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To cite this article: Michael J. Duncan, Elizabeth Bryant & David Stodden (2017) Low fundamental movement skill proficiency is associated with high BMI and body fatness in girls but not boys aged 6–11 years old, *Journal of Sports Sciences*, 35:21, 2135-2141, DOI: [10.1080/02640414.2016.1258483](https://doi.org/10.1080/02640414.2016.1258483)

To link to this article: <https://doi.org/10.1080/02640414.2016.1258483>



Published online: 21 Nov 2016.



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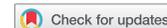
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Low fundamental movement skill proficiency is associated with high BMI and body fatness in girls but not boys aged 6–11 years old

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ABSTRACT

This study examined differences in children's body mass index (BMI) and body fatness (BF%) as a function of gender and fundamental movement skill (FMS) proficiency. Following ethics approval and parental consent, 248, 6–11 year-old children (112 boys, 136 girls) underwent assessment of 7 FMS: sprint run, side gallop, hop, kick, catch, throw and vertical jump. FMS tertiles ("high", "medium" or "low" FMS) were created based on the summed components of the FMS. Skinfold measures were used to calculate BF%. Physical activity (PA) was assessed using pedometry and maturation predicted using anthropometry. Data were analysed using a 2 (Gender) × 3 (FMS tertile) ways analysis of covariance (ANCOVA), controlling for age, maturation and PA. Age ($P = .001$) and maturation ($P = .006$) were associated with BMI. Girls classified as high FMS proficiency had significantly lower BMI compared to girls with low and medium FMS proficiency. Age ($P = .0001$) and maturation ($P = .007$) were associated with BF%. BF% was also higher for girls with low FMS compared to those with medium and high FMS. BF% and BMI were not different across FMS tertile in boys. Such findings suggest focusing on FMS may be especially important for healthy weight, particularly in girls.

ARTICLE HISTORY

Accepted 25 October 2016

KEYWORDS

Motor competence; obesity; physical activity; children

Introduction

The mastery of fundamental movement skills (FMS) is purported to be essential for the development of more specialised movement patterns enabling youth to participate in organised and non-organised physical activities (Clark & Metcalfe, 2002; Gallahue & Ozmun, 2011). FMS are globally defined (Clark & Metcalfe, 2002; Stodden et al., 2008) as object control (catching/throwing), locomotor (running/jumping) and stability (balance) skills (Gallahue & Ozmun, 2011). In recent years, there has been increasing research interest on the topic of FMS development as it relates to health, particularly in children and adolescents (Logan, Webster, Robinson, Getchell, & Pfeiffer, 2015; Robinson et al., 2015) and latterly adults (Stodden, Langendorfer, & Robertson, 2009; Stodden, True, Langendorfer, & Gao, 2013).

Although FMS, as it is directly incorporated in motor development, is featured as a key part of the school National Curriculum in England (Department for Education, 2013), Australia's Health and Physical Education Curriculum (Australian Curriculum, Assessment and Reporting Authority, 2012) and is a primary goal of the US elementary school physical education programme (Society of Health and Physical Educators, 2013), there is evidence that the mastery of these FMS in children and adolescents is low (Cliff et al., 2012; Erwin & Castelli, 2008; Okely, Booth, & Chey, 2004; Okely, Booth, & Patterson, 2001). Such a situation is concerning as children who do not receive adequate motor skill instruction and practice demonstrate developmental delays in motor

competence (Goodway & Branta, 2003; Goodway, Robinson, & Crowe, 2010). As hypothesised by the theoretical model by Stodden et al. (2008), if children demonstrate developmental delay in motor proficiency, they will engage in lower levels of health enhancing physical activity (PA) and, as a consequence, be more likely to develop an unhealthy weight status. Overall, strong evidence indicates that children with higher BMI will have poorer FMS (Cliff, Okely, Smith, & McKeen, 2009; Erwin & Castelli, 2008; Okely et al., 2004; Southall, Okely, & Steele, 2004) as well as other measures of motor proficiency such as the McCarron Assessment of Neuromuscular Development and the Battery for Measuring Motor Performance of Preschool Children (Cattuzzo et al., 2016). However, limited research (e.g., Bryant, Duncan, & Birch, 2014) have been conducted examining this issue in British children. This is important as the environments across various countries, particularly relating to climate and culture-related differences, may affect the types of activities and children's engagement in PA, potentially influencing opportunity to develop FMS.

In all, 1 research study from the UK identified age, gender and weight status differences in FMS proficiency in children aged 6–11 years (Bryant et al., 2014). However, this study did not control for potential effects of maturation or habitual PA in their sample. Based on their data, Bryant et al. (2014) also suggested that future research was needed to attempt to examine if children with greater FMS mastery had lower BMI as a means to better understand the link between FMS and overweight/obesity. The most recent data from the National

Child Measurement Programme in England points to an increased prevalence of overweight and obesity in Year 6 (age 10–11) children (33.2%) compared to children in reception (age 4–5) where prevalence was 21.9% (Health and Social Care Information Centre, 2015). Whether developmental delay in the acquisition of FMS has an impact on this increased prevalence of overweight/obesity from reception to Year 6 has yet to be established, but understanding how FMS may relate to BMI and body fatness is an important first step before effective targeting of interventions to reduce BMI/fatness can be put in place in schools or other community settings. The current study sought to address this issue and aimed to examine differences in BMI and body fatness as a function of gender and FMS proficiency in British primary school children.

Method

Participants

Study and sample design

Following university ethics committee approval, the present study was carried out in 1 primary school in central England in January 2011. About 248 children (112 boys, 136 girls), aged 6–11 years (Mean \pm SD of age = 8.3 ± 1.5 years) were recruited for the study following parental informed consent. Children from the age of 6–11 were recruited as this is an important time frame to develop motor skills (Society of Health and Physical Educators, 2013; Vandaele, Cools, de Decker, & de Martelaer, 2011). Children were drawn from 1 school, which was selected with the assistance of the City Council's Lead advisory teacher for physical education. The school was noted as being broadly representative of the schools within the city. The school was within mid range of electoral wards for deprivation and socio-economic status within the city and did not have any specialist physical education programmes (such as interventions or specific focus) in place at the time of testing. None of the children had any disabilities or special educational needs related to impaired motor development.

Fundamental movement skill (FMS) assessment

FMS was assessed using the guidelines taken from the New South Wales (NSW) "Move it Groove it; PA in primary schools: Summary Report" (2003). The "Process Orient Checklist" (POC) was taken from this report to assess FMS, which has frequently been used in research on FMS (Cliff et al., 2009; Okely et al., 2001, 2004). The assessment demonstrates developmental validity as it correlates with other validated FMS assessments (Logan et al., 2015). The checklist is comprised of different motor skills: sprint run, side gallop, hop, kick, catch, overarm throw, vertical jump and static balance. Each skill is broken down into 5 or 6 components. The testing was carried out in a school sports hall by a team of 8 trained researchers, according to the Move it Groove it guidelines (NSW, 2003), who assisted in video recording of the FMS.

About 7 FMS were assessed in the present study and were split into locomotor (sprint, hop and gallop) and static (jump, catch, kick and throw) skills. Locomotor and static skills were split for data collection purposes as they needed different camera angles to ensure that all components of the skills

were visible in the camera. For the static skills, the camera was set up on the coronal plane, whilst the locomotor skills had the camera set-up on the sagittal plane following guidelines for qualitative analysis of movement as recommended by Knudson and Morrison (2002).

For all 7 FMSs, each skill was demonstrated once with no coaching points in accordance with "Move it Groove it" (NSW, 2003) guidelines. Each child performed each skill 3 times. Each FMS was video recorded (Sony video camera, Sony, UK) and subsequently edited into single film clips of individual skills on a computer using Quintic biomechanics analysis software (Quintic Consultancy Ltd., UK). The skills were also analysed using this software, enabling the videos to be viewed frame by frame, magnified and replayed. The POC was used to determine how many of the components were demonstrated by each child for each motor skill. The average of all the 3 trials was used for subsequent analysis. The number of components demonstrated for each skill were then summed to derive a "total FMS" score (scores ranging from 0 to 40). Using the same process, a "locomotor FMS" score (scores ranging from 0 to 22) and an "object control FMS" score (scores ranging from 0 to 18) were also created by summing the number of components demonstrated for the sprint, hop, vertical jump and gallop for the locomotor FMS and kick, catch and overarm throw for the object control FMS score. For each FMS score (total FMS, locomotor and object control), tertiles were created with children being classified as "high", "medium" or "low" for each subscale. Such a procedure has been employed by previous researchers (Williams et al., 2008). The decision to use tertiles follows recommendations from a recent review (Logan et al., 2015) as a useful way to assess evidence for a proficiency barrier hypothesis (Seefeldt, 1980).

About 2 researchers experienced in the assessment of children's movement skills (having previously assessed movement skills in the context of a previous research study) analysed the FMS videos. Prior to the current study, both raters were trained in 2 separate 2–3-hour sessions by watching videoed skills of children's skill performances and rating these against a previously rated "gold standard" rating. Training was considered complete when each observer's scores for the 2 trials differed by no more than 1 unit from the instructor score for each skill (>80% agreement). This is congruent with prior research using a similar methodology (Barnett, Minto, Lander, & Hardy, 2014). Prior to analysis, inter- and intra-rater reliability analysis was performed for all the FMSs between the 2 researchers. Inter-rater reliability was 90.3% and intra-rater reliability was 97.6%, demonstrating good reliability (Jones, Okely, Caputi, & Cliff, 2010).

Assessment of physical activity

Habitual PA was measured using a sealed pedometer (New Lifestyles NL2000, Montana, USA) worn over 4 days (2 weekdays and 2 weekend days) (Troost, Pate, Freedson, Sallis, & Taylor, 2000) with the average daily steps taken as a measure of PA. During familiarisation, the participants were instructed on pedometer attachment (at the waist), its removal (only during showering/bathing, swimming or sleeping) and reattachment on waking each morning. Participants were asked not to tamper with the pedometer

and to go about their normal activities during the monitoring period. The model of pedometer employed in the study shows good validity and has been found to be highly accurate in the assessment of step counts (Crouter, Schneider, & Bassett, 2005). Daily step counts were stored in the internal memory of each pedometer enabling recall of each day's step count on collection of each pedometer. Across the period of measurement, the participants were asked to complete a pedometer log to verify that the pedometers were worn for the entire time of the study. Values <1000 steps or >40,000 steps per day were excluded from the analysis in accordance with recommendations for the treatment of pedometer derived PA (Rowe, Mahar, Raedeke, & Lore, 2004).

Anthropometric measurements

Height (cm), sitting height (cm), leg length (cm) and mass (kg) were recorded to the nearest cm and 100 g, respectively, using a stadiometer (SECA Instruments, Ltd., Germany), electronic weighing scales (SECA, Instruments, Ltd., Germany) and anthropometric measuring tape, respectively, with children wearing their standard physical education kit (shorts and t-shirt) and without shoes. BMI was calculated as $\text{Kg} \cdot (\text{m}^{-2})$. The age at peak height velocity (APHV) was determined using height, sitting height, leg length, body mass and chronological age as a measure of maturation using the Mirwald prediction equation (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002).

Body fat percentage (BF%). BF% was calculated using skinfold assessment from 2 sites – tricep and medial calf. Only 2 measures from these 2 sites were taken following guidelines from Thompson, Gordon and Pescatello (2009) and according to the International Society for the Advancement of Kinanthropometry criteria. The Slaughter et al. (1988) skinfold equation was used to calculate each participant's BF%. Although the Slaughter et al. (1988) skinfold equation was originally validated on children aged 8 years and above, subsequent research has shown, using data from the Pediatric Rosetta Body Composition Project and the Bogalusa Heart Study, correlations of >0.9 between body fatness determined using the Slaughter et al. (1988) equation and DEXA determined body fatness in children aged 5 years old and above (Freedman, Horlick, & Berenson, 2013). The same trained researcher took the skinfold measurements to maintain consistency, and the technical error of measurement at the tricep and medial calf was 3.57% and 3.12%, respectively, showing appropriate intra-tester reliability.

In the present study, both BMI and body fatness were examined as BMI is used nationally in the UK to classify obesity status despite the criticisms of BMI as a proxy for actual obesity, especially in children (Nevill & Holder, 1995). As a consequence, we felt it important to present data using BMI and an actual measure of adiposity. All anthropometric measurements were taken prior to the performance of the FMS. Based on criteria from the International Obesity Task Force (Cole, Bellizzi, Flegal, & Dietz, 2000), 75% of children were classified as "normal weight" and 25% as "overweight" or "obese".

Statistical analysis

In order to examine any differences in both BMI and BF% and FMS score, a 2 (Gender) \times 3 (high, medium, low FMS) ways analysis of covariance (ANCOVA), controlling for chronological age, APHV and PA was used to examine differences across levels for total FMS score, locomotor FMS score and object control FMS score. Thus, 3 separate ANCOVAs were conducted with BMI as the dependant variable and 3 with BF% as the dependant variable. BMI and per cent body fatness Z-scores were used as dependant variables. In this way, any differences between the dependant variable (either BMI or body fatness) as a result of gender, FMS score or their interaction could be determined whilst also accounting for any association between the dependant variable and the covariates (Field, 2013). Where any significant differences were detected, Bonferroni post hoc comparisons were used to indicate where those differences lay. Statistical significance was set at $P = 0.05$ and all analysis was completed using the Statistical package for Social Sciences (SPSS) version 21.

Results

Mean \pm SE of BMI and body fat percentage split by gender, total FMS tertile, object control FMS tertile and locomotor FMS tertile are presented in Table 1.

Total FMS

For BMI, age ($P = .001$, $\beta = .900$) and APHV ($P = .006$, $\beta = -.536$), but not pedometer determined PA ($P = .536$) were significantly associated with BMI where increasing age was associated with higher BMI and older APHV was associated with lower BMI. There was also a significant gender \times FMS tertile interaction ($P = 0.05$, see Figure 1). Bonferroni *post hoc* pairwise comparisons revealed that BMI was not significantly different in boys irrespective of FMS classification. For girls, there was significantly lower BMI for children classified as high FMS proficiency compared to low FMS proficiency ($P = .015$) and those classed as medium FMS proficiency compared to low FMS proficiency ($P = .027$). There was no significant difference in BMI between children classed as high and medium for FMS proficiency ($P = .576$).

Table 1. Mean \pm SE and 95% confidence intervals for BMI and per cent body fat split by gender and FMS tertile for total FMS, object control FMS and locomotor FMS.

	BMI (kg/m^2)			Body fatness (%)		
	M	SE	95% CI	M	SE	95% CI
Gender						
Boys	16.9	.31	16.3–17.5	14.1	.23	13.6–14.5
Girls	16.7	.30	16.1–17.4	15.2	.22	14.7–15.9
Total FMS tertile						
Low	17.2	.35	16.6–17.9	14.8	.26	14.1–15.3
Medium	16.6	.34	15.9–17.3	14.2	.25	13.7–14.7
High	16.5	.40	15.7–17.3	14.1	.29	13.5–14.7
Object control FMS tertile						
Low	16.5	.37	15.8–17.3	14.3	.27	13.7–14.8
Medium	17.2	.38	16.4–17.9	14.6	.27	14.1–15.2
High	16.7	.47	15.8–17.6	14.3	.34	13.7–15.1
Locomotor FMS tertile						
Low	17.7	.34	17.1–18.4	15.1	.25	14.5–15.6
Medium	16.7	.31	16.9–17.3	14.3	.23	13.8–14.7
High	16.0	.47	15.1–16.9	13.8	.34	13.2–14.6

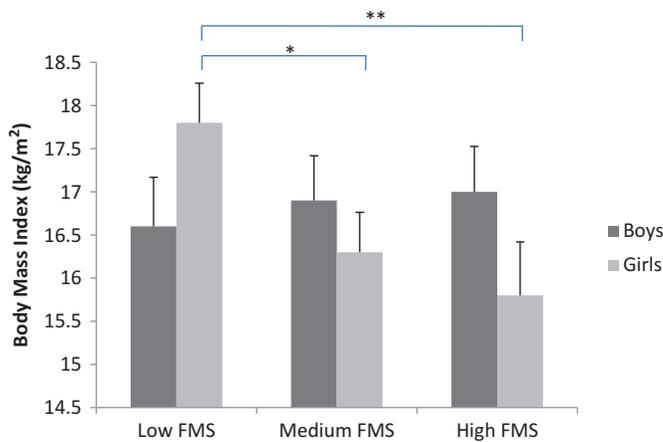


Figure 1. Mean \pm SE of body mass index (kg/m^2) of boys and girls categorised as low, medium or high for total FMS proficiency (* $P = 0.027$, ** $P = 0.015$).

This pattern was replicated for per cent body fat with age ($P = .0001$, $\beta = .301$) and APHV ($P = .007$, $\beta = -.173$) being significantly associated with fatness, where PA was not ($P = .541$). There was also a significant gender by FMS tertile interaction ($P = .036$, see Figure 2) where body fatness was not significantly different across FMS tertile for boys but, in girls, body fatness was higher for girls in the low FMS category compared to those in the medium ($P = .017$) and high ($P = .006$) FMS categories with no significant difference between children in high and medium categories ($P = .451$). Body fatness was also significantly higher for girls, compared to boys, in the low FMS category ($P = .014$).

Object control and locomotor FMS

When data were analysed using tertiles for FMS object control scores, there were no significant gender \times FMS tertile interactions for BMI or body fatness (both $P > 0.05$). There were also no significant main effects for PA, gender, or FMS tertile for BMI or body fat (all $P > 0.05$). Age was significant as a covariate for both BMI ($P = .0001$, $\beta = .262$) and body fatness ($P = .001$,

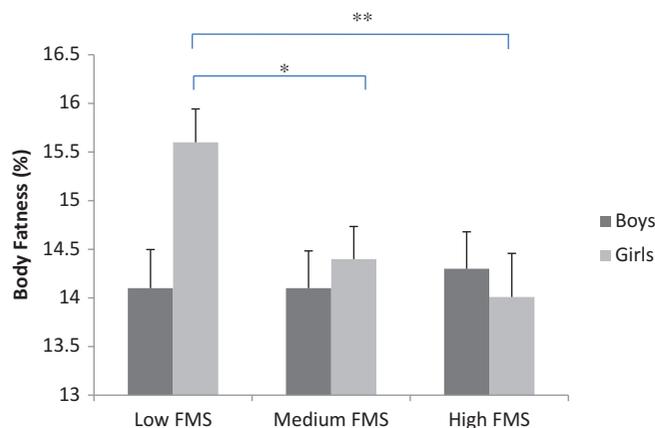


Figure 2. Mean \pm SE of body fatness (%) of boys and girls categorised as low, medium or high for total FMS proficiency (* $P = 0.017$, ** $P = 0.006$).

$\beta = .571$) as was APHV ($P = .015$, $\beta = -.163$ for BMI and $P = .019$, $\beta = -.345$ for body fatness).

With respect to locomotor competency, for both BMI and body fatness, there was no gender \times FMS tertile interaction (both $P > 0.05$). Gender was not significant in the case of BMI ($P > 0.05$). However, there was a significant gender main effect for body fatness ($P = .029$) with boys having lower per cent fatness compared to girls ($14.1 \pm .24\%$ in boys and $15.2 \pm .22\%$ in girls). There were also significant locomotor FMS tertile main effects for BMI ($P = .011$, see Figure 3) and body fatness ($P = .013$, see Figure 4). For BMI, children classed as low for locomotor FMS proficiency had significantly higher BMI compared to those classed as medium ($P = .006$) and high ($P = .0001$) FMS proficiency. Likewise, for body fatness, children classed as low for locomotor FMS proficiency had significantly higher body fatness compared to those classed as medium ($P = .021$) and high ($P = .0001$) FMS proficiency. Age was significantly associated with BMI ($P = .0001$, $\beta = .931$) and body fatness ($P = .0001$, $\beta = .662$) as was APHV ($P = .0001$, $\beta = -.554$ for BMI and $P = .0006$, $\beta = -.384$ for body fatness). In both cases, there was no significant main effect for PA ($P > 0.05$ for BMI and body fat).

Physical activity

The Mean \pm SE of average steps/day for children in the current study was 8551 ± 299 . Boys engaged in significantly greater PA ($P = 0.001$) than girls. Mean \pm SE of average steps/day was 9473 ± 499 steps/day for boys and 7719 ± 312 steps/day for girls.

Discussion

Prior research has suggested that FMS proficiency is related to weight status (Cliff et al., 2009; Erwin & Castelli, 2008; Okely et al., 2004; Southall et al., 2004), but additional research was needed with British children to examine if children with greater FMS mastery had healthier weight status. The current study has acted on that suggestion by examining differences in BMI and per cent body fatness between boys and girls and

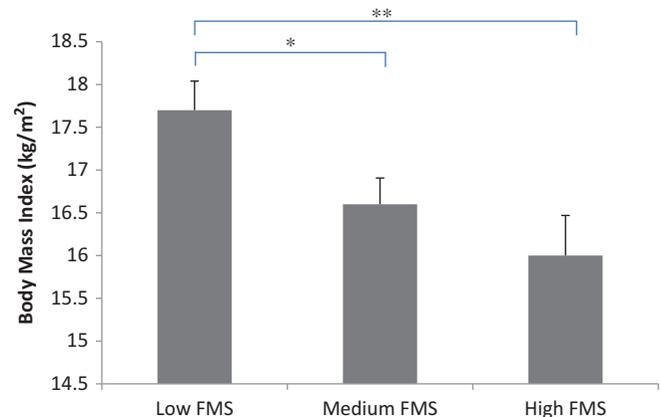


Figure 3. Mean \pm SE of body mass index (kg/m^2) of children categorised as low, medium or high for locomotor FMS proficiency (* $P = 0.006$, ** $P = 0.0001$).

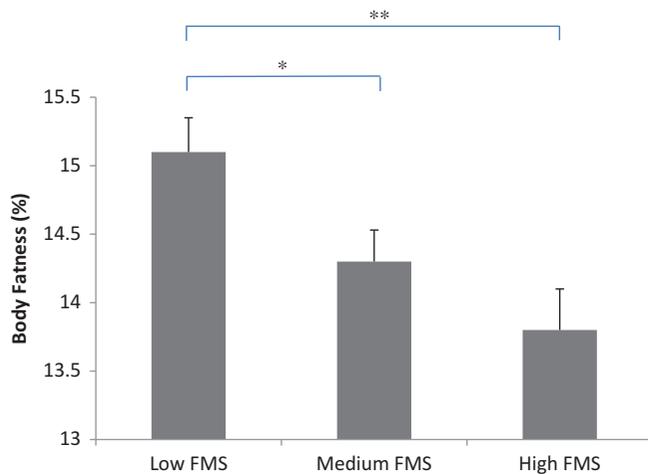


Figure 4. Mean \pm SE of body fatness (%) of children categorised as low, medium or high for locomotor FMS proficiency (* $P = 0.021$, ** $P = 0.0001$).

children of low, medium and high FMS proficiency. In addition, the present study controlled for confounding factors relating to both weight status and FMS, namely chronological age, maturation and habitual PA.

Thus, the data presented here extend the current research that has examined FMS and weight status in children. The results of the study are novel in that BMI and body fatness did not differ between boys who had low, medium or high levels of FMS proficiency but girls who had high or medium levels of FMS had significantly lower BMI and body fat percentage compared to girls who were classed as low in FMS.

Robinson et al. (2015) have suggested that motor proficiency is a precursor and a consequence of weight status in childhood and adolescence with multiple studies identifying that poorer FMS or motor proficiency is associated with higher BMI (Bryant et al., 2014; Cliff et al., 2009; Erwin & Castelli, 2008; Graf et al., 2004; Okely et al., 2004; Southall et al., 2004). The strength of reported relationships differs with age and some studies have reported that the strength of association declines as children start to reach puberty (D'Hondt et al., 2011; Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012). In a bid to control for this, we included predicted APHV as a covariate in the analyses performed as few studies have controlled for this confounding variable. The results of the present study add some support for the previously reported associations between FMS and weight status (Cliff et al., 2009; Erwin & Castelli, 2008; Graf et al., 2004; Okely et al., 2004; Southall et al., 2004). However, in the present study, when controlling for PA, age and APHV, it was only in girls where significantly higher BMI and BF% were seen when FMS proficiency was low. Using this approach is important as the ANCOVA analysis controls for known confounding variables, namely PA and maturation, which differ between boys and girls and may have different impacts on motor proficiency. Without controlling for such confounders, researchers may erroneously conclude that FMS has no impact on BMI or BF% or is related to boys and girls in the same way. The results presented here suggest that focusing on development of all FMS in physical and health education might be of greater benefit for girls than boys, specifically in girls with low FMS. However, when split

into object control and locomotor FMS, there was no difference in BMI or body fatness as a function of FMS proficiency for object control skills. Conversely, when locomotor FMS are considered, the significant main effects for BMI and BF% indicated, irrespective of gender, that children who had higher FMS proficiency had lower BMI and BF%. Such a finding agrees with previous research which found body composition to be negatively related to locomotor skills proficiency but did not reveal any differences for object control motor skills which are relatively stationary in nature (Graf et al., 2004; Okely et al., 2004; Southall et al., 2004). These findings have been explained by Robinson et al. (2015) due to excess mass impeding stabilisation and/or propulsion of the body, which in turn promotes poorer FMS. Excess mass impeding propulsion particularly occurs with locomotor FMS. D'Hondt, Deforche, De Bourdeaudhuij and Lenoir (2009) add that, mechanically, obesity influences body geometry and increases the mass of different body segments with non-contributory mass (fat mass) resulting in biomechanical movement inefficiency and could be detrimental for motor proficiency. Likewise, Cliff et al. (2012) suggested that children of higher BMI may use their arms to a greater extent to demonstrate mastery. The use of summed components to determine FMS proficiency, as in the present study, does not allow pinpointing of whether 1 component within 1 particular FMS was exhibited to a greater or lesser extent in children with high BMI or BF%. However, a posteriori examination of data for each FMS did not reveal any discernible pattern for children with high BMI or BF% to exhibit particular components within any of the FMS over their leaner counterparts. It is evident that there are explanations to support the relationship between low FMS proficiency and high BMI/BF%. However, for total FMS, differences in BMI and BF% were only present in girls. This has not been reported in the literature previously and explaining why this case is difficult. It has been reported that more time spent in organised PA and MVPA aids the development of FMS (Okely et al., 2001; Vandaele et al., 2011). It has also been reported that boys spend more time in MVPA compared to girls (Fairclough et al., 2013; Okely et al., 2001). As a consequence, boys may have more exposure to development of FMS, via higher levels of PA, irrespective of weight status. In the current study, boys were significantly more active than girls lending some support to this argument. However, this suggestion is speculative and further research is needed which verifies the data presented here.

Of particular relevance to the findings presented in this study, an untested hypothesis proposed by Seefeldt (1980) suggested a "proficiency barrier" for motor competence where there is a critical threshold for FMS proficiency, that is, demanded in order to apply FMS to more advanced transitional skills and sport. If an individual falls below this threshold, they may be at greater risk for decreased PA and health-related fitness (Haubenstricker & Seefeldt, 1986). Malina (2014) recently suggested this was a key question for understanding the development of obesity and although the current study did not identify a critical threshold for FMS, the findings presented here are supportive of this concept. To date, few studies have examined whether the concept of Seefeldt's proficiency barrier exists in relation to FMS and indices of

health. Future research is therefore needed which seeks to address this important concept. In the present study, we summed the total number of components demonstrated by each child for each of the FMS examined as a means to provide a variable which represented motor proficiency. We then used tertiles to create groups representing low, medium and high motor proficiency as recommended by Logan et al. (2015). This process provides a way to examine overall motor proficiency in a holistic manner. However, we acknowledge that it does not allow for the determination of FMS mastery, where an individual demonstrates all components of a skill.

PA was included as a covariate in the analyses performed in the present study as the theoretical model of Stodden et al. (2008) suggests that PA promotes the development of FMS and there are data suggesting a causal relationship between PA and motor development in children (Robinson et al., 2015). However, PA was not significant as a covariate in any of the analyses. This may be due to the mode of measurement of PA employed in the present study or because the strength of any association between PA and FMS may be dependent on the developmental stage of the children being examined (Stodden et al., 2008). In the present study, habitual PA, assessed via pedometry, was used as a covariate as a means to control for PA. However, although an objective measure of PA, pedometers are limited in their ability to only compute ambulatory activity and provide a measure of overall daily PA. As such, the present study can only suggest that overall PA was not associated with FMS (total, object control or locomotor), which is in agreement with some studies on the topic (Erwin & Castelli, 2008) but contrary to the overall findings from two recent review articles (Holfelder & Schott, 2014; Logan et al., 2015). However, Logan et al. (2015) highlight that the relationships seen between PA and FMS for children of the ages in the present study are typically low to moderate in nature. Furthermore, those studies that have reported positive associations between PA and FMS have tended to use accelerometry (Hume et al., 2008; Morgan, Okely, Cliff, Jones, & Baur, 2008), reporting both the association between FMS and moderate and vigorous PA (Hume et al., 2008) or weak, but significant ($r = .024$) relationships between FMS and total PA (Morgan et al., 2008). When time spent in moderate and vigorous PA is considered the relationship between PA and FMS appears to be stronger (Logan et al., 2015). This potentially explains the discrepancy between the results presented here compared to conclusions drawn from review papers. Future research using accelerometers and examining specific intensities of PA or sedentary behaviour would therefore be useful in providing a better understanding of the association between FMS, PA and measures of weight status.

This study is however limited by the cross-sectional nature of the data presented here and the fact that participants were only drawn from 1 school. Although, we sought to recruit participants that were broadly representative of the local authority where data collection took place, the generalisability of these findings are limited. There are a number of factors such as the way in which children are socialised into PA, the after school sport provision available and social norms relating to PA and opportunity to develop FMS which may have impacted on the locomotor and object control skills

demonstrated by the children in this study. Future larger scale research would be useful which draws from across the deprivation spectrum and also considers other variables, such as those previously mentioned, in order to provide a more comprehensive model for the role of FMS in healthy/unhealthy weight in British children. Additional studies are needed which examine whether enhancing FMS might lead to reducing body fatness, via PA.

The results of this study do demonstrate that girls with low levels of total FMS mastery have higher BMI and BF% compared to girls with better FMS mastery whereas this was not evident in boys. There may therefore be a need for public health practitioners, physical educationalists and paediatric exercise scientists to better explore strategies to enhance motor proficiency in girls as different to those used for boys.

Disclosure statement

No potential conflict of interest was reported by the authors.

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