 ± 1.2	3.9 ± 1.2	3.5 ± 1.3	4.0 ± 1.2	3.5 ± 1.2	4.2 ± 0.7	3.7 ± 1.2					
		T	3.2 ± 1.5	3.6 ± 1.4	3.2 ± 1.5	3.5 ± 1.6	3.5 ± 1.3	4.1 ± 1.1	3.5 ± 1.4					
	Slide	M	6.6 ± 1.2	6.4 ± 1.5	7.4 ± 1.1	6.8 ± 1.5	6.5 ± 1.7	6.9 ± 1.4	6.7 ± 1.5	**0.001 ****	0.03	0.06	0.03	NA
	MS = 8	F	5.8 ± 1.3	6.3 ± 1.5	6.5 ± 1.0	6.7 ± 1.6	6.5 ± 1.5	6.1 ± 1.2	6.3 ± 1.4					
		T	6.1 ± 1.3	6.4 ± 1.5	6.9 ± 1.2	6.8 ± 1.5	6.5 ± 1.6	6.6 ± 1.4	6.5 ± 1.4					
	HJ	M	4.3 ± 2.1	5.0 ± 1.9	5.2 ± 1.9	5.1 ± 1.8	5.1 ± 1.7	5.6 ± 1.9	5.1 ± 1.9	0.61	0.00	0.75	0.01	NA
	MS = 8	F	5.1 ± 1.6	4.9 ± 2.1	4.9 ± 1.8	4.9 ± 1.5	5.4 ± 1.4	4.6 ± 1.7	5.0 ± 1.7					
		T	4.8 ± 1.8	5.0 ± 2.0	5.0 ± 1.8	5.0 ± 1.7	5.2 ± 1.6	5.0 ± 1.9	5.0 ± 1.8					
	LM ST	M	28.6 ± 5.8	29.1 ± 5.4	31.4 ± 5.6	28.2 ± 5.2	28.9 ± 4.7	31.1 ± 6.0	29.4 ± 5.5	0.50	0.00	0.15	0.02	NA
	MS = 46	F	28.3 ± 5.2	30.2 ± 4.5	29.5 ± 3.7	28.6 ± 4.9	29.8 ± 4.3	28.9 ± 4.9	29.3 ± 4.6					
		T	28.4 ± 5.4	29.6 ± 5.0	30.3 ± 4.7	28.3 ± 5.1	29.3 ± 4.5	30.1 ± 5.6	29.3 ± 5.1					
TGMD-3 O-C skills	T-H	M	5.8 ± 2.2	6.1 ± 2.0	6.5 ± 2.4	7.1 ± 2.0	7.0 ± 1.8	6.9 ± 2.1	6.6 ± 2.1	**<0.001 *****	0.14	**<0.001 *****	0.1	Y2<all/ Y3<Y5/ Y4<Y5
	Strike	F	3.1 ± 1.2	4.7 ± 1.9	4.5 ± 2.3	5.8 ± 2.3	5.4 ± 2.4	5.8 ± 2.0	4.8 ± 2.2					
	MS = 10	T	4.2 ± 2.1	5.5 ± 2.0	5.3 ± 2.5	6.6 ± 2.2	6.3 ± 2.2	6.4 ± 2.1	5.7 ± 2.3					

	FH	M	4.1 ± 2.0	5.0 ± 1.9	5.2 ± 1.7	6.4 ± 1.8	5.1 ± 1.9	5.8 ± 1.9	5.3 ± 2.0	**<0.001**	0.12	**<0.001**	0.11	Y2<all/ Y3<Y5+Y7/
	Strike	F	2.2 ± 1.4	3.7 ± 1.8	3.7 ± 2.1	4.4 ± 2.1	4.1 ± 2.5	4.6 ± 2.2	3.7 ± 2.1	*******		*******		Y5<Y6/Y5>Y6
	MS = 8	T	3.0 ± 1.9	4.4 ± 2.0	4.3 ± 2.1	5.6 ± 2.2	4.6 ± 2.2	5.3 ± 2.1	4.6 ± 2.2					
	Kick	M	5.0 ± 2.1	6.2 ± 1.8	6.7 ± 1.7	5.9 ± 1.9	5.8 ± 1.9	6.2 ± 1.6	6.0 ± 1.9	**<0.001**	0.21	**<0.001**	0.07	Y2<all
	MS = 8	F	3.3 ± 1.2	3.9 ± 0.9	4.5 ± 1.2	4.1 ± 1.3	4.8 ± 1.6	4.9 ± 2.0	4.2 ± 1.5	*******		*******		
		T	4.0 ± 1.8	5.1 ± 1.9	5.4 ± 1.8	5.2 ± 1.9	5.3 ± 1.8	5.6 ± 1.9	5.1 ± 1.9					
	OH	M	5.4 ± 1.8	5.7 ± 1.9	6.3 ± 1.8	6.5 ± 1.6	6.2 ± 1.8	6.1 ± 2.2	6.1 ± 1.9	**<0.001**	0.17	**0.01**	0.04	Y2<all
	Throw	F	3.4 ± 1.6	4.7 ± 2.0	5.0 ± 2.1	4.4 ± 2.0	4.4 ± 1.4	4.2 ± 1.8	4.4 ± 1.9	*******		*****		
	MS = 8	T	4.2 ± 1.9	5.3 ± 2.0	5.5 ± 2.1	5.7 ± 2.0	5.4 ± 1.9	5.3 ± 2.2	5.2 ± 2.1					
	UH	M	5.8 ± 1.8	6.3 ± 1.5	6.1 ± 1.4	6.6 ± 1.4	6.6 ± 1.5	6.3 ± 1.4	6.3 ± 1.4	**0.03**	0.01	**0.002**	0.05	Y2<Y5+Y6
	Throw	F	5.3 ± 1.6	5.6 ± 1.6	6.0 ± 1.4	6.4 ± 1.3	6.4 ± 1.3	6.1 ± 1.3	5.9 ± 1.5	*****		******		
	MS = 8	T	5.5 ± 1.5	6.0 ± 1.6	6.0 ± 1.4	6.6 ± 1.4	6.5 ± 1.4	6.2 ± 1.3	6.1 ± 1.5					
	Catch	M	3.5 ± 1.2	4.5 ± 1.3	5.0 ± 1.4	4.3 ± 1.2	4.6 ± 1.1	4.8 ± 0.9	4.5 ± 1.2	0.82	0.00	**<0.001**	0.16	Y2<all
	MS = 8	F	3.1 ± 1.4	4.4 ± 1.3	4.9 ± 1.3	4.7 ± 1.1	4.7 ± 1.3	5.1 ± 0.9	4.4 ± 1.4			*******		
		T	3.2 ± 1.3	4.4 ± 1.3	4.9 ± 1.3	4.5 ± 1.2	4.6 ± 1.2	4.9 ± 0.9	4.4 ± 1.3					
	Dribble	M	2.6 ± 1.7	3.5 ± 1.6	4.4 ± 1.2	4.9 ± 1.4	4.9 ± 1.4	4.9 ± 1.1	4.2 ± 1.6	**0.006**	0.02	**<0.001**	0.3	Y2<all/
	MS = 8	F	2.1 ± 1.6	3.0 ± 1.7	3.1 ± 1.4	4.7 ± 1.3	4.7 ± 1.1	4.9 ± 1.2	3.6 ± 1.8	******		*******		Y3<Y5,Y6+Y7/
		T	2.3 ± 1.7	3.3 ± 1.7	3.7 ± 1.5	4.6 ± 1.2	4.8 ± 1.3	4.9 ± 1.1	3.9 ± 1.7					Y4<Y5,Y6+Y7
	O-C ST	M	32.2 ± 7.5	37.3 ± 6.9	40.3 ± 6.5	41.5 ± 5.9	40.2 ± 5.7	41.2 ± 5.7	39.0 ± 6.9	**<0.001**	0.26	**<0.001**	0.27	Y2<all/
	MS = 54	F	22.6 ± 4.7	30.0 ± 6.4	31.7 ± 5.9	34.6 ± 5.5	34.4 ± 5.0	35.6 ± 5.8	31.1 ± 7.1	*******		*******		Y3<Y5,Y6+Y7/ Y4<
		T	26.5 ± 7.6	34.0 ± 7.6	35.3 ± 7.4	38.9 ± 6.6	37.6 ± 6.1	38.7 ± 6.3	35.2 ± 8.1					Y5+Y7
TGMD-3	**GMQ**	M	60.8 ± 11.7	66.4 ± 10.9	71.7 ± 10.2	69.7 ± 9.5	69.1 ± 8.7	72.3 ± 8.5	68.5 ± 10.4	**<0.001**	0.26	**<0.001**	0.16	Y2<all/ Y3<Y7
	MS = 100	F	50.9 ± 8.1	60.2 ± 8.7	61.2 ± 7.7	63.2 ± 8.3	63.2 ± 8.3	64.5 ± 9.8	60.3 ± 9.6	*******		*******		
		T	54.9 ± 10.8	63.6 ± 10.4	65.6 ± 10.2	67.2 ± 9.6	66.9 ± 8.7	68.8 ± 9.9	64.6 ± 10.8					
Additional skills	VJ	M	7.2 ± 2.1	7.6 ± 2.0	8.6 ± 1.9	7.0 ± 2.2	7.8 ± 2.8	8.6 ± 2.5	7.7 ± 2.3	0.79	0.00	**0.03**	0.03	Y2<Y7
	MS = 12	F	7.1 ± 1.9	7.5 ± 2.2	7.0 ± 1.9	8.2 ± 2.2	8.6 ± 2.5	8.1 ± 2.4	7.7 ± 2.2			*****		
		T	7.1 ± 2.0	7.6 ± 2.1	7.6 ± 2.1	7.5 ± 2.3	8.2 ± 2.6	8.4 ± 2.5	7.7 ± 2.3					
	Balance	M	6.6 ± 2.2	7.4 ± 2.6	8.4 ± 1.7	7.3 ± 2.3	7.5 ± 1.9	7.9 ± 1.9	7.5 ± 2.2	**0.001**	0.03	**<0.001**	0.16	Y2<Y3+Y4/
	MS = 10	F	6.9 ± 2.5	8.5 ± 1.8	8.8 ± 1.4	8.4 ± 1.7	8.6 ± 1.2	8.2 ± 1.9	8.2 ± 1.9	******		*******		Y4>Y6+Y7
		T	6.8 ± 2.4	7.9 ± 2.3	8.6 ± 1.5	7.7 ± 2.1	8.0 ± 1.7	8.0 ± 1.8	7.8 ± 2.1					

Note: S = sex, M = male, F = female, T = total, η_p^2 = partial eta squared, LM = Locomotor, O-C = Object-control, GMQ = Gross Motor Quotient, *MS* = Max Score, HJ = Horizontal jump, T-H Strike = Two-hand strike, FH Strike = Forehand strike, OH Throw = Overhand throw, UH throw = Underhand throw, T-H Catch = Two-hand catch, VJ = Vertical jump, Y = Year, *****$p < 0.05$, ******$p < 0.01$, *******$p < 0.001$

Table 3. Difference in FMS proficiency between overweight/obese and non-overweight participants

	Skill	Weight status	Mean (raw score) ± SD	95% CI	p	Cohens-d
TGMD-3 LM skills	Run	N-OW	5.34 ± 1.68	0.87, 1.61	**<0.001 *****	**0.8**
		OW/O	4.10 ± 1.39			
	Gallop	N-OW	4.68 ± 1.56	-0.49, 0.30	0.63	0.06
		OW/O	4.78 ± 1.62			
	Hop	N-OW	4.53 ± 1.57	0.15, 0.85	**0.005 ****	**0.3**
		OW/O	4.03 ± 1.33			
	Skip	N-OW	3.54 ± 1.47	-0.32, 0.39	0.859	0.02
		OW/O	3.51 ± 1.23			
	Slide	N-OW	6.62 ± 1.41	0.20, 0.93	**0.002 ****	**0.4**
		OW/O	6.05 ± 1.54			
	HJ	N-OW	5.21 ± 1.83	0.59, 1.41	**<0.001 *****	**0.6**
		OW/O	4.21 ± 1.54			
	LM ST	N-OW	29.9 ± 5.1	2.0, 4.5	**<0.001 *****	**0.7**
		OW/O	26.7 ± 4.3			
TGMD-3 O-C skills	T-H Strike	N-OW	5.89 ± 2.34	0.22, 1.30	**0.006 ****	**0.3**
		OW/O	5.12 ± 2.07			
	Forehand S	N-OW	4.59 ± 2.30	-0.29, 0.67	0.452	0.09
		OW/O	4.41 ± 1.79			
	Kick	N-OW	5.22 ± 1.95	0.01, 0.93	0.046	0.2
		OW/O	4.75 ± 1.76			
	OH Throw	N-OW	5.27 ± 2.05	-0.38, 0.67	0.603	0.06
		OW/O	5.14 ± 2.16			
	UH Throw	N-OW	6.19 ± 1.47	-0.09, 0.66	0.130	0.2
		OW/O	5.90 ± 1.54			
	Dribble	N-OW	3.91 ± 1.70	-0.52, 0.35	0.700	0.05
		OW/O	4.00 ± 1.75			
	T-H Catch	N-OW	4.44 ± 1.33	-0.31, 0.36	0.902	0.01
		OW/O	4.42 ± 1.28			
	O-C ST	N-OW	35.5 ± 8.2	-0.27, 3.81	0.89	0.2
		OW/O	33.8 ± 7.3			
TGMD-3	**GMQ**	N-OW	65.5 ± 10.8	2.31, 7.72	**<0.001 *****	**0.5**
		OW/O	60.4 ± 10.1			
Additional Skills	VJ	N-OW	7.9 ± 2.3	0.37, 1.51	**0.001 ****	**0.4**
		OW/O	6.9 ± 2.1			
	Balance	N-OW	7.9 ± 2.1	-0.11, 0.92	0.122	0.2
		OW/O	7.5 ± 2.0			

Note: N-OW = Non-overweight, OW/O = Overweight/obese, CI = Confidence interval, LM = Locomotor, O-C = Object-control, GMQ = Gross Motor Quotient, HJ = Horizontal jump, T-H Strike = Two-hand strike, FH Strike = Forehand strike, OH Throw = Overhand throw, UH throw = Underhand throw, T-H Catch = Two-hand catch, VJ = Vertical jump, ** $p < 0.01$, ***$p < 0.001$