**(a) Article Title:** Interpreting measures of fundamental movement skills and their relationship with health-related physical activity and self-concept

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## Abstract

The aims of this study were to determine proficiency levels of fundamental movement skills (FMS) using cluster analysis in a cohort of UK primary school children; and to further examine the relationships between FMS proficiency and other key aspects of health-related physical activity behaviour. Participants were 553 primary children aged between 9 and 12, 294 boys and 259 girls, who were assessed across eight different FMS. Physical activity behaviours included markers of physical fitness, recall of physical activity behaviour and physical self-concept. Hierarchical cluster analysis was used to classify groups based on FMS proficiencies and discriminant analysis to predict FMS proficiency based upon the physical activity variables. This interpretation of FMS performance revealed distinct groups of FMS proficiency in both genders with several gender specific components of physical activity shown to discriminate children with differing levels of FMS proficiency ($p < .05$, $r > .40$).


*Keywords:* Fundamental movement skills, physical activity, self-concept, children.

## Introduction

Despite compelling evidence that both the physical fitness and health status of children and adolescents are substantially enhanced by regular physical activity, it is still unclear why some youth are more physically active than others (Stodden & Holfelder, 2013). In response, the concept of physical literacy has emerged in contemporary sport development policy and practice (Lloyd, Colley, & Tremblay, 2010). However, despite the efforts of Whitehead (2010) and others the lack of clarity in the current models used to operationalise the theoretical concept (Giblin, Collins, & Button, 2014) has led to physical literacy in many programmes being operationalised as the development of physical competency and often just as fundamental movement skills (FMS; Keegan, Keegan, Daley, Ordway, & Edwards, 2013). Although physical competency is recognised as an important dimension of physical literacy (Whitehead, 2010) the exact balance of movement capacities (i.e., fundamental, combined and complex) required to attain physical competency has yet to be clearly expressed (Giblin et al., 2014). Despite this lack of conceptual clarity, FMS are viewed as the building blocks for more complex motor skills and patterns and represent the underlying performance competencies required for adequate participation in many forms of physical activity (Cliff, Okely, Smith, & McKeen, 2009). FMS are common motor activities comprised of a series of observable movement patterns, consisting of locomotor skills (e.g., run, hop and jump), manipulative skills (e.g., catch, throw and kick), and stability skills (e.g., static and dynamic balance; Gallahue & Donelly, 2003). Acquiring proficiency in FMS during childhood has been suggested as a vital component of children’s physical, cognitive and social development, (Malina, 2009).

Over the past decade, an overall decline in both children’s motor skill performance and physical activity has been reported (Hardy, Barnett, Espinel, & Okely, 2013). The underlying explanations for this decline are unclear (Tompsett, Burkett, & McKean, 2014), and the causes are clearly multidimensional in nature. One potential obstacle to an increased understanding of this decline may be linked to our interpretation of FMS proficiency, an accurate evaluation of which is critical for assessing and shaping pedagogical decisions for enhancing physical literacy in children. Researchers have attempted to address this issue through the use of standardized means for calculating individual item scores. Thus, several studies have calculated a total score for each individual FMS skill, based on a criterion of *mastery* if all components of the skill are demonstrated, *near mastery* if one component is absent and *poor* if two or more components are not evident from a set number of trials (e.g., Van Beurden, Zask, Barnett, & Dietrich, 2002). A number of FMS scoring systems focus either on distinct categories of motor competencies such as locomotor skills, object control skills or use a combination of categories to aggregate FMS scores. For example, catching and throwing, are summarized as an object control score, and presented as a single result (e.g., Cohen, Morgan, Plotniknoff, Barnett, & Lubans 2015). However, grouping skills into these distinct categories may mask some individual skill performance with the result that inadequacies in specific movement skills that require greater focus can go unnoticed by practitioners.

As a result, Giblin et al. (2014) suggested that more research was required to refine the procedures used in assessing and classifying FMS to enable more accurate interpretation of the results obtained and greater effectiveness in their use in promoting skill proficiency. More recently, Barnett, Miller, Laukkanen, and Morgan (2016) emphasised the need for FMS assessment to accurately identify specific FMS deficits in individuals and contribute to the provision of a learning environment that is developmentally appropriate, This may, for example, necessitate that an individual FMS be learnt and practiced initially in a closed environment (e.g., without the influence of other skills or such pressures as competition and outcome scores), before being integrated with other FMS within a more advanced learning environment (e.g., sport specific contexts). Given such suggestions, this study used cluster analysis, as a means to categorize individuals that displayed similar characteristics, when taking into account the full range of skills measured. This analysis enables a necessary discrimination to be made between individuals who may have registered a similar aggregate score, but one achieved across a very different range of skills.

In addition to investigating effective means for assessing overall FMS proficiency, this research also focused on the relationship between FMS proficiency and other aspects of children's physical activity behaviour that form the building blocks of physical literacy. Stodden and colleagues' (2008) spiral model of engagement-disengagement in physical activity points towards a dynamic and reciprocal relationship between FMS competence and physical activity behaviours in mid childhood (ages 8 to 10) years) and onwards towards adolescence. They advocate that in this developmental model it is important to substantiate which variables of health-related physical activity (i.e., physical fitness, physical self-concept, physical activity, and weight status) have the potential to impact FMS performance as any future intervention to promote and sustain health outcomes should have a clear strategy to address all of these elements.

In other literature, it has been suggested that a significant inverse association exists between FMS proficiency and both weight status (Cliff, Okely, & Magarey, 2011) and cardio-respiratory fitness (Hardy et al., 2013). It has also been suggested that muscular strength is critical for successful FMS development and performance (Behringer, Vom Heede, Matthews, & Mester, 2011). Physical self-concept (i.e., an individual's perception of his/her own physical competence) has been shown to be an important correlate of FMS proficiency in children (Robinson, 2011). Further, Barnett, Van Beurden, Morgan, Brooks, and Beard (2008b) suggested that children's physical activity behaviour may also be partially attributed to their actual FMS competence.

Considering these issues and the potential importance of FMS as a means to both understanding dimensions of children's physical literacy and explaining their lifelong involvement with health-related physical activity, the purpose of the present study is to: examine a more discriminating classification of FMS performance, and apply it to an exploration of the relationships between FMS proficiency and other key aspects of physical activity behaviour in a cohort of 9-12-year-old UK school children. It is hypothesised that children with more proficient FMS profiles will demonstrate more favourable measures of the associated physical activity variables.

# Method

## Participants and Settings

Following the granting of ethical approval, 591 children, aged between 9 and 12, from 18 schools in the South-East Wales region of the UK, attended the test centre; 553 complete data sets were recorded comprising 294 males (*M* age = 10.9 years, *SD* = 0.62), and 259 females (*M* age = 10.7 years, *SD* = 0.64). Parental consent and child assent were obtained for each participant. All data were collected during normal school hours.

## Instruments and Measures

**Fundamental movement skills.** FMS proficiencies were assessed using selected process orient checklists taken from the Australian resource 'Get Skilled: Get Active' (NSW Department of Education and Training, 2000). The resource includes checklists of skills from all categories of FMS (locomotor, manipulative and stability; Gallahue & Donnelly, 2003) and is valid for use with both children and adolescents. The checklist, contains eight individual FMS, including four locomotor skills (run, vertical jump, side gallop, leap) three manipulative skills (catch, overhand throw, kick) and one stability skill (static balance). The reliability and validity of the skills and their components have been previously established (Okely & Booth, 2000). Get Skilled: Get Active was preferred to other measures of FMS (e.g., the TGMD-2; Ulrich, 2000) as it includes a stability component of FMS assessment and is culturally acceptable for use with children in this population (Foweather, 2010).

**Anthropometry and physical fitness.** Anthropometric and physical fitness assessments were conducted with the High Priority battery from the ALPHA (Assessing Levels of Physical Activity and Fitness) Health-Related Fitness Test Battery for Children and Adolescents Test Manual (Ruiz et al., 2011). The battery includes assessments of body composition (weight, height, BMI), cardio-respiratory fitness (20m multi-stage test) and musculoskeletal fitness (handgrip strength, standing long jump). In addition, the study included a separate motor fitness measure the 20-metre sprint, which has previously been reported to be a valid and reliable measure of speed in children (Morrow, Jackson, Disch, & Mood, 2005).

**Physical activity.** The Physical Activity Questionnaire for Children (PAQ-C; Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997) was used as an indicator of the children's 'typical' level of physical activity behaviour (cf. Welk & Eklund, 2005). The instrument uses nine multiple choice questions to assess a child's physical activity over the previous seven days. The PAQ-C has been shown to have adequate test-retest reliability (range: $r$ = 0.75 - 0.82) and validity (range: $r$ = 0.45 - 0.53; Crocker et al., 1997). The choice of the PAQ-C for use with this population was based on a review of physical activity self-report measures by Biddle, Gorley, Pearson, & Bull (2011), who supported its validity, reliability, and practicality for use with children and adolescents. The instrument has also been recommended by the ALPHA Health-Related Fitness Test Battery for Children and Adolescents (Ruiz et al., 2011) for use with European samples of young people.

**Physical self-concept.** The Children and Youth Physical Self Perception Profile was used to examine participants' perceptions of Global Self-Worth (GSW), Physical Self-Worth and its sub-domains of Sports Competence (SC), Physical Conditioning (PC), Body

Attractiveness (BA) and Physical Strength (PS). Each scale is assessed by six items scored on a four-point scale with the average score used to represent the value for the scale. Previous work by Welk, Corbin, Dowell, and Harris (1997) and Welk and Eklund (2005) have demonstrated adequate reliability and a good fit for the CY-PSPP measurement model. In addition, Welk and Eklund also established that the instrument can be used in research with children as young as nine years of age. As it has not been used with a population of children from South-East Wales, we conducted a confirmatory factor analysis (CFA) of the CY-PSPP to establish its utility for the present sample.

**Procedure**

Data were collected by an experienced FMS practitioner and a team of trained research assistants. The FMS assessments were video recorded (Sony video camera, Sony, UK) and analysed using performance analysis software (Studio Code, NSW, Australia) in accordance with the ‘Get Skilled: Get Active’ guidelines. A process oriented checklist was used to determine the total number of components performed correctly for each skill attempt and analysed by the study author. If there was any uncertainty about whether a feature was consistently present or not, it was checked as absent. For reliability of the FMS assessment inter- and intra-rater reliability analysis was performed on a randomly selected sample of completed FMS sets by the author and a second experienced FMS practitioner and determined using linear weighted Kappa (Fleiss, Levin, & Paik, 2003). Physical fitness assessments and data collection followed the procedures described in the High Priority ALPHA Test Battery (Ruiz et al., 2011). The 20 metre sprint efforts followed the procedures outlined by Oliver and Meyers (2009) and were recorded with Smart Speed dual beam electronic timing gates (Fusion Sport, Queensland, Australia). The CY-PSPP and the PAQ-C survey instruments were administered in a classroom at the test centre, to small groups (no greater than 6 participants), of same gender. The purpose of both the survey instruments was explained to the children and it was stressed that there were no right or wrong answers. Each item in both the surveys was read to the children with research assistants circulating throughout the room to provide extra assistance. Prior to administration of the CY-PSPP, example items were provided and demonstrated to the participants based on Whitehead's (1995) recommendations for its use with young children.

## Statistical Analysis

**Confirmatory factor analysis**. The factorial validity of the CY-PSPP was examined using CFA with the Mplus statistical programme (Muthen & Muthen, 2010). The demographic variables used were gender; male ($n$ = 294), female ($n$ = 259) and group ($n$ = 553). The CFA models were fitted for each group separately to test for configurable invariance. Global model fit indices were examined at each stage of the CFA, along with detailed assessment of the completely standardized factor loadings, the standardized residuals, and the modification indices. All CFAs were conducted using the robust maximum likelihood estimation procedure with a Satorra–correction (S-B$\chi^2$) and fit indices corrected for robust estimation based on the recommendation of Hu and Bentler (1999) amongst others who suggest that multiple criteria be used to evaluate the fit of the overall model to the data. These fit indices, in addition to the normed chi-square test ($\chi^2$), included the chi-square to degrees of freedom ratio ($\chi^2/df$), the Comparative Fit Index (CFI; Bentler, 1990), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA; Steiger, 1990) and the Standardized root mean square residual (SRMR; Bollen, 1989). Hu and Bentler's (1999) recommendations for good fit were adopted, with a $\chi^2/df$ ratio of 3:1 or less indicating good fit, and cut off values of 0.95 for CFI, 0.06 for RMSEA and 0.08 for SRMR. To examine whether the CY-PSPP displayed equivalence of measures across genders, a measurement invariance approach was employed via multi-group CFA. Measurement invariance assessed invariance of construct, factor loading, item intercepts and error variances in a hierarchical ordering with increased constraints from one model to the next. As a result, a model is only tested if the previous model in the hierarchical ordering has been shown to be equivalent across groups. In addition to the fit indices described above, the Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) indices were used to indicate model fit.

**FMS group classification and proficiency.** Intra-and inter-rater reliability for all FMS measures displayed a level of agreement that was good or above (Kw range = 0.68 to 0.93) and (Kw range = 0.61 to 0.81) respectively, based on Altman's (1991) thresholds to describe reliability. Data were split by gender and preliminary analyses confirmed these two groups differed ($p < .05$). Ward's two-way hierarchical cluster analysis (JMP version 10.02; SAS Institute, Marlow, UK) was used to classify groups based on the FMS item scores. The number of clusters was determined at the point where the scree plot of the distance values plateaued. To verify the classification analysis, differences between the clusters on total FMS score were assessed using t-test for females (2 groups) and ANOVA for males (3 groups) with Tukey's post hoc. To describe the features that best described the clusters, a decision tree induction (DTI) method was used (Morgan, Williams, & Barnes, 2013). The DTI was split then pruned to retain the $r^2$ minimising the likelihood of over fitting. Finally, the validity of the model was assessed via inspection of the ROC curve, area under the curve and the corresponding confusion matrix.

**Discriminant analysis.** Following FMS group classification, discriminant analysis was used to examine which of the FMS groups scored more highly on the other physical activity variables. Initial screening of dependent variables revealed non-normal distributions and outlying cases were modified by assigning the outlying case(s) a raw score that was one unit larger (or smaller) than the next most extreme score. The analysis was then reassessed to confirm the assumptions corresponding to linearity, normality, multicollinearity and heterogeneity of variance-covariance matrices. For the discriminant analysis, loadings > 0.4 were considered significant, based on Stevens' (1992) conservative recommendation. A classification matrix was constructed to assess the predictive accuracy of the discriminant functions using a proportional chance criterion of > 56% (Hair, Anderson, Tatham, & Black, 1998). Classification accuracy was examined using Press's Q statistic, compared to the $\chi 2$ critical value of > 6.63.

## Results

### Confirmatory Factor Analysis

The results of analysis conducted to evaluate CY-PSPP measurement model fit are presented in Table 1. A $\chi^2/df$ ratio of 3:1 or less is successfully demonstrated in each model. The CFI indexes exceeded the 0.90 criterion, RMSEA values were below .06, and SRMR were below .10, all indicating an adequate overall fit of the model. All questionnaire items loaded onto their designated factors with non-zero loadings. Median loadings for the full group, boys subsample and girls subsample were 0.76 (range = 0.59 – 0.92), 0.75 (range = 0.61 – 0.92) and 0.75 (range = 0.55 – 0.95), respectively. These findings suggest an adequate fit for the CY-PSPP measurement model to these data and reasonable psychometric properties. Inter correlations amongst sub domains signified zero cross loadings on all other factors. In general, the correlations among the sub domains (SC, PC, BA, and PS) were moderate to strong across the full group ($r$ = 0.57 – 0.93), boys sub group ($r$ = 0.56 – 0.96), and girls sub group ($r$ = 0.51 – 0.93). As expected, the sub domains demonstrated stronger associations with the PSW than with GSW in all groups. The correlations between GSW and PSW were higher than the correlations between GSW and the other CY-PSPP sub domains for all groups.

Measurement invariance across boys and girls sub groups to evaluate the CY-PSPP factor structure for gender sensitivity is shown in Table 1. The fit indices in Table 1 confirm an excellent fit of the independent factor structure; Model 1 provides excellent multiple fit indices to the data ($\chi^2/df$, CFI index, RMSEA, SRMR, AIC/BIC value) indicating that the factorial structure of the construct is equal across groups. As configural invariance was supported, coefficients were then constrained to be equal to test for metric invariance. Model 2 has good fit indices; therefore, constraining the factor loading to be the same across the groups. The scalar invariance model (Model 3) provided a good fit to the data as did the error variance invariance model (Model 4). The overall goodness of fit indices and the tests of differences in fit between adjacent models therefore support measurement invariance. Taken together, the data provide supportive evidence for the validity of the CY-PSPP with this population.

Insert Table 1 here

**FMS Classification**

**Boys.** Three groups emerged from the analysis; Low (total FMS = 18 ± 4), Intermediate (total FMS = 25 ± 4), and High (total FMS = 31 ± 3) Proficiency. When total FMS scores for these groups were compared, all the group means differed significantly, Low versus High = 13 (95% CI = 11-14); Low versus Intermediate = 7 (95% CI = 5-8), and Intermediate versus High = 6 (95% CI = 5-7). Figure 1 shows the frequency distribution of FMS performance of the cluster groups on each FMS. The final DTI model (Figure 2) had a total of seven splits. From the column contributions, the FMS with the largest difference between the cluster groups was vertical jump ($G^2$ = 78.03) followed by the overhand throw ($G^2$ = 64.26), then leap ($G^2$ = 31.19). Side gallop ($G^2$ = 23.06), static balance ($G^2$ = 18.58) and the catch ($G^2$ = 18.49) also featured, but to a lesser extent. The FMS of run and kick made no contribution between the groups. The high proficiency cluster demonstrated strongest performances for the splits on vertical jump; overhand throw, static balance, catch and side gallop. The low proficiency group were poor in the vertical jump and poorest in the splits of side gallop and the leap. The intermediate proficiency group demonstrated lower performance than the high proficiency group but better performance than the low group across all splits except for the catch. In summary, whether the child scored high or not on vertical jump (first split), subsequent skills identified the high proficiency cluster as being the most competent of the groups across the identified splits.

**Girls.** Two groups (Low and High Proficiency) were identified. The Low and High Proficiency group had total FMS scores of 21, ± 4 and 28, ± 3, which were significantly different, mean difference = 6, 95% CI = 5-7. Figure 1 shows the frequency distribution of scores of the two clusters on each FMS. Comparisons between the groups showed the high proficiency group were the most proficient across all FMS. The final girls' DTI model (Figure 2) had five splits ($r^2$ = 0.48) that differentiated between the two clusters. Static balance ($G^2$ = 84.36) was the FMS variable with the largest contribution to the model. The catch ($G^2$ = 44.51), vertical jump ($G^2$ = 27.34) and leap ($G^2$ = 10.84) followed but their impact was much smaller. Run, side gallop, kick and overhand throw made no contribution and did not feature in the final model. Girls who scored higher on the static balance and the vertical jump demonstrated higher probability of being in the high cluster group. Girls who scored lower on the static balance but higher on the catch, static balance and the leap splits also demonstrated higher probability of being in the high cluster group. In contrast, the low cluster group demonstrated poorer skill proficiency across all splits. In summary, whether good performance was observed in static balance (first split), subsequent skills identified the high proficiency group as being the most proficient.

Insert Figures 1 and 2 here

## Descriptive Statistics

Descriptive statistics for male and female FMS groups for all the independent variables are reported in Table 2. In boys, the high proficiency group demonstrated better performance measures of physical fitness, physical activity recall and physical self-perception than both the intermediate and low proficiency groups. The low group demonstrated the lowest performance scores across all these measures. In girls, the high proficiency group demonstrated higher scores on measures of physical fitness, physical activity recall and physical self-perception than the low group.

Insert Table 2 here

## Discriminant Analysis

**Boys.** Analysis revealed two discriminant functions. The first function explained 86.7% of the variance, canonical $R^2 = 0.26$, whereas the second function explained only 13.3%, canonical $R^2 = 0.05$. In combination, these discriminant functions significantly differentiated the cluster groups, $\Lambda = 0.70$, $\chi 2$ (24) = 102.73, $p < .001$; although removing the first function indicated that the second function did not significantly differentiate the groups, $\Lambda = 0.95$, $\chi^2$ (11) = 15.27, $p = 0.17$. Closer analysis of the discriminant loadings in Table 3, reveals that Sprint, MSFT, SLJ and CY-PSPP Condition sub scale exceeded the criterion on the first function (> 0.40). The discriminant function plot showed that the first function discriminated the high group from the intermediate group and the low group. With 67.3% of the original grouped cases correctly classified, the intermediate group were 87.2% correctly classified, the high group were 34.2% and the low group were 29%, Press's Q = 17.69 (> 6.63), p < 0.05. The classification ratio exceeds the proportional chance criterion of 56 % demonstrating predictive accuracy of the discriminant function (Hair et al., 1998).

**Girls.** A single discriminant function that explained all the variance was identified, canonical $R^2 = 0.14$. The function significantly differentiated the groups, $\Lambda = 0.86$, $\chi 2$ (12) = 36.65, $p < .001$. Closer analysis of the discriminant loadings in Table 3 revealed that Sprint, SLJ, HG, PAQ-C, and MSFT, were significant predictors of group membership (> .40). Classification results showed that 69.5 % of original grouped cases were correctly classified (low group = 47.1%, high group = 84.1%, Press's Q = 39.39 (> 6.63), $p < .05$. The classification ratio exceeds the proportional chance criterion of 56 % demonstrating predictive accuracy of the discriminant function (Hair, et al., 1998).

Insert Table 3 here

## Discussion

The novel approach of using cluster analysis to examine FMS proficiency successfully identified groups with different proficiency levels. In addition, discriminant analysis revealed that FMS proficiency level could be predicted by a combination of several physical activity related variables for both males and females. Specifically, these were cardio respiratory fitness and lower body musculoskeletal strength in both boys and girls and upper body musculoskeletal strength in girls. Physical activity recall was a significant predictor for girls, whereas for boys, the physical condition subscale of the CY-PSPP was prominent.

For both boys and girls, FMS proficiency levels were low (based on similar reporting of FMS proficiency in children) and not dissimilar to levels demonstrated in other UK based studies with similar aged children (e.g., Foweather, 2010). This is concerning given the importance placed on FMS in enhancing physical literacy and promoting health (Tompsett et al., 2014). It is generally believed that most children should master the less complex FMS (i.e., sprint run, vertical jump, catch, side gallop and over-arm throw) by age nine and more complex FMS (i.e., leap and kick) by age ten (Hardy, King, Espinel, Cosgrove, & Bauman, 2010). Attainment of movement proficiency at this level is purported to form a foundation for physical literacy, the absence of which might lead to activity avoidance and the associated implications for health (Stodden et al., 2008). As highlighted earlier, it is the *interpretation* of the FMS scores that may be important in revealing insights into children's FMS proficiency. The classification method adopted in this study was effective in distinguishing group membership and provides practitioners with more precise details of FMS proficiency that avoids misclassification which in turn may help those children most in need of additional support.

In addition to identifying FMS group membership and a more refined focus on FMS ability with boys and girls it is also mindful to recognise FMS differentials that exist across genders. In this study, it was shown that girls displayed poorer proficiency in specific manipulative skills (i.e., overarm throw and kick) compared to boy's groups. These findings support previous research in gender differentials across FMS (e.g., Hardy et al., 2013) amongst others who suggest boys tend to possess higher proficiency in manipulative skills than girls although this divide is not as clear within locomotor skills.

A subsidiary aim of this study was to directly test the factorial validity of the CY-PSPP. For this population, CFA clearly supported the hierarchical structure of the CY-PSPP and yielded a clean factor structure, supporting claims by Welk and Eklund (2005) that young children can judge themselves differently according to the physical domain of their lives being addressed.

The second major aim of the present study was to examine the relationship between FMS proficiency and the potential impact of several key health related measures of physical activity involvement (Stodden et al., 2008) at what has been suggested to be a critical developmental age (Malina, 2009). In this study, discriminant analysis revealed that for both boys and girls, measures of physical fitness were significant predictors of FMS proficiency. More specifically in both genders, these measures included cardio respiratory fitness, the sprint run and musculoskeletal fitness (i.e., upper body strength in girls and lower body strength in boys and girls). A positive relationship between FMS ability and cardio respiratory fitness levels has previously been demonstrated (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008a; Okely, Booth, & Patterson, 2001). In addition, Hardy, Reinten-Reynolds, Espinel, Zask, and Okely (2012) confirmed a clear and consistent association between low competency in FMS and inadequate cardio-respiratory fitness in children. Although this relationship appears robust, the directionality of this relationship is unclear. For example, Cohen et al. (2015) have suggested that improvements in overall FMS competency may act as a causal mechanism for physical activity behaviour change and subsequent improvements in cardio respiratory fitness. Despite this uncertainty, promoting both FMS and cardio respiratory fitness would seem to be beneficial for children.

Regarding musculoskeletal fitness Stodden, True, Langendorfer, and Gao (2013) have suggested that a certain level of force production and force attenuation is needed to proficiently perform many ballistic FMS (e.g., throwing, kicking, striking, jumping, running, and leaping). Behringer et al. (2011) have identified that children showed greater training induced gains in the skills of jumping, running, and throwing after a programme of strength training. At present, levels of muscular fitness appear to be declining in UK children (Cohen et al., 2011), which might negatively impact FMS proficiency as witnessed in this study. Further, the development of strength is closely related to sprint performance, another significant predictor in this study. This is consistent with the finding that the development of sprint speed has been shown to be a distinguishing characteristic of successful participation in physical activities in both children and adults (Hammami, Makhlouf, Chtara, Padulo, & Chaouachi, 2015).

It is important to note here that BMI was not related to FMS performance in boys and girls, which is consistent with the studies of Castelli and Valley (2007) and Hume et al. (2008). However, these findings contrast with several studies that reported that elevated BMI has a negative effect on FMS performance (Cliff et al., 2009; Okely, Booth, & Chey, 2004; Southall, Okely, & Steele, 2004). Most apparent in these studies is the seemingly negative relationship between BMI and locomotor FMS (e.g., run, hop, side gallop). Locomotor skills may be more related to BMI than object control skills as these skills require more ‘whole body' movement and transfer of body weight, and so are more difficult to perform given overweight and obese childrens' increased overall mass (Okely et al., 2004). Okely and colleagues (2004) suggested that the relationship between skill competence and being overweight may be reciprocal. Therefore, although BMI might be an important measure in terms of health and physical activity its actual relationship with FMS remains unclear and further investigation is clearly needed.

In this study, it was shown that for girls, but not boys, involvement in physical activity significantly discriminated between the FMS groups. Okely et al. (2001) and Raudsepp and Pall (2006) have also found that the relationship between FMS and time in organised physical activity outside of the school environment was stronger for girls than boys. A distinction between organised (i.e., involving adult interventions such as in club sport and other instructional activity) and non-organised activity did not form part of the present study. Future research would benefit from differentiating between these types of activity.

The physical condition (PC) subscale of the CY-PSPP differentiated between the boys' FMS groups. Physical condition represents the individual's perceptions regarding the level of their physical condition, physical fitness, stamina, their ability to maintain exercise and how confident they feel in the exercise and fitness setting. Spiller (2009) suggests that through participation many boys learn that the optimal functionality and performance of their bodies (i.e., physical condition) is more important than other facets such as appearance and participation in physical activity, typically providing a better 'fit' for the development of males' identity and FMS skill acquisition. In addition, Foweather (2010) suggests that with advancing age children are more able to make informed judgements about their level of physical condition and so it is likely that the relationship between physical activity and motor competence will strengthen in those with advanced levels of physical condition. No other CY-PSPP subscales significantly predicted FMS proficiency in boys or girls.

The present study holds several limitations. The PAQ-C only assesses general levels of physical activity for individuals in the school system. It does not provide an estimate of frequency, time and intensity nor does it differentiate between organised and non-organised activity. In addition, subjectivity, social desirability bias, and variable recall ability especially in young people are considered limitations of the physical activity self-report instrument used in this study. To increase the strength and accuracy of reported physical activity behaviour Chinapaw, Mokkink, Van Poppel, Van Mechelen, and Terwee (2010) suggested that a combination of self-report and accelerometery be adopted. Children’s motivation during field tests of physical fitness depends upon several factors such as motivation, understanding and perceived success (Fairclough et al., 2016). For these reasons, the physical fitness test results in this study should be interpreted with caution. The failure to confirm an association with some of the associated physical activity involvement variables may be due to the more conservative 0.40 cut off value used in the discriminant analysis of this study. While other research has used 0.30 as the cut-off point, the authors believe based on Stevens’ (1992) suggestion that 0.40 is justified as it identifies only the key variables that contribute the most to the discriminating function.

In summary, the novel interpretation of FMS performance in this study has provided researchers with an alternative method of portraying FMS competence. Having the provision to identify and specifically target the weakest FMS might better inform practitioners trying to improve movement skills. The present study also identified gender-specific components of physical activity that discriminate children with differing levels of FMS proficiency.

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**Table 1.** Measurement model (A) fit of CFA for the full group, male and female sub groups, and Measurement invariance (B) of the CY-PSPP factor structure.

| Measurement Model (A) | *n* | SB-$\chi^2$ | $\chi^2$ | *df* | *P* < | CFI | TLI | RMSEA (90% CI) | SRMR |
|---|---|---|---|---|---|---|---|---|---|
| Full group | 553 | 1362.507 | 2.35 | 579 | 0.001 | 0.950 | 0.898 | 0.048 (0.043-0.052) | 0.038 |
| Boys subgroup | 294 | 920.885 | 1.59 | 579 | 0.001 | 0.906 | 0.898 | 0.047 (0.042-0.052) | 0.059 |
| Girls subgroup | 259 | 1128.288 | 1.94 | 579 | 0.001 | 0.934 | 0.928 | 0.055 (0.050-0.061) | 0.044 |

| Invariance Model (B) | SB-$\chi^2$ | $\chi^2$ | *df* | *P* < | CFI | TLI | RMSEA | SRMR | BIC | AIC |
|---|---|---|---|---|---|---|---|---|---|---|
| Model 1 | 1297.741 | - | 579 | 0.001 | 0.900 | 0.892 | 0.046 | 0.051 | 46801.951 | 46264.242 |
| Model 2 | 2084.538 | 797.74 | 1188 | 0.001 | 0.882 | 0.875 | 0.051 | 0.066 | 47198.541 | 46254.273 |
| Model 3 | 2130.261 | 752.42 | 1218 | 0.001 | 0.880 | 0.876 | 0.051 | 0.067 | 47051.415 | 46238.295 |
| Model 4 | 2256.413 | 717.38 | 1274 | 0.001 | 0.801 | 0.867 | 0.050 | 0.065 | 4694.312 | 46198.654 |

**Note.** CY-PSPP=Children and Youth Physical Self-Perception Profile; **SB-$\chi^2$**: Satorra-Bentler scaled goodness of fit chi-square statistic; *df*: degrees of freedom for chi-square statistic; CFI: comparative fit index; TLI: Tucker-Lewis Index; RMSEA: Root mean squared error of approximation; 90% CI: 90% confidence interval of the point estimate; SRMR: Standardized root mean square residual; BIC: Bayesian Information Criterion; AIC: Akaike Information Criterion. Model 1: testing equivalence of measurement model across gender; Model 2: CFA analysis for Boys and Girls with measurement invariance of factor loadings; Model 3: CFA analysis for Boys and Girls of factor loadings and intercepts; Model 4: CFA analysis for Boys and Girls with measurement of factor loadings, intercepts, and residuals.

**Table 2.** Means and standard deviations of physical characteristics and performance measures for boys and girls FMS group classification

| | Descriptive group data (mean ± SD) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Boys** | | | | **Girls** | | |
| Variables | Total Group (*n* = 294) | Low Group (*n* = 31) | Inter. Group (*n* = 187) | High Group (*n* = 76) | Total Group (*n* = 259) | Low Group (*n* = 102) | High Group (*n* = 157) |
| BMI | 18.5 ± 2.9 | 19.5 ± 4.9 | 18.4 ± 2.7 | 18.2 ± 2.3 | 19.1 ± 3.1 | 19.07 ± 3.43 | 19.03 ± 2.81 |
| SLJ (cm) | 143 ± 22 | 129 ± 20.7 | 141 ± 20.4 | 153 ± 19.9 | 131 ± 18 | 125 ± 17.17 | 135 ± 18.13 |
| DHG (Kg) | 18.5 ± 3.4 | 17.7 ± 3.1 | 18.1 ± 3.4 | 19.8 ± 3.3 | 17.1 ± 3.3 | 16.17 ± 3.57 | 17.74 ± 3.01 |
| MSFT (m) | 821 ± 400 | 506 ± 339 | 773 ± 360 | 1066 ± 389 | 612 ± 304 | 539 ± 263 | 659 ± 320 |
| SPRINT (sec) | 4.14 ± 0.33 | 4.50 ± 0.41 | 4.15 ± 0.28 | 3.96 ± 0.29 | 4.31 ± 0.34 | 4.44 ± 0.37 | 4.24 ± 0.30 |
| PAQ-C | 3.44 ± 0.65 | 3.06 ± 0.71 | 3.46 ± 0.64 | 3.53 ± 0.58 | 3.22 ± 0.65 | 3.06 ± .065 | 3.33 ± 0.63 |
| CY-PSPP | 18.91 ± 3.03 | 17.32 ± 3.38 | 18.90 ± 2.94 | 19.60 ± 2.88 | 18.0 ± 3.11 | 17.49 ± 3.00 | 18.29 ± 3.14 |
| CY-SC | 3.16 ± 0.65 | 2.85 ± 0.78 | 3.14 ± 0.64 | 3.31 ± 0.54 | 2.97 ± 0.65 | 2.85 ± 0.63 | 3.04 ± 0.65 |
| CY-PC | 3.14 ± 0.63 | 2.76 ± 0.70 | 3.11 ± 0.60 | 3.36 ± 0.70 | 2.98 ± 0.65 | 2.86 ± 0.64 | 3.06 ± 0.65 |
| CY-BA | 2.95 ± 0.75 | 2.72 ± 0.89 | 2.97 ± 0.76 | 2.99 ± 0.74 | 2.79 ± 0.75 | 2.73 ± 0.74 | 2.82 ± 0.75 |
| CY-PS | 2.91 ± 0.68 | 2.71 ± 0.71 | 2.89 ± 0.68 | 3.04 ± 0.65 | 2.75 ± 0.65 | 2.68 ± 0.61 | 2.80 ± 0.67 |
| CY-PSW | 3.27 ± 0.57 | 2.98 ± 0.60 | 3.29 ± 0.56 | 3.37 ± 0.54 | 3.10 ± 0.62 | 3.02 ± 0.66 | 3.15 ± 0.59 |
| CY-GSW | 3.50 ± 0.50 | 3.31 ± 0.64 | 3.50 ± 0.48 | 3.53 ± 0.49 | 3.39 ± 0.55 | 3.34 ± 0.55 | 3.42 ± 0.55 |

**Note.** BMI = Body mass index; SLJ = Standing long jump; DHG = Dominant handgrip; MSFT = Multistage fitness test; PAQ-C = Physical activity questionnaire children; CY-PSPP =Children and youth physical self-perception profile; CY-PSPP- SC = Sport competence subscale; **CY**-PSPP –PC = Physical condition subscale; CY-PSPP –BA =Body attractiveness subscale; CY-PSPP –PS = Physical strength subscale; CY-PSPP –PSW = Physical self-worth subscale; CY-PSPP –GSW = Global self-worth subscale

**Table 3.** Zero order correlations, internal consistency reliability coefficients and discriminant function analysis loadings on FMS performance for boys and girls

| Variables | BMI | SLJ | DHG | MSFT | SPR | PAQ-C | CY-PSPP | CY-SC | CY-PC | CY-BA | CY- | CY-PSW | α | DFA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boys (*n* = 294) | | | | | | | | | | | | | | |
| BMI | - | | | | | | | | | | | | | -.18 |
| SLJ (cm) | - | - | | | | | | | | | | | | .58* |
| DHG (Kg) | - | .28** | - | | | | | | | | | | | .35 |
| MSFT (m) | - | .47** | .16** | - | | | | | | | | | | .75* |
| SPRINT | .34** | - | -.31** | .55** | - | | | | | | | | | -.83* |
| PAQ-C | -.01 | .14 | .11 | .22** | -.22* | - | | | | | | | | .31 |
| CY-PSPP | .27** | .39** | .13* | .43** | -.44** | .41** | - | | | | | | | - |
| CY - SC | .19** | .37** | .13* | .39** | -.38** | .51** | .84** | - | | | | | 0.73 | .33 |
| CY - PC | - | .42** | .15* | -.51** | -.45** | .42** | .79** | .66** | - | | | | 0.74 | .46* |
| CY - BA | .38** | .30** | -.02 | .33** | -.34** | .20** | .81** | .57** | .50** | - | | | 0.80 | .15 |
| CY - PS | .05 | .28** | .31** | .26** | -.26** | .29** | .73** | .60** | .55** | .42** | - | | 0.77 | .23 |
| CY - PSW | -.26** | .29** | .05 | .34** | -.37** | .32** | .87** | .65** | .60** | .71** | .52** | - | 0.72 | .30 |
| CY - GSW | -.27** | .21** | -.01 | .25** | -.30** | .22** | .78** | .56** | .48** | .68** | .38** | .75** | 0.75 | .19 |
| Girls (*n* = 259) | | | | | | | | | | | | | | |
| BMI | - | | | | | | | | | | | | | -.02 |
| SLJ (cm) | -.32* | - | | | | | | | | | | | | .72* |
| DHG (Kg) | .26** | .35** | - | | | | | | | | | | | .60* |
| MSFT (m) | - | .51** | .14* | - | | | | | | | | | | .50* |
| SPRINT | .25** | -.66* | - | -.50** | - | | | | | | | | | -.75* |
| PAQ-C | -.10 | .22** | .11 | 17** | -.18** | - | | | | | | | | .52* |
| CY-PSPP | -.27** | 31** | .13* | .41** | -.33** | .39** | - | | | | | | | - |
| CY - SC | -.19** | .30** | .18** | .37** | -.32** | .42** | .83** | - | | | | | 0.72 | .36 |
| CY - PC | -.22** | .36** | .16** | .48** | -.39** | .37** | .80** | .67** | - | | | | 0.73 | .39 |
| CY - BA | -.40** | .25** | -.03 | .30** | -.22** | .23** | .82** | .53** | .55* | - | | | 0.80 | .15 |
| CY - PS | .07 | .18** | .26** | .22** | -.24** | .31** | .71** | .56** | .49** | .42** | - | | 0.75 | .23 |
| CY - PSW | -.31** | .22** | .01 | .34** | -.24** | .35** | .89** | .69** | .62** | .78* | .51** | - | 0.75 | .25 |
| CY - GSW | -.20** | .18** | .04 | .26** | -.20** | .19** | .78** | .57** | .50** | .63** | .43** | .72** | 0.76 | .17 |

**Note.** BMI = Body mass index; SLJ = Standing long jump; DHG = Dominant handgrip; MSFT = Multistage fitness test; SPR = Sprint; PAQ-C = Physical activity questionnaire children; CY-PSPP = Children and youth physical self-perception profile; CY-PSPP- SC = Sport competence subscale; CY-PSPP –PC = Physical condition subscale; CY-PSPP –BA =Body attractiveness subscale; CY-PSPP –PS = Physical strength subscale; CY-PSPP –PSW = Physical self-worth subscale; CY-PSPP –GSW = Global self-worth subscale. Pearson's zero order correlations: * Significant value ($p < 0.05$); ** Significant value ($p < 0.01$) (two-tailed); DFA = Discriminant function analysis loadings; *****Significant loadings (≥ ± 0.40; Stevens, 1992)

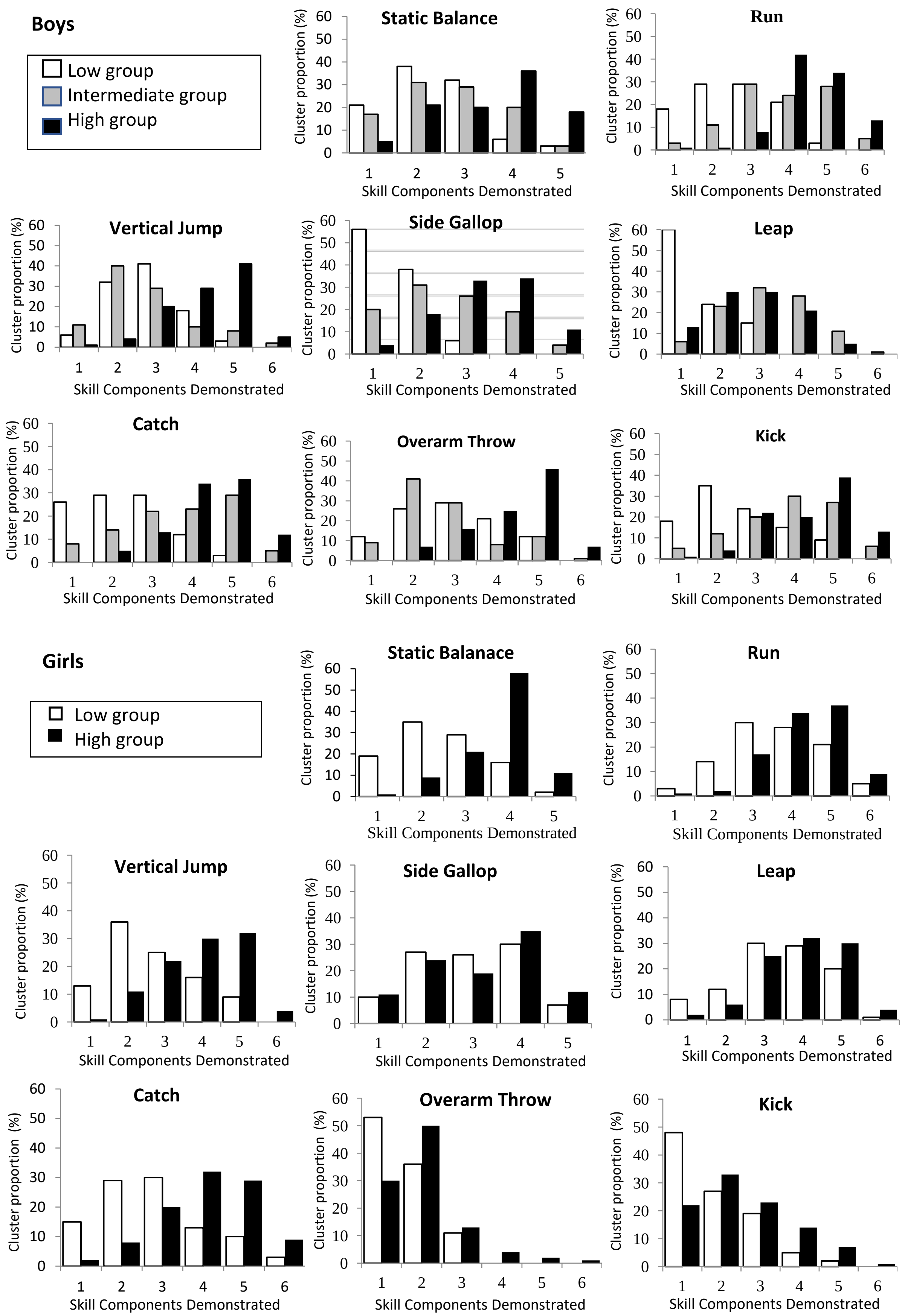
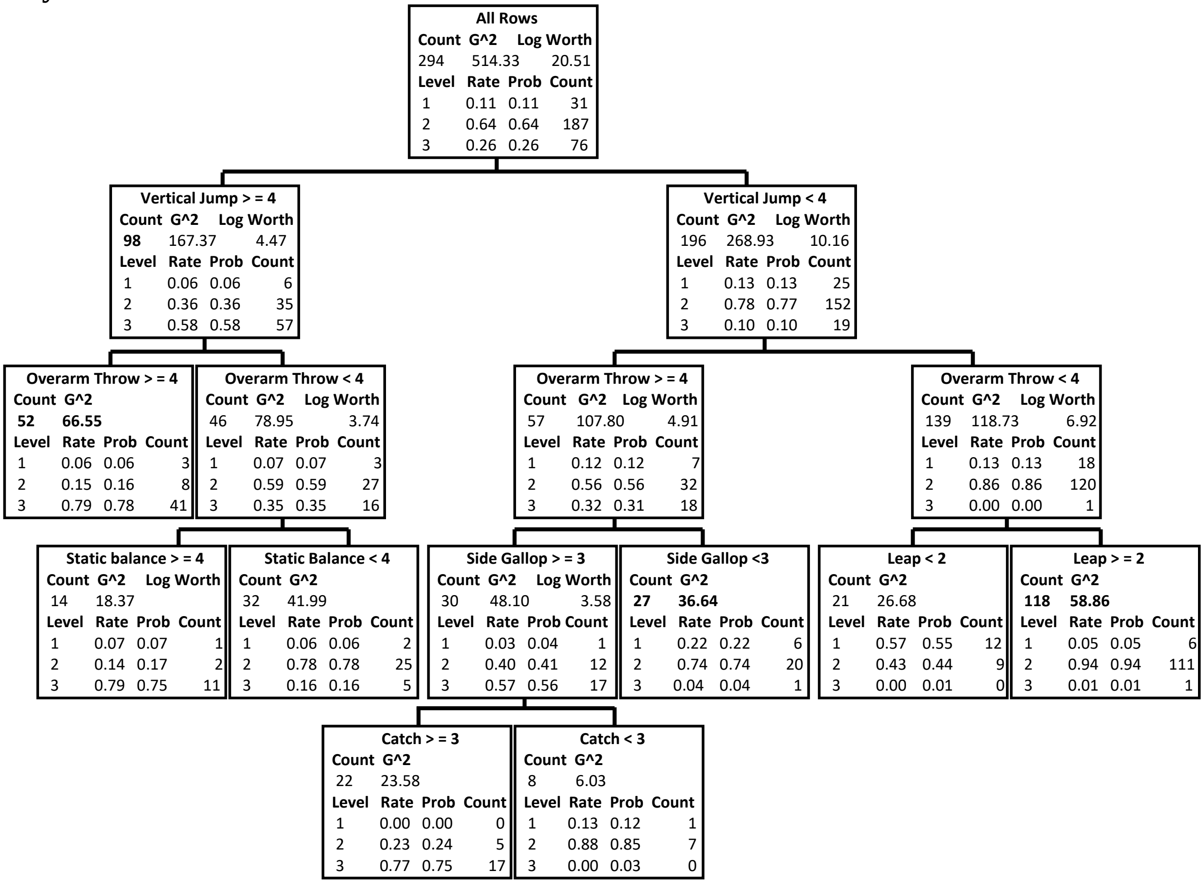



**Figure 1.** Frequency distribution of boys and girls FMS skill components present via group classification on each FMS.

**Boys**




**Girls**

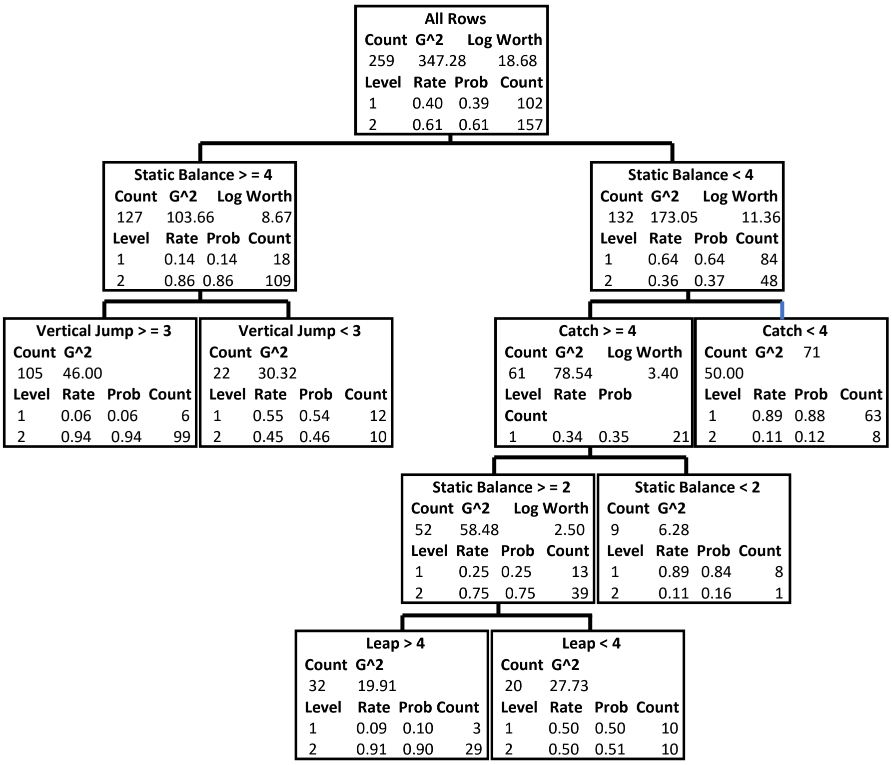



**Figure 2.** Final decision trees including the 7 splits for boys FMS groups (Level 1 = Low group; Level 2 = Intermediate group; Level 3 = High group) and the 5 splits for girls FMS groups (Level 1 = Low group; Level 2 = High group).