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# Fundamental Movement Skill Proficiency Among British Primary School Children: Analysis at a Behavioral Component Level

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## Abstract

Fundamental Movement Skill (FMS) proficiency is an important antecedent of physical activity for children and adolescents. Many studies report children's overall FMS proficiency to be low. However, in order to develop effective intervention strategies, it is critical to understand FMS proficiency at a behavioral component level. This study investigated British primary school children's FMS proficiency across all three FMS domains, reporting proficiency at both an individual skill level and at a behavioral component level. Participants were 219 primary school children, aged 7–10 years (Boys 111, girls 108) from central England. We assessed (a) eight FMS (run, jump, hop, skip, catch, overarm throw, underarm throw, stability) using the second and third revisions of the Test of Gross Motor Development, and (b) stability, using the rock skill from the Rudd stability assessment tool. We calculated descriptive statistics and frequencies for each FMS and their behavioral components. We explored gender differences using the Mann-Whitney U-test, and differences between school years using the Kruskal-Wallis test. There was a similar pattern in the prevalence of failure for behavioral components across skills, with children failing on components

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requiring (a) the simultaneous use of both upper and lower limbs and (b) contralateral actions. Detailed descriptive analysis of low proficiency levels highlighted coordination and the process for power/force production. These data can be used to guide development and plan targeted interventions for the weakest skills and behavioral components of 7-10 year old British primary school children to increase their FMS levels.

**Keywords**

fundamental movement skills, proficiency, primary school children, stability, behavioral components

**Introduction**

Motor development refers to the continuous developmentally-related process of change in movement abilities that occur across an individual's lifespan (Haywood & Getchell, 2019). Comprehensive theoretical models (J. Clark & Metcalfe, 2002; Gallahue et al., 2012) provide explanations of the complex concepts of motor development, thus enhancing our knowledge and understanding of motor behavior (Payne & Isaacs, 2011). One consistency across all models is a phase of development for acquiring fundamental movement skills (FMS), considered important for lifelong engagement in physical activities (J. Clark & Metcalfe, 2002; Gallahue et al., 2012; Salehi et al., 2017). FMS are most commonly defined as an organized series of basic movement patterns that require a combination of two or more body limbs (Logan et al., 2018). FMS are considered to be the initial building blocks for more complex specialized movement patterns (J. Clark & Metcalfe, 2002; Gallahue et al., 2012), and they go through a defined, observable process from immaturity to proficiency (Goodway et al., 2019).

The importance of FMS proficiency has been shown in a conceptual developmental model by Stodden (2008). This model proposes that FMS play a key role in the initiation, maintenance, or decline in physical activity (PA) (Stodden et al., 2008). Following the model's development, various studies have empirically tested its assertions (Robinson et al., 2015). Investigations among children have reported a positive association between FMS proficiency and PA levels (L. A. Bolger et al., 2019; K. E. Cohen et al., 2014; Fowweather et al., 2015; Hall et al., 2018; Lubans et al., 2010). Further, research has shown that FMS contributes other important benefits for personal health and well-being (Robinson et al., 2015), such as, cardiorespiratory fitness (L. A. Bolger et al., 2019; Cattuzzo et al., 2016), weight status (Bryant et al., 2014; Okely et al., 2004; Rodrigues et al., 2016), academic achievement (Jaakkola et al., 2015) and

physical self-efficacy (Peers et al., 2020). Despite the importance of FMS, proficiency levels have been reported to be low amongst both children and adolescents worldwide (L. A. Bolger et al., 2019; Duncan et al., 2019; Morley et al., 2015; O'Brien et al., 2016; Okely & Booth, 2004).

Although FMS is a feature within the PE curriculum worldwide (Australian Curriculum, Assessment and Reporting Authority, 2012; Department of Education, 2013; Society of Health and Physical Educators, 2013), collectively there are barriers in the delivery of FMS within school physical education (PE) classes, with common problems being limited curriculum and inadequate knowledge and resources (Mckenzie & Lounsbery, 2009). There is a remaining over-predominant focus on FMS quantity rather than quality (C. C. T. Clark, 2019), restricting children's ability to fully develop. In addition, low proficiency levels worldwide may also be due to culture differences (Barnett et al., 2019). Direct comparisons of various findings between different studies reporting children's proficiency levels should be considered with caution, given differences between studies in the areas of children's skills, the assessment tools employed and the participant populations studied. Nevertheless, even with these considerations, there is broad evidence that FMS interventions are needed in order to address a general state of low proficiency, with targeted FMS interventions in PE having been shown to increase FMS competence in children and adolescents (Lorås, 2020). Planning for and achieving effective interventions for FMS will require detailed and specific information as to which skills are not proficient. The development of FMS is not acquired naturally (J. Clark & Metcalfe, 2002; Gallahue & Ozmun, 2006). In order to best develop FMS proficiency, skills must be acquired through appropriate tasks (Logan et al., 2012; Newell, 1986) with feedback and direct instruction (Goodway et al., 2003; Rink, 2014). As a consequence, before any intervention to enhance FMS can be put in place, specific knowledge regarding children's developmental status will be needed (Goodway et al., 2019).

Studies investigating children's FMS proficiency have generally relied on process-oriented assessment tools. This type of assessment measures how children move and provides precise and detailed descriptions on the level, characteristics and quality of a movement pattern (Logan et al., 2017). Despite the rich information that process-orientated tools provide, the extensive research studies documenting FMS levels to date have only reported FMS as a whole or have provided data for classified FMS domains, consisting of stability, object-control and locomotor abilities (Gallahue & Donnelly, 2003; Gallahue et al., 2012; Haywood & Getchell, 2019). Reporting FMS at this holistic level has limited our knowledge regarding children's developmental status, including, for example, what skills and skill characteristics are underdeveloped. If studies begin to fully utilize process-orientated assessment tools by documenting FMS at both individual skill and behavior levels, our FMS understanding could be extended to the point of providing teachers/coaches/health practitioners with needed data

regarding the important developmental characteristics that lead to overall skill proficiency (Hands, 2002; Logan et al., 2017). This broader understanding would assist these professionals in developing guiding strategies to more precisely address children's currently low level of FMS proficiency by targeting activities that aim particularly at developing the weaker skills at a behavioral component level. To date, only four studies have focused on an analysis of skill proficiency at both a skill and component level (Duncan et al., 2019; Foulkes et al., 2015; Hardy et al., 2010; O'Brien et al., 2016). Although this is a positive trend, three of these studies were limited to preschool and secondary school levels, and the one study that focused on primary school children only evaluated four skills. Given that primary school is the period in which children have the greatest developmental potential and capability of performing proficiently (Gallahue et al., 2012; Goodway et al., 2019) a lack of data among this population creates an urgent need to examine specific FMS proficiencies at the levels of both individual skills and behavioral components for this cohort.

Additionally, while maturation and sex have been proposed to influence FMS, potentially accounting for differences in FMS development (Goodway et al., 2019; Stodden et al., 2008), differences in individual skills between children of varying age and sex have not been sufficiently explored. Furthermore, there is controversy in the literature as to whether stability, defined as the ability to sense a shift in the connection of the body parts that alters one's balance and underpins FMS (Woollacott & Shumway-Cook, 1990), is a skill or a postural adjustment to environmental circumstances. We consider stability a skill, in line with Newell's most recent conceptualization of FMS (Newell, 2020), and we believe this view provides a comprehensive analysis of FMS development to aid a further understanding of FMS proficiency. Many studies have reported on FMS proficiency levels, but they have not provided sufficient information to guide strategies and targeted interventions for children's optimal FMS development. In light of these several considerations, our purpose in this study was to examine British primary school children's proficiency in object-control, stability and locomotor skills across sex and age, in order to report FMS proficiency at both an individual skill level and a behavioral component level while also investigating age and sex differences in FMS development. We hypothesized that, children would demonstrate low proficiency generally, that their proficiency would be lower in object control skills compared to locomotor skills, and that boys would demonstrate higher levels of proficiency than girls.

## Method

### Participants

We recruited 219 participants aged 7–10 years (111 boys, 108 girls;  $M$  age = 8.7 years,  $SD = 1.0$ ;  $M$  height = 132.6 cm;  $SD = 8.1$ cm;  $M$  weight = 33.4 kg,

$SD = 9.2$ ) from three schools in central England using convenience sampling. All participants were healthy and free from disability. Schools were comparable in terms of ethnic makeup and the low-medium (4–7) socio-economic status of their students for the county in which they were based (T. S. Team, 2018). We obtained written parental(s)/guardian(s) consent and child assent for all participants prior to data collection within the school setting.

### *Anthropometrics Measurements*

We took anthropometric measurements to an accuracy of 0.1 cm for height and 0.1 kg for weight, with children in light clothing and bare feet, using a SECA portable stadiometer and weighing scales (SECA 213, SECA 877, Hamburg, Germany). We calculated body mass index (BMI) as  $(\text{kg}/\text{m}^2)$ .

### *Fundamental Movement Skills Assessment*

We assessed FMS using a composite of eight skills reflecting three domains; locomotor, object control and stability. Seven skills were drawn from the second and third revisions of the Test of Gross Motor Development (TGMD) (Ulrich, 2000, 2017), and one skill was drawn from the Rudd stability assessment tool (Rudd et al., 2015). We adhered to All procedures outlined in the TGMD second and third revision and the Rudd stability assessment tool.

The TGMD's validity and reliability ( $\alpha = .76-.92$ ) have been established for this age group (Ulrich, 2000). The test is widely used worldwide to assess children's FMS proficiency (Logan et al., 2012; Morgan et al., 2013). We incorporated six skills from the second revision of the TGMD (TGMD-2) and one skill from the third version (TGMD-3). We removed the strike from TGMD-2 and replaced it with the underarm throw from TGMD-3, as the underarm throw is a more relevant skill for a British population. Due to the popular types of sport participation within the British population (Sport Participation Report, 2018), the seven skills we used to assess FMS consisted of four locomotor skills (i.e. run, horizontal jump, hop and skip) and three object-control skills (i.e. two-handed catch, overarm throw and underarm throw). We designated these seven specific skills because five of the them (Jump, Run, Underarm throw, Overarm throw and Catch) have been identified as the predominant skills to be targeted for development (aimed at children of the participating age) by the English National Curriculum for Physical Education (Department of Education, 2013). We identified the remaining two (Hop and Skip) because they assess co-ordination and unipedal movement, both of which have been shown to be important components within sports and sport participation (Lopes et al., 2011; Vandorpe et al., 2012).

We video-recorded the children performing three trials of each skill in a sagittal plane (Nikon video camera, UK). We then analyzed the second and

third of the three trials using Windows Media Player 2013 (Microsoft, Version: 12), as this software enabled the videos to be slowed, replayed and scored using a process-oriented checklist. Skills were assessed by whether the participant had demonstrated the TGMD-specified criteria for the observed skills. The number of performance criteria varied from 3-4, and six of the skills had four component performance criteria while one had three component performance criteria. For each component, we gave a score of 1 if the component was observed as present, or 0 if the component was absent (Ulrich, 2000). Scores from the two (2nd and 3rd) trials were summarized, and this raw score for each skill was summed with others to yield a total FMS score (range: 0-54). Scores from the Run, Jump, Hop and Skip skills were summed separately to create a score for the locomotor skill subset (range: 0-30), and scores from Catch, Underarm and Overarm throw were summed separately to create a score for the object-control skill subset (range: 0-24).

Two experienced researchers analyzed the FMS videos. Both were previously trained in three separate training sessions in which they watched video tapes of children's skill performances and rated these against the 'gold standard' rating. Congruent with prior research, training was considered complete when each observer's scores for the two trials differed by no more than one unit from the instructor score for each skill (<80% agreement)(Barnett et al., 2013). Intraclass correlation coefficients for inter and intra-rater reliability (between the two experienced researchers) were .925 (95% CI = .87-.95) and .987 (95% CI = .94-.98) respectively, demonstrating good reliability (Jones et al., 2010; Koo & Li, 2016).

The Rudd stability assessment tool, is a valid and reliable measure for stability control (Rudd et al., 2015). We assessed the 'rock' stability skill, with the participants initially in a seated rocking position, rocking back and forth twice on their lower back, shoulders and neck before transferring weight to their feet, and driving into a standing position (Rudd et al., 2015). Again, we video-recorded three trials in a sagittal plane (Nikon video camera, UK) and we analyzed the last two of the three trials using Windows Media player 2013 (Microsoft, Version: 12). Scoring for each trial was based on four component performance criteria (1 for present 0 for absent), summed over two trials to create a stability subset score (range: 0-8). Again, two experienced researchers, both of whom had been previously trained, analyzed the stability videos. Intraclass correlation coefficients for inter and intra-rater reliability (between the two experienced researchers) were .985 (95% CI = .974-.992) and .995 (95% CI = .991-.997) yet again, demonstrating good reliability (Jones et al., 2010; Koo & Li, 2016).

### *Data Analysis*

Descriptive statistics and frequencies for each of the eight FMS and their behavioral components were calculated using a previously established procedure



(Duncan et al., 2019; O' Brien et al., 2016). 'Mastery' was determined by correct performance of all behavioral components on both trials. 'Near-mastery' was determined by a failure on one behavioral component in one or both trails with correct performance for the remaining components. 'Poor' was determined by any score below these two categories. (i.e. if the performance was incorrect in two or more of the behavioral components on both trials). This process was congruent with procedures described by (O' Brien et al., 2016). Raw scores for each FMS in every individual were collapsed into categorical variables with mastery coded as '3', near-mastery as '2' and poor as '1'. We determined (a) the percentage of children achieving mastery, near-mastery and poor on each of the eight skills and (b) the prevalence of failure on each of the behavioral components.

We performed statistical analyses using the Statistical Package for Social Science (SPSS, version 25, IMB Corp, Armonk, New York). We assessed the normality of the data distribution using the Kolmogorow-Smirnov test, and we identified our data to be non-normally distributed ( $p < 0.01$ ). Therefore, we used non-parametric procedures for inference testing. Sex differences in overall FMS, locomotor skills, objective-control, stability and individual skill scores were examined using the Mann-Whitney U test, and differences between school years were examined using the Kruskal-Wallis test. Pearson's correlation analysis were performed to examine the association between sex and the frequency of poor and near mastery for each individual skill. We set statistical significance at  $p < 0.05$ , and we reported effect size in accordance with J. Cohen (1988) and Rosenthal (1991, 2000) (classifying Pearson's correlation coefficient,  $r$ , as; small (0.1), medium (0.3) and large (0.5)(Field, 2013).

## Results

Descriptive characteristics of the participant sample, including percentages of boys and girls below mastery level failing to execute the behavioral components for each of the skills, can be found in Tables 1 to 3. Among the object-control skills, most children classified as 'poor' and 'near mastery' on the Catch skill failed the behavioral components requiring that the ball be 'caught and controlled with hands only' and 'elbows bending to absorb force.' For underarm throw, the behavioral component with the highest failure rate for both sexes and competence level was 'stepping forward with the foot opposite to the throwing hand;' and, for overarm throw, it was 'rotation of the hip and shoulder to a point where the non-dominate side faces an imaginary target.' Apart from girls classified as 'near mastery' in the overarm catch, their weakest component was 'follow-through beyond ball release diagonally across the body towards the side opposite to throwing arm.' For the stability measure, both sexes and competence level showed the same highest failure percentage on the component requiring participants to 'rock backwards onto the nape of the neck and shoulder



**Table 1.** Prevalence of Failure (%) Amongst Boys and Girls Classified as 'Poor' or 'Near Mastery' for Each Behavioral Component in the 3 Object-Control Skills.

| Performance criteria   | Boys |      | Girls |      |
|--|------|------|-------|------|
|  | Poor | NM   | Poor  | NM   |
| Catch C1. Preparation phase where elbows are flexed, and hands are in front of the body                            | 26.5 | 20.9 | 17.9  | 15.9 |
| Catch C2. Arms extend in preparation for ball contact  | 41.2 | 18.6 | 42.9  | 18.2 |
| Catch C3. Ball is caught and controlled by hands only  | 58.5 | 25.6 | 64.3  | 31.8 |
| Catch C4. Elbows bend to absorb force  | 67.6 | 27.9 | 64.3  | 29.5 |
| Underarm Throw C1. Preferred hand swings down and back reaching behind trunk                                       | 87.6 | 7.1  | 92.0  | 5.0  |
| Underarm Throw C2. Steps forward with the foot opposite to the throwing hand                                       | 99.0 | 78.6 | 98.9  | 90.0 |
| Underarm Throw C3. Ball is tossed forward hitting the wall without a bounce  | 7.2  | 0    | 10.2  | 5.0  |
| Underarm Throw C4. Hand follows through after ball release at chest level  | 19.6 | 0    | 18.2  | 0    |
| Overarm Throw C1. A downward arc of the throwing arm initiates the windup  | 34.1 | 16.7 | 5.9   | 6.3  |
| Overarm Throw C2. Rotation of hip and shoulder to a point where the non-dominant side faces an imaginary target    | 93.2 | 46.7 | 95.3  | 31.3 |
| Overarm Throw C3. Weight is transferred by stepping with the foot opposite the throwing hand                       | 65.9 | 13.3 | 70.6  | 0    |
| Overarm Throw C4. Follow-through beyond ball release diagonally across the body towards side opposite throwing arm | 45.5 | 3.3  | 58.8  | 37.5 |

while keeping their legs pulled into the body at all times, rocking back to seated position.'

Among the locomotor skills, boys and girls who were classified as 'poor' on the run failed to demonstrate 'non-supported leg bent at approximately 90 degrees.' However, those classified as 'non mastery' failed to demonstrate 'foot placement near or on-like (not flat footed).' In the jump, boys who were classified as 'poor' were unable to perform 'preparatory movement that includes flexion of both knees with arms extended behind the body,' whereas girls classified as 'poor' were unable to 'extend arms forcefully forward and upward, reaching full extension above head,' which was also the same behavioral components that boys and girls classified as 'near mastery' failed to execute.

**Table 2.** Prevalence of Failure (%) Amongst Boys and Girls Classified as ‘Poor’ or ‘Near Mastery’ for Ach Behavioral Component in the 4 Locomotor Skills.

| Performance criteria   | Boys  |      | Girls |      |
|--|-------|------|-------|------|
|  | Poor  | NM   | Poor  | NM   |
| Run C1. Brief period where both feet are off the ground  | 0     | 0    | 0     | 0    |
| Run C2. Arms in opposition to legs, elbow bent   | 52.0  | 11.9 | 54.5  | 18.2 |
| Run C3. Foot placement near or on-line (not flat footed)   | 68.0  | 52.5 | 45.5  | 56.4 |
| Run C4. Non-supported leg bent approximately 90 degrees  | 72.0  | 26.2 | 81.1  | 9.1  |
| Jump C1. Preparatory movement includes flexion of both knees with arms extended behind the body  | 61.5  | 7.7  | 35.7  | 2.0  |
| Jump C2. Arms extend forcefully forward and upward reaching full extension above head            | 100.0 | 76.9 | 92.9  | 72.5 |
| Jump C3. Take off and land on both feet simultaneously   | 19.2  | 1.5  | 25.0  | 2.0  |
| Jump C4. Arms are brought downward during landing  | 26.9  | 1.5  | 25.0  | 3.9  |
| Hop C1. Non-hopping leg swings forward in a perpendicular fashion to produce force               | 53.8  | 10.5 | 52.5  | 18.5 |
| Hop C2. Foot of non-hopping leg remains behind hopping leg (does not cross in front of the body) | 65.9  | 42.1 | 61.3  | 55.6 |
| Hop C3. Arms flex and swing forward to produce force   | 85.7  | 47.4 | 81.3  | 18.5 |
| Hop C4. Hops for consecutive times before stopping   | 17.6  | 0    | 16.3  | 0    |
| Skip C1. A rhythmical repetition of the step-hop on alternate feet                               | 73.1  | 4.8  | 37.5  | 3.0  |
| Skip C2. Foot of non-supported leg carried near surface during hop phase                         | 84.6  | 1.6  | 81.3  | 10.6 |
| Skip C3. Arm alternately moving in opposition to legs at about waist level                       | 73.1  | 88.9 | 81.3  | 77.3 |

Boys classified as ‘poor’ and ‘near mastery’ and girls classified as ‘poor’ in the hop all failed in the same behavioral component which related to ‘arms flexing and swinging forward to produce force,’ whereas girls classified as ‘near mastery’ failed to demonstrate ‘foot of non-hopping leg remaining behind hopping

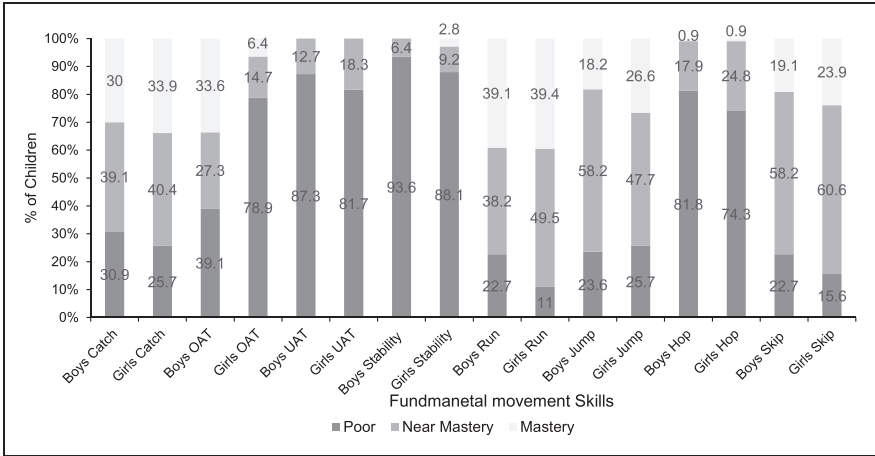
**Table 3.** Prevalence of Failure (%) Amongst Boys and Girls Classified as 'Poor' or 'Near Mastery' for Each Behavioral Component in the Stability Skill.

| Performance criteria   | Boys |      | Girls |      |
|--|------|------|-------|------|
|  | Poor | NM   | Poor  | NM   |
| Stability Rock C1. Able to maintain and hold a seated tuck position (Legs should be pulled in tight to chest)  | 68.3 | 0    | 73.7  | 0    |
| Stability Rock C2. Rocks backwards onto nape of neck and shoulder keeping legs pulled into the body at all time. Rock back to seated position  | 91.3 | 71.4 | 93.7  | 60.0 |
| Stability Rock C3. Rock back for a second time, keeping legs pulled into body (tuck shape)   | 78.8 | 14.3 | 76.8  | 10.0 |
| Stability Rock C4. During the second rock when returning to the seat position transfer weight to feet and drives up to standing position without placing hands on the floor at any stage | 77.9 | 28.6 | 64.2  | 0    |

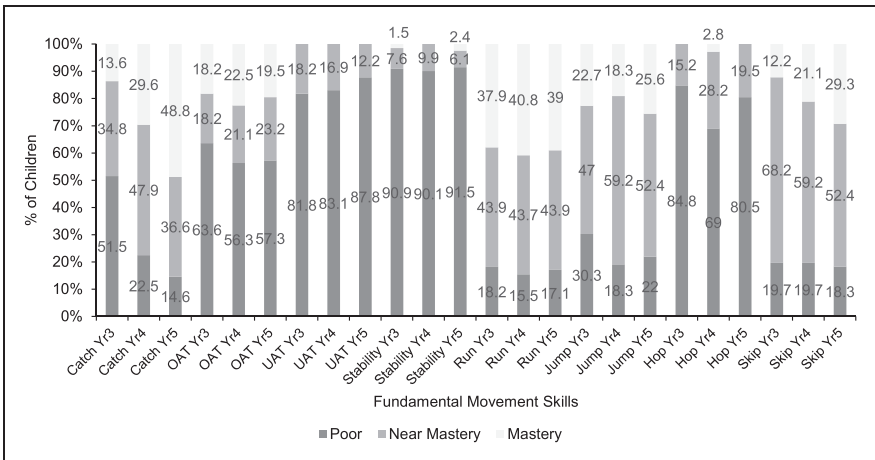
leg.' Finally, for the skip, boys and girls who were classified as 'poor' failed to demonstrate 'foot of non-supported leg carrying near surface during hop phase,' whereas boys and girls classified as 'near mastery' failed to demonstrate 'arms alternating moving in opposition to legs at about waist level.'

Descriptive data show that overall competencies were low across the whole sample, with no children achieving mastery in all eight skills. Furthermore, 27% ( $n = 60$ ) failed to achieve mastery in any of the eight skills examined in this study. Regarding sex, a similar percentage of boys (26%) and girls (25%) displayed non-mastery of any skills. Measurement between school years (Year 3; seven–eight year olds, Year 4; eight–nine year olds and Year 5; nine–ten year olds) revealed a decrease in the percentage classified as non-mastery as the school year went up, with 56% of children in Year 3, 25% in Year 4 and 19% in Year 5. The percentage of boys and girls attaining 'poor', 'near mastery' or 'mastery' in each of the eight skills (Run, Jump, Hop, Skip, Stability, Underarm throw, Overarm throw, and Catch) is presented below in Figure 1.

In relation to individual skills, Pearson's correlation analysis showed a significant association between overarm throw and sex ( $\chi^2_{\text{overarm throw}} = 13.45$   $p < 0.05$ ), and between run and sex ( $\chi^2_{\text{run}} = 7.18$   $p < 0.05$ ). Boys were more likely to be 'near mastery' at the overarm throw than girls. Whereas girls were more likely to be 'near mastery' at the run than boys. No further associations were found between the remaining six skills ( $p > 0.05$ ). Furthermore, the most difficult skill to master was stability irrespective of sex and school year, where 93.6% of boys and 88% of girls were classed as 'poor'. Run had the greatest percentage of mastery where 39.6% of boys and 38.9% girls attained



**Figure 1.** The Percentage of Boys and Girls Classified as ‘Poor’, ‘Near Mastery’ and Mastery in All Eight of the Skills.



**Figure 2.** The Percentage of Children in Years 3, 4 and 5 Boys Classified As ‘Poor’, ‘Near Mastery’ and Mastery in All Eight of the Skills.

‘mastery’. This was also evident at Year 3 (37.9%) and Year 4 (40.8%) however, not in Year 5 where catch achieved the highest percentage of mastery (48.8%) (see Figure 2).

A Mann-Whitney U Test comparing the two groups on ranked data (Field, 2009), showed a significant difference between children of different sexes in locomotor skills ( $U = 4773.50$ ,  $z = -2.61$ ,  $p = .014$ ,  $r = -.18$  small) and

**Table 4.** Presents Mean  $\pm$  SD, Median and Coefficient of Variation (CV%) for Total FMS, Locomotor FMS, Object-Control FMS, Stability FMS and Each Individual Skill for Boys and Girls.

| Score                                       | Boys         |        |       | Girls        |        |       | P     |
|---|--------------|--------|-------|--------------|--------|-------|-------|
|   | Mean (SD)    | Median | CV%   | Mean (SD)    | Median | CV%   |       |
| Total FMS score<br>(locomotor & object)     | 36.26 (5.61) | 37.00  | 15.5% | 36.36 (4.75) | 37.00  | 13%   | .858  |
| Total FMS score<br>(inclusion of stability) | 38.29 (6.36) | 39.00  | 16.6% | 38.73 (5.51) | 39.00  | 14.2% | .683  |
| Locomotor score                             | 20.34 (3.76) | 21.00  | 18.5% | 21.71 (3.44) | 22.00  | 15.8% | .009* |
| Object-control score                        | 15.92 (3.64) | 16.00  | 22.9% | 14.65 (2.86) | 14.50  | 19.5% | .002* |
| Catch                                       | 6.15 (1.67)  | 6.00   | 27.1% | 6.29 (1.61)  | 6.00   | 25.6% | .566  |
| Overarm throw                               | 5.71 (2.18)  | 6.00   | 38.3% | 4.19 (1.82)  | 4.00   | 43.3% | .000* |
| Underarm throw                              | 4.05 (1.22)  | 4.00   | 30.1% | 4.17 (1.23)  | 4.00   | 29.6% | .495  |
| Stability                                   | 2.03 (1.92)  | 2.00   | 94.9% | 2.37 (2.32)  | 2.00   | 97.8% | .456  |
| Run   | 6.50 (1.46)  | 6.00   | 22.5% | 6.81 (1.14)  | 7.00   | 16.7% | .179  |
| Jump  | 5.96 (1.51)  | 6.00   | 25.4% | 6.28 (1.45)  | 6.00   | 23%   | .164  |
| Hop   | 3.96 (1.54)  | 4.00   | 38.8% | 4.32 (1.53)  | 4.00   | 35.5% | 0.65  |
| Skip  | 3.92 (1.57)  | 4.00   | 40.0% | 4.31 (1.26)  | 4.00   | 29.2% | .101  |

Note. Maximum scores possible for total, locomotor and object-control skills are 54, 30 and 24.

\*Significant gender differences ( $p < .05$ ).

object-skills ( $U = 4514.50$ ,  $z = -3.17$ ,  $p = .002$ ,  $r = -.21$  small), with girls having greater competence than boys in locomotor skills, and boys having greater competence in object-control skills. However, no significant sex differences were observed for total FMS ( $p = .858$ ) or total FMS with the inclusion of stability ( $p = .683$ ). In individual skills, boys scored significantly higher than girls in the overarm throw ( $U = 3581.50$ ,  $z = -5.22$ ,  $p < .0001$ ,  $r = -.35$  medium). No further sex differences were found (see Table 4).

Results from the Kruskal-Wallis tests showed a significant difference between total FMS (Object & Locomotor skills) ( $H = 9.82$ ,  $p = .007$ ) and object-control skills ( $H = 11.49$ ,  $p = .003$ ) and stability skill ( $H = 7.80$ ,  $p = 0.02$ ) but showed no significant difference between locomotor skills ( $p = 3.76$ ) or total FMS with the inclusion of stability ( $H = 7.87$ ,  $p = .159$ ). Pairwise comparisons indicated that total FMS was significantly higher in Year 5 compared to Year 3 ( $p = .011$ ,  $r = -.24$ ) and Year 4 compared to Year 3 ( $p = .035$ ,  $r = -.22$ ). However, no significant difference was recorded between Years 4 and 5 ( $p = 1.00$ ). Object-control skills differences were only significant between Year 5 and 3 with Year 5 scoring higher than Year 3 ( $p = .003$ ,  $r = -.27$ ), whereas, for stability, there were only significant differences between Year 3 and 4, with Year 3s scoring higher ( $p = .019$ ,  $r = .23$ ). Regarding individual skills, catch was significantly higher in

**Table 5.** Presents Mean  $\pm$  SD, Median and Coefficient of Variation (CV%) for Total FMS, Locomotor FMS, Object-Control FMS, Stability FMS and Each Individual Skill for Years 3, 4 and 5.

| Score  | Years 3      |        |       | Years 4      |        |        | Years 5      |        |        | P         |
|--|--------------|--------|-------|--------------|--------|--------|--------------|--------|--------|-----------|
|  | Mean (SD)    | Median | CV%   | Mean (SD)    | Median | CV%    | Mean (SD)    | Median | CV%    |           |
| Total FMS score<br>(locomotor<br>& object)     | 34.64 (5.14) | 35.00  | 14.8% | 36.85 (5.41) | 38.00  | 14.7%  | 37.20 (4.76) | 38.00  | 12.8%  | .007*     |
| Total FMS score<br>(inclusion<br>of stability) | 37.38 (6.19) | 37.00  | 16.6% | 38.63 (5.97) | 39.00  | 15.4%  | 39.30 (5.65) | 40.00  | 14.4%  | .159      |
| Locomotor score                                | 20.47 (3.58) | 21.00  | 17.5% | 21.35 (3.82) | 21.00  | 17.9%  | 21.17 (3.59) | 22.00  | 17%    | .376      |
| Object-control                                 | 14.17 (3.33) | 14.00  | 23.5% | 15.49 (3.57) | 16.00  | 23.1%  | 16.02 (2.89) | 16.00  | 18%    | .003*     |
| Catch overarm<br>throw                         | 5.32 (1.67)  | 5.00   | 31.1% | 6.31 (1.53)  | 6.00   | 24.2%  | 6.87 (1.37)  | 7.00   | 19.9%  | .000*.500 |
| Underarm Throw                                 | 4.71 (2.22)  | 4.00   | 47.1% | 5.00 (2.15)  | 4.00   | 42.9%  | 5.13 (2.10)  | 4.00   | 40.9%  | .360      |
| Stability run                                  | 4.14 (1.34)  | 4.00   | 32.3% | 4.18 (1.33)  | 4.00   | 31.9%  | 4.02 (1.03)  | 4.00   | 25.6%  | .020*.797 |
|  | 2.74 (2.14)  | 2.50   | 78.2% | 1.79 (1.99)  | 1.00   | 111.4% | 2.11 (2.17)  | 2.00   | 102.7% |           |
|  | 6.58 (1.35)  | 6.00   | 20.5% | 6.75 (1.25)  | 6.00   | 18.5%  | 6.62 (1.37)  | 6.00   | 20.6%  |           |
| Jump   | 5.91 (1.68)  | 6.00   | 28.4% | 6.14 (1.40)  | 6.00   | 22.7%  | 6.27 (1.39)  | 6.00   | 22.1%  | .503      |
| Hop  | 4.08 (1.40)  | 4.00   | 34.2% | 4.35 (1.47)  | 4.00   | 40%    | 4.01 (1.47)  | 4.00   | 36.6%  | .294      |
| Skip   | 3.91 (2.30)  | 4.00   | 33.2% | 4.11 (1.42)  | 4.00   | 34.5%  | 4.27 (1.54)  | 4.00   | 36.1%  | .92       |

Note. Maximum scores possible for total, locomotor and object-control skills are 54, 30 and 24. \*significant school year differences ( $p < .05$ ).

Year 5 ( $p < .001$ ,  $r = -.47$ ) and Year 4 ( $p = .002$ ,  $r = -.29$ ) compared to Year 3. No other significant differences were found (see Table 5).

## Discussion

In this paper, we report FMS proficiency levels across three FMS domains (locomotor, object-control and stability) in terms of both individual skills and their behavioral components for a large sample of British primary school children. Importantly, this adds to a small body of literature that has assessed FMS proficiency at both individual skill and behavior component levels, and this is the first FMS data set to include the stability domain. Additionally, we examined multiple skills in and differences across sex and age groups within this sample. The results of the present study highlight these participants' generally low competence levels, as no children in the sample achieved mastery across all eight of the skills assessed. This finding is consistent with previous investigations that has also reported low proficiency levels among children and adolescents (L. E. Bolger et al., 2018; Duncan et al., 2019; Foulkes et al., 2015; Hardy et al., 2010; McGrane et al., 2017; Morley et al., 2015). We observed sex differences for object-control and locomotor skills, with boys having a significantly higher performance than girls in object-control and girls scoring significantly higher than boys in locomotor skills. These findings agree with assertions made by L. A. Bolger et al. (2019) in relation to primary school children in Ireland. However, when each individual FMS was considered separately, sex differences were less apparent. Boys only performed significantly better on the overarm throw compared to girls. The skill with the highest percentage (stability) and the lowest percentage (run) of children achieving 'poor' was the same across both sexes. Similarly, in regard to school year differences, FMS subset scores showed significant differences in total FMS (locomotor & object) between Year 3 and Years 4 and 5. Similar differences were noted for object-control skills between Years 3 and 5, supporting prior work that also found school year differences (L. A. Bolger et al., 2019; Duncan et al., 2019). Individual skills revealed only "catch" to be significantly greater in Years 4 and 5 compared to Year 3. Findings in behavioral components revealed that the highest prevalence of failure across all skills was due to requirements on these components for greater co-ordination and/or process of movement for force production. These findings add further to a limited body of available data on FMS proficiency among British primary school children.

Regarding our aforementioned observations of low FMS competency in this sample, less than 40% of participants achieved mastery in each skill, with 27% not achieving mastery in any of the skills. These findings align with previous research both inside and outside of the UK (L. E. Bolger et al., 2018; Bryant et al., 2014; Duncan et al., 2019; Foulkes et al., 2015; Goodway et al., 2010; O'Brien et al., 2016). However, our findings differ slightly from previous work in



that we also found low proficiency in stability or balance, which is not always considered a skill. We included balance as a skill in this analysis to provide a more holistic overview of children's motor characteristics. Our findings of low proficiency are a concern for children's overall development in that FMS are required in order to develop more complex sports-specific skills (e.g., proficiency in overarm throw associated with badminton clear or tennis serve) and in order to have a positive engagement in lifelong sports and PA (Gallahue et al., 2012; Robinson et al., 2015; Stodden et al., 2008). With over a quarter of these children having not achieved mastery in any of the eight FMS examined, our results highlight a serious issue in children's FMS development and indicate a need for school-based PE interventions and community sports to help children develop sufficient FMS proficiency to be on a positive trajectory for lifelong PA.

Factors that may constrain FMS development are several, including main constraints that can be categorized into (a) individual constraints or individual characteristics that can be physical (e.g., body mass and height) and/or mental (e.g., motivation and attention span); (b) environmental constraints or external factors in the environment in which the task is taking place, that can be social (e.g., how others are acting around you) and/or physical (e.g., weather conditions); and (c) task constraints specific to the actual task being delivered (e.g., goal, feedback and instructions of a task) (Haywood & Getchell, 2019; K. Newell, 1986). Past research indicates that a constraints-based teaching/coaching method that attempts to manipulate certain constraints will best allow children to reach mature movement patterns (Chow et al., 2016; Renshaw et al., 2010). Data presented here at both individual skill and behavioral levels provides the essential elements of task constraints that interventions must target.

Examining the more difficult to master behavioral components also adds insight, since we found that the behavioral components with the highest failure percentage were those that required the simultaneous use of both upper and lower limbs and contralateral actions. Examples include not stepping forward with the opposite foot to the throwing hand (Underarm throw component 2), moving arms alternately at waist level in opposition to the legs (Skip component 3), flexing arms and swinging forward to produce force in the hop (Hop component 3), and rotating the hip and shoulder to a point where the non-throwing side faces the wall (Overarm throw component 2). These findings are consistent with those from the small number of previous studies that have also investigated the behavioral components of FMS in various populations of (a) Irish adolescents (O' Brien et al., 2016); (b) Australian pre-schoolers (Hardy et al., 2010); and (c) British pre and primary school children (Duncan et al., 2019; Foulkes et al., 2015). These findings highlight a deficit in co ordination and the process for power/force production, as mechanical factors that are known to affect potential movement development (Gallahue et al., 2012). Considering our findings from a developmental sequence perspective (ordinal level of components), those children who were less proficient had poor coordination and/or dynamic

stability and so lacked the skill sequences that provide power production. For example, among children who were less proficient at throwing, their developmental sequence demonstrated front facing throwing with stationary feet and no trunk rotation. In contrast, those children who were proficient at throwing, demonstrated a developmental sequence of sideways throwing and long contralateral step and trunk rotation (Goodway et al., 2019). The increase in power production is due to the co ordination and dynamic balance required to perform a long contralateral step in order to significantly transfer force to the ball (Gabbard, 2004; Goodway et al., 2019; Logan et al., 2017; Payne & Isaacs, 2011). Therefore, our data showed that interventions should focus on mechanical efficiency and biomechanical principles of action/reaction (Seefeldt, 1980) in order to increase children's FMS proficiency. For example, interventions could employ coaching cues or attentional focus instructions. Furthermore, regarding physical intervention, plyometric type exercises may be best.

Regarding our observation of sex differences in relation to FMS domains such that boys outperformed girls in object-control skills and girls outperformed boys in locomotor skills, other studies have reported similar findings (L. A. Bolger et al., 2019; Hardy et al., 2010). However, unlike most past studies, our focus on individual skills indicated little difference between the sexes at this level. Only one individual skill differed in that boys outperformed girls on the overarm throw. Thus, grouping skills into FMS domains potentially masks a full and accurate understanding of sex differences, perhaps hindering efforts to assist boys' and girls' in their separate development of FMS. This is a key finding of the present study, further supported by our descriptive data showing that both boys and girls performed similarly in the run, hop, stability rock and catch. All children also performed better at run and catch and poorest at stability and hop. It is not surprising that the highest level of proficiency was for the run as this was found in past research as well (L. A. Bolger et al., 2019; Duncan et al., 2019; Foulkes et al., 2015; Hardy et al., 2010; O' Brien et al., 2016). Running is one of the earliest emerging skills (Goodway et al., 2019). The deficiency we found in stability is a significant concern, given that stability has been described as the most basic skill (Gallahue et al., 2012). Additionally, but of equal concern is that poor stability can impact the ability to perform other FMS skills (Rudd et al., 2015), as poor stability limits co ordination and the ability to produce and receive force. This finding was further evidenced by our discovery that those behavioral components that had the highest prevalence of failure required either co-ordination or force production. Improving stability proficiency should, therefore, be a priority if intervention efforts are to be successful in improving FMS development in children. Each skill has its own developmental path, leading to different skills coexisting at different developmental stages (Goodway et al., 2019). Therefore, strategies and interventions to increase FMS proficiency must reflect the complexity of the individual motor skill and its unique developmental timeframe.

Regarding our investigation into school year differences among FMS domains and individual skills, we found year differences, as noted, in overall FMS (combining locomotor and object control) and in the object-control domain; but component skill level evaluations highlighted “catch” as the only skill difference between Year 3 and Years 4 and 5. Children in Years 4 and 5 may have been more proficient at catch due to maturation of the visual system, allowing more precise visual tracking (Dekker et al., 2019). While we might have expected older cohorts to be more proficient across all FMS, due to their general growth and maturation (Charlesworth, 2016; Cohen et al., 2014), past studies have shown adolescents to exhibit similar levels of proficiency as children (McGrane et al., 2017; O’ Brien et al., 2016). Just as our study found no children to have achieved mastery in all eight FMS, a study of Irish adolescents found only one of 242 participants to be proficient in all eight skills examined (O’ Brien et al., 2016). Thus, while growth and maturation have potential to yield greater FMS proficiency, the rate and extent of development is individualized, and it is substantially influenced by the environment and task instruction (e.g., appropriate teaching, instruction and feedback) (Goodway et al., 2019; Newell, 1986). Therefore, these factors, rather than age alone, must be considered in FMS development.

Future research related to the presence of a characteristic (TGMD-2 criteria) and product FMS outcome in individual skills and behavioral components is needed in order to better understand factors contributing to FMS deficiencies identified in the present study. Nevertheless, this analysis of individual skill and behavioral component level skills initiated some revelation of the environmental and task constraints of FMS development that teachers and coaches need to know in order to better plan interventions for assisting specific rather than only broad developmentally appropriate movement and task achievements (Hardy et al., 2010; Logan et al., 2012; O’ Brien et al., 2016). This task-analysis highlighted weaknesses that can be addressed directly in a comfortable, nurturing teaching environment. A more specific understanding can guide an instructional focus on what most needs improving, and provide specific feedback to modify task achievement with the greatest impact on FMS development (Barnett et al., 2016; Garcia & Garcia, 2006; Goodway et al., 2003; Robinson & Goodway, 2009).

## **Limitations and Direction for Future Research**

With regard to this study’s limitations, we only studied 7-10 year olds, limiting our ability to generalize these results to other age groups. We selected this age range because the National Curriculum for Physical Education in England has stated that children should have mastered their FMS by the time, they reach this stage of development (Key stage 2). Additionally, did not account for relative age effects in this analysis. Relative age effects (i.e., the effects of greater

proficiency among the slightly older aged children born from September – December rather than later in a given year group) have been previously shown to influence FMS and physical fitness (Birch et al., 2010; Cupeiro et al., 2020). An examination of the relative age effect or defining children's ages more precisely when comparing ages should be a consideration in future research of this kind.

## Conclusion

In the current study we examined FMS proficiency levels in British primary school children and found a low FMS proficiency across the eight skills examined, involving domains of locomotor, object-control and stability skills. Key findings were that no children mastered all the FMS skills examined; and, at the level of individual components (but not at the level of broad domains), FMS deficiencies were not statistically different across age and sex. We conclude that, to improve FMS development in all children to the point of FMS proficiency, intervention efforts should focus on stability skills and on improving co-ordination and force/power production.

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