The effectiveness of two interventions on fundamental movement skill proficiency among a cohort of Irish primary school children

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ABSTRACT

This study examined the effectiveness of a physical activity (PA) (Year 1) and a multicomponent fundamental movement skill (FMS) (Year 2) intervention on primary school children's FMS proficiency.

Data were collected from 6- and 10-year-old cohorts from two intervention schools and age-matched groups from one control school, in south Ireland. In Year 1 (N=187), intervention (n=96) and control (n=91) groups, were children from senior infant (6-year-old cohort) and fourth class (10-year-old cohort). In Year 2 (N=357), intervention (n=195) and control (n=162) groups were children from senior infant and first class (6-year-old cohort) and fourth and fifth classes (10-year-old cohort). FMS assessment was conducted across both academic years, using the Test of Gross Motor Development-2. Linear mixed models were used to investigate the effectiveness of each intervention, adjusting for age group.

Following Year 1, the intervention group significantly improved locomotor proficiency (p<.05), with no changes in object-control or overall proficiency. No group-time interactions were found. Following Year 2, the intervention group significantly improved locomotor, object-control and overall proficiency (p<.001). Group-time interaction effects were found for both subsets and overall FMS in favour of the intervention group (p<.001). FMS proficiency among primary school children was significantly greater following the multicomponent FMS intervention.

Key words: MOTOR LEARNING, PEDIATRICS, MOTOR DEVELOPMENT, EARLY CHILDHOOD; PHYSICAL ACTIVITY

INTRODUCTION

Children's ability to perform basic observable patterns of movement, known as fundamental movement skills (FMS) (Gallahue, Ozmun, & Goodway, 2012), is lower than desired (Bardid et al., 2016; Bolger et al., 2017; Khodaverdi & Bahram, 2015; Mitchell et al., 2013; Sepessato, Gabbard, Valentini, & Rudisill, 2013). Recent evidence and trends indicate lower FMS proficiency among children, when compared to normative data collected 20 years ago (Bardid et al., 2016; Spessato et al., 2013). FMS (e.g. running, jumping, throwing) are considered the foundation or 'building blocks', upon which more complex sport-specific skills are based. The acquisition of these FMS facilitate and are beneficial for participation in physical activity (PA) and sport among childhood and adolescence (Gallahue et al., 2012; Logan, Robinson, Wilson, & Lucas, 2011). FMS are often categorised into locomotor skills, involving the movement of the body from one location to another (e.g. running, jumping) and object-control skills, involving the manipulation of an object (e.g. catching, kicking) (Lubans, Morgan, Cliff, Barnett, & Okely, 2010).

FMS proficiency are associated with numerous health benefits and are important for the physical, psychological, social, and overall well-being of children (Barnett et al., 2016). Proficiency in FMS has been shown to be positively associated with higher levels of moderate-vigorous physical activity (MVPA) (Holfelder & Schott, 2014), physical fitness (Barnett et al., 2016; Cattuzzo et al., 2016), cognitive functioning and academic performance (Haapala, 2013), and is inversely associated with a healthy weight status (Barnett et al., 2016; Lubans et al., 2010). Longitudinal evidence reveals that FMS proficiency tracks through childhood (Branta, Haubenstricker, & Seefeldt, 1984; Malina, 1990), into adolescence (Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; McKenzie et al., 2002) and is a significant predictor of adolescent MVPA (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009). Worldwide, studies report large declines in MVPA with age, with decreases of as much as 55-64% observed

in children from the age of five to 18 years old (Active Healthy Kids Australia, 2014; Kimm et al., 2002; Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). However, those with higher FMS proficiency have been found to exhibit marginal decline in overall PA and so the development of FMS proficiency may not only be a mechanism to increase PA levels (including MVPA) and target obesity in childhood but may also prevent against age-related decline in overall PA (Barnett et al., 2009; Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2015; Lopes, Rodrigues, Maia, & Malina, 2011).

Although children have the potential to master FMS by the age of seven (Gallahue et al., 2012), FMS are not acquired naturally (Barnett et al., 2016; Clark, 2005). Rather, it is through quality practice of the skill, as well as quality instructional provision during learning that these skills are developed and mastered (Gallahue et al., 2012; Payne & Isaacs, 2002). Therefore, the early years (3-7 years old) are a critical period in the development of FMS (Gallahue et al., 2012). During this developmental period in Ireland, children (4-13 years old) spend approximately 4.5-5.5 hours (class and school dependent) in primary school throughout the academic year (a minimum of 40% of their waking day) (Department of Education and Skills, 2017). The primary school setting offers an ideal opportunity for the development of FMS. In addition, primary schools in Ireland boast the necessary resources, facilities, possible opportunity within the Physical Education curriculum and access to all attending children (including those who are at risk of developmental delays, being inactive and/or overweight/obese) to facilitate FMS development (Lander, Eather, Morgan, Salmon, & Barnett, 2017; Wiart & Darrah, 2001).

In a systematic review of the effectiveness of PA interventions (school-based) on PA and physical fitness in children and adolescents (Kriemler et al., 2011), few studies were included which evaluated the effectiveness of such interventions on what is referred to as 'motor skill' competence (i.e. FMS or motor tasks). Mixed findings were reported, with four

of the six included studies showing significant intervention effects on some of the motor skills/tasks assessed (Kriemler et al., 2011). Currently, there is a dearth of research investigating the effectiveness of PA interventions which do not have a specific FMS focus, on fundamental movement skill proficiency.

School-based motor skill interventions, however, have been reported to positively improve FMS proficiency among primary school aged children (Morgan et al., 2013). One such intervention which has been successfully implemented for over 10 years is Project Energize, a health promotion intervention programme delivered across primary schools in New Zealand (Rush et al., 2016). Since its first implementation in 2005/2006 across 124 primary schools, it has since developed and is currently implemented in all 242 primary schools in the Waikato area as well as 70 schools from other areas, reaching 53,000 children (Rush et al., 2016). Project Energize has been shown to be a sustainable project, effective in increasing FMS, reducing obesity and increasing physical fitness among school children, while remaining cost effective and efficient (Rush et al., 2016). Central to Project Energize is a qualified specialist (i.e. teachers or graduates in the field of exercise and nutrition) known as an 'Energizer'. The qualified specialist implemented the intervention and acted as 'agents of change' in their designated school(s), as opposed to additional members of staff. The roles and responsibilities of the qualified specialist included conducting a needs analysis with school staff and teachers as well as providing and discussing models and plans for physical education and fitness classes. Useful information and resources (including FMS manuals) were also provided to teachers (Mitchell et al., 2013). Following the Project Energize intervention among 5- to 12-year-olds in New Zealand, significant FMS improvements were observed in all 10 FMS assessed using the Test of Gross Motor Development (kick, throw, strike, skip, jump, leap, gallop, bounce, catch, hop, slide, and run). Individual skill improvements ranged from 13.7% (in the run) to 36.3% (in the strike) (Mitchell et al., 2013).

Motor skill interventions most consistently associated with improvements in FMS have been identified as those including a multi-disciplinary approach, of long duration (> 6 months), providing multiple sessions per week, delivered by a physical education specialist and those incorporating parental involvement (e.g. 'at home' practice assisted or supervised by parents, parent evenings) (Tompsett, Sanders, Taylor, & Cobley., 2017). A large effect size for overall (*standardised mean error* = 1.42) and locomotor (*standardised mean* error = 1.42) proficiency have been reported following such interventions, with a medium effect size (*standardised mean error* = .63) reported for object-control proficiency (Morgan et al., 2013). It is suggested that greater instruction and practice are needed for object-control skills than locomotor skills due to the greater perceptual demand and complexity of the object-control skill components, accounting for the disparity in intervention effects (Morgan et al., 2013).

A recent assessment of FMS proficiency among a cohort of Irish primary school children (*n*=203) revealed that FMS levels are less than satisfactory, with children demonstrating significantly poorer FMS proficiency levels compared with US normative data (*n*=1208) (Bolger et al., 2017). Furthermore, a study conducted by O'Brien, Belton and Issartel (2016) highlight that Irish primary school children enter adolescence with low FMS proficiency. Based on the theorised reciprocal relationship between FMS and PA (Stodden et al., 2008), it is not surprising, therefore, that childhood physical inactivity is a major problem and concern in Ireland (Kelly, Gavin, Molcho, & Nic Gabhainn, 2012; Morgan et al., 2008). International comparisons reveal that Irish children have low PA levels as well as high levels of sedentary behaviour (Tremblay, 2014), with only 19% of primary school aged children reaching the recommended 60 minutes of MVPA daily (Woods, Moyna, Quinlan, Tannehill, & Walsh, 2010). Also, despite the recommended time allocation of 60 minutes for Physical Education per week (accounting for a mere 4% of curriculum time), it has been found that Irish primary school children only received 46 minutes of Physical Education time per week

(European Commission/EACEA/Eurydice, 2013), which was found to be lower than all other EU countries. Furthermore, according to a World Health Organization study involving 53 European countries, Ireland has been predicted to be the fattest of these nations by 2030 (Webber et al., 2014).

Given the current levels of FMS and PA among Irish children, the implementation of an effective intervention is warranted. Such an intervention may provide children with the necessary skills to facilitate PA and sport participation across the lifespan. Therefore, the aims of the study were to examine the effectiveness of: (i) a PA intervention (without an FMS focus) and, (ii) a multicomponent FMS-based intervention (each delivered across one academic year) on the locomotor, object-control, overall FMS proficiency, and FMS mastery levels of a cohort of Irish primary school children.

Methods

Participants

Data collection was conducted as part of *Project Spraoi*, a primary school-based PA and nutrition intervention project (Coppinger, Lacey, O'Neill, & Burns, 2016) based on Project Energize, New Zealand (Rush et al., 2016). The 'Project Energize' intervention was tailored for implementation in an Irish setting, accounting for cultural, environmental and curriculum differences (including most popular sports, weather, facilities, open space and time available for Physical Education and PA within the school curriculum) between the countries (Coppinger et al., 2016). Three primary schools including two urban single-sex intervention schools (one boys and one girls) and one rural mixed control school from a region in southern Ireland were invited to participate. To align with Project Energize, two cohorts of similar age (6-year-old and 10-year-old) were selected for testing. Testing age-groups, similar to those assessed by Project Energize were selected (6-year-old and 10-year-old cohorts), as these age groups have been highlighted as important developmental periods during childhood. The 6-year-old cohort

was selected, as this will allow the evaluation of the effectiveness of the interventions among children as they experience the 'mid-childhood rise in BMI (known as 'adiposity rebound'), which has been identified as a critical period for later morbidity and mortality in adulthood. The 10-year-old cohort was selected as this will allow the evaluation of the effectiveness of the interventions among children as they transition into puberty (Graham et al., 2008). Ethical approval was obtained from Cork Institute of Technology Research Ethics Review Committee.

Intervention 1: PA Intervention

From a total of 301 eligible children from senior infants (~6-year-olds) and 4th classes (~10-year-olds), written informed parental consent for involvement in the study was obtained for 203 children (67% consent rate). Data were collected at both baseline (October 2014) and follow-up (June 2015) from 187 children (92% retention rate), including 96 children from the intervention schools (51 boys, 45 girls) and 91 children from the control school (52 boys, 39 girls). Missing data was accounted for by absences and school events (see Table 1).

Intervention 2: Multicomponent FMS Intervention

From a total of 595 eligible children from senior infants (~6-year-olds), 1st (~7-year-olds), 4th (~10-year-olds) and 5th (~11-year-olds) classes, written informed parental consent for involvement in the study was obtained for 448 children (75% consent rate). Data were collected at both baseline (October 2015) and follow-up (June 2016) from 357 children (80% retention rate). This included 195 children from the intervention schools (92 boys, 103 girls), all of whom had received the PA intervention during the previous academic year and 162 children from the control school (92 boys, 70 girls), 75 (46%) of whom were also in the control group for the PA intervention. Missing data accounted for by absences, school events and injuries (see Table 1).

Anthropometric Measures

Anthropometric data were collected prior to FMS assessment. Height was measured to an accuracy of .1cm using a Leicester portable height scales. Body mass was measured to an

accuracy of .1kg, using a Tanita WB100MZ portable electronic scale. Shoes were removed for both measures. Body Mass Index (BMI) was calculated as weight (kg) divided by height (m^2). Children were classified into BMI categories (i.e. normal, overweight/obese) using age and sex-specific cut-off points developed by Cole, Bellizzi, Flegal, and Dietz (2000).

FMS Assessment

FMS proficiency was measured using the Test of Gross Motor Development-Second Edition (TGMD-2) (Ulrich, 2000). This FMS assessment instrument, which has been used globally to assess FMS proficiency among children (Bakhtiar, 2014; Bolger et al., 2017; Burrows, Kolen, & Keats, 2014; Cliff, Okely, Smith, & McKeen, 2009; Hardy, King, Farrell, Macniven, & Howlett,, 2010; Spessato et al., 2013), is a criterion and norm-referenced, process-oriented tool that has been found to be both valid and reliable for use among children aged 3-10 years (Ulrich, 2000). The TGMD-2 consists of two subsets of skills; locomotor and object-control. The six locomotor skills assessed are the run, gallop, slide, leap, hop and horizontal jump. The six object-control skills assessed are the kick, catch, overhand throw, strike, underhand roll, and dribble.

FMS Data Collection

Data were collected at four time points: September 2014 (pre-intervention 1), June 2015 (post-intervention 1), September 2015 (pre-intervention 2), and June 2016 (post-intervention 2). Testing was conducted by a cohort of nine trained evaluators from the *Project Spraoi* Research Team (postgraduate researchers and staff of Cork Institute of Technology and University College Cork). Prior to testing, evaluators completed an FMS-testing training workshop which was delivered by a research practitioner with extensive experience using the TGMD-2. Testing of each class group replicated the protocol used and described by Bolger et al. (2017).

FMS Scoring Protocol

The videos of the test trials were uploaded to a laptop, and analysed retrospectively. Each FMS consists of 3-5 behavioural components. If a component was performed correctly, a score of 1 was awarded. If the behavioural component was performed incorrectly, a score of 0 was awarded. This procedure was carried out for each of the two test trials, and scores from both trials were then summed to obtain a raw skill score (Ulrich, 2000). 'Mastery' of an FMS was achieved, when all components of a skill were present (i.e. skill performed correctly) across both test trials.

Locomotor and object-control subset scores were calculated by summing the raw scores of the individual skills within each subset (Locomotor Score Range: 0-48; Object-Control Score Range: 0-48). Subsequently, locomotor and object-control standard scores were derived, based on age and sex, using the conversion tables outlined in the TGMD-2 (Ulrich, 2000). Locomotor and object-control standard scores were summed, and then converted to a Gross Motor Quotient (GMQ), based on age and sex. GMQ was then used to categorise the locomotor, object-control and overall FMS performance of each child into one of seven categories, ranging from *very poor* to *very superior*. Children with a standard score (locomotor/object-control) between 1-3 were classified as *very poor*, between 4-5 classified as *poor*, 6-7 as *below average*, 8-12 as *average*, 13-14 as *above average*, 15-16 as *superior* and 17-20 as *very superior* in terms of locomotor/object-control proficiency (Ulrich, 2000). Subtest standard scores and classification categories allow comparisons to be made across the subtests (locomotor and object-control), which aid the identification of strengths/weaknesses in the respective subtests. A similar scoring protocol was used to classify the overall FMS proficiency of children using the GMQ (*very poor*: <70; *poor*: 70-79; *below average*: 80-89; *average*: 90-110; *above average*: 111-120; *superior*: 121-130; *very superior*: >130) (Ulrich, 2000). GMQ scores and classification categories, reflect the overall gross motor development (combined

locomotor and object-control proficiency) of an individual. Both standard scores and GMQ may be used to guide the development of appropriate motor development programmes.

Inter- and intra-rater reliability was established between a research practitioner with extensive experience using the TGMD-2, and the two principal researchers conducting the video analysis. Inter- and intra-observer agreements were calculated for 10% of the sample, using the equation (agreements/ (agreements + disagreements)) x 100 (Thomas, Nelson, & Silverman, 2011). The inter- and intra-reliability scores across the 12 FMS ranged from 86-99% agreement, all of which are accepted standards and greater than the recommended 85% threshold required to demonstrate reliability (Thomas et al., 2011).

Interventions

Intervention 1

The PA intervention was designed and developed based on Project Energize, New Zealand (Rush et al., 2016). Following a needs analysis conducted with the principal and teachers in each school, the intervention was adapted and tailored to the specific needs of the school. The intervention was delivered by the qualified specialist across 26 weeks (the academic year 2014-2015, excluding school holidays) in two single-sex primary schools (one girls and one boys). Each week, two 25-minute *huff and puff* lessons (i.e. games/activities facilitating MVPA) were delivered in accordance with the Irish Physical Education curriculum strands of Athletics, Dance, Games, Outdoor Adventure and Gymnastics. Sessions delivered by the qualified specialist replaced the allotted Physical Education class time in the girls' school, while the boys' school also received a 30-minute weekly Physical Education class delivered by the classroom teacher. This difference was due to individual school preferences. The role of the qualified specialist was multi-faceted, including developing and designing *huff and puff* lesson plans and associated resources, modelling PA lessons, as well as providing on-going support to classroom teachers throughout the intervention. Teacher professional development was also

provided through a practical training workshop. This workshop aimed to increase FMS knowledge and covered the following aspects: (i) developmentally age-appropriate cues and demonstration of correct FMS technique, (ii) identification of common errors and correction of techniques relevant to each FMS and (iii) developmentally age-appropriate FMS activities incorporating each of the FMS. Classroom teachers also received FMS and classroom activity manuals, developed by the qualified specialist (manual content described in Table 2). Various PA initiatives and sports days were also organised throughout the academic year to promote PA in the school and home environment (see Table 2). Classroom teachers were encouraged to deliver a minimum of 20 minutes of MVPA on school days during which children did not receive a specialist-led session (i.e. three school days per week). Activities incorporating MVPA which could be used to facilitate additional PA, were modelled during sessions delivered by the qualified specialist, demonstrated during the practical training workshop and also included in the various resource manuals distributed to each classroom teacher. The control school did not receive any intervention material or support (i.e. classroom teachers delivered the Irish Physical Education curriculum only, which was delivered during a weekly 1-hour Physical Education class).

Intervention 2

The multicomponent FMS intervention, was developed using elements from Project Energize (Mitchell et al., 2013; Rush et al., 2016), the Y-PATH school-based FMS and PA intervention for Irish adolescents (Belton, O'Brien, Meegan, Woods, & Issartel, 2014) and previous motor skill interventions (Logan et al., 2011; Morgan et al., 2013). It was delivered by the qualified specialist (who had delivered the Year 1 intervention) across the academic year 2015-2016 (excluding school holidays) in the two single-sex schools. The FMS intervention consisted of numerous FMS-specific components, of which are described in Table 2. Across the 26-week intervention, each individual FMS was the focus for a two-week block, the order of which was

determined by each school, to reflect the skills applicable within the Physical Education strand being delivered at the time. For example, the run was one of the skills focussed on during the period in which the Athletics strand was usually delivered. A two-week recap period (consisting of four lessons) was also provided prior to the culmination of the intervention. Each of these recap lessons incorporated the revision of four FMS and engagement in age-appropriate activities involving the practice of these skills.

Data Analysis

Statistical analysis for Intervention 1 and Intervention 2 were carried out using SPSS version 22.0. Only participants with complete data sets at baseline and post-intervention testing were included in the analyses. Descriptive statistics were calculated by treatment group (i.e. intervention/control) and age group (6-year-olds/10-year-olds) to describe baseline and post-intervention age, height, mass, BMI, locomotor and object-control subset scores and total FMS scores.

At baseline of Intervention 1 and Intervention 2, equivalence testing was used to assess group similarities (intervention/control) in locomotor standard score, object-control standard score, and GMQ score. The equivalence margin was selected based on the difference in standard scores and GMQ between treatment groups at baseline reported by previous research (Johnstone, Hughes, Janssen, & Reilly, 2017), as suggested by Walker and Nowacki, 2011. Intervention effects on subset standard scores and GMQ were investigated using linear mixed models, with treatment group (intervention or control), time (pre- or post-intervention) and group-time interaction forming the base of the model and age/class groups (senior infants/1st class or 4th/5th class) as a random effect. Intraclass correlation was calculated to compare the variation between age/class groups as a fraction of the total variance.

For Intervention 2, Cochrane Q tests were used to investigate if there was a statistically significant difference in the proportion of children in each TGMD-2 category from pre- to post-

intervention for each treatment group, for locomotor standard score, object-control standard score and GMQ. Cochrane's Q tests were also used to investigate if there was a statistically significant difference in the proportion of children achieving mastery in the 12 individual FMS from pre to post-intervention, within each treatment group. The alpha level required for significance for all tests was set at $p < .05$.

Results

Intervention 1

Table 3 presents the mean locomotor standard score, object-control standard score, and GMQ, accounting for age and sex, at pre- and post-intervention 1, with respect to treatment group. At baseline, equivalence was found between the intervention and control group for locomotor standard score ($p < .001$), object-control standard score ($p < .001$), or GMQ ($p < .01$).

Results from the linear mixed models are displayed in Table 3. It was found that the intervention group significantly improved locomotor standard score ($p = .041$). However, there were no significant changes in object-control standard score or GMQ among the intervention group. Similarly, among the control group, there were no significant changes in locomotor standard score, object-control standard score, or GMQ. No group-time interactions (i.e. significant differences between groups over time) were found for locomotor standard score, object-control standard score, or GMQ, $p > .05$ for all.

Intervention 2

Mean locomotor standard score, object-control standard score, and GMQ, accounting for age and sex, for both intervention and control group at pre- and post-intervention 2 are presented in Table 3.

Results revealed that there were no significant difference in pre-intervention 2 scores between intervention and control group for locomotor standard score ($t = .649$, $p = .517$), object-control standard score ($t = -1.114$, $p = .826$), and GMQ ($t = -.298$, $p = .382$). Results

from the linear mixed models (Table 3), found that the intervention group significantly improved locomotor standard score, object-control standard score, and GMQ from pre- to post-intervention. In contrast, the control group significantly dis-improved in locomotor standard score, object-control standard score, and GMQ from pre- to post-testing. A group-time interaction effect was found in favour of the intervention group for locomotor standard score, object-control standard score, and GMQ.

Prevalence of Mastery Levels

The proportion of children achieving mastery (percentage mastery) at pre- and post-intervention 2 in each of the 12 FMS, by group and age, are presented in Table 4. The percentage mastery in the 6-year-old intervention group, significantly increased in eight skills (run, hop, slide, jump, throw, roll, kick, and dribble), and decreased in the gallop ($p < .05$). Increases in percentage mastery among this group, in the leap, catch, and strike were not significant. Among the control group there was a significant increase in the percentage mastery in the slide while there were significant decreases in the gallop and the throw ($p < .05$). There were no significant differences in the percentage mastery in the other nine skills for the control group.

In the 10-year-old intervention group, there were significant increases in the percentage of children who achieved mastery in seven skills (hop, slide, jump, throw, roll, kick, and dribble), while there was a significant decrease in the catch ($p < .05$). Increases in percentage mastery in the run, leap, and strike were not significant for children in the intervention group. Among 10-year-old children in the control group, there were significant increases in the percentage mastery in three skills (leap, kick, and dribble) and significant decreases in three skills (gallop, catch, and roll). There were no significant differences in the percentage mastery in the other six skills.

TGMD-2 Categories

LOCOMOTOR Standard Score

The proportion of children from the intervention and control groups in each of the seven TGMD-2 (ranging from *very poor* to *very superior*) categories for locomotor standard score, at pre and at post-intervention 2, are shown in Table 5. While 50% of children in the intervention group remained in the same category following the intervention, 34% of children improved by one category, 8% by 2 categories, and 2% by 3 categories. In contrast, 69% of the control group remained in the same category, 7% improved one category, while the remaining 25% dis-improved into a category at least one level below. At baseline and follow up, no child in either the intervention or control group, was categorised as *very poor*. In the intervention group, the proportion of children in the *poor*, *below average*, and *average* categories significantly decreased following the intervention ($p < .05$), while the proportion in the *above average* category increased significantly ($p < .001$). While the number of children in the *superior* and *very superior* categories increased from baseline to post-intervention these increases did not reach statistical significance. In contrast, in the control group, the proportion of children in the *below average* group significantly increased ($p < .001$), while the proportion of children in the *average* group significantly decreased ($p < .01$). Decreases in the percentage of children considered *above average* and *superior* as well as an increase in those in the *poor* category were also evident, although none of these differences were significant.

OBJECT CONTROL Standard Score

The proportion of children from the intervention and control groups in each of the seven TGMD-2 categories for object-control standard score, at pre- and post-intervention 2, are shown in Table 5. At post-intervention 2, while 49% of children in the intervention group remained in the same category, 31% of children improved by one category, 8% by 2 categories, and 3% by three categories. Although a similar proportion of children in the control group remained in the same category (46%) as the intervention group, 46% of children dis-improved

into a category at least one level lower than pre-intervention 2, while only 8% improved into a higher category. At both pre- and post-intervention 2, there were no children from either intervention or control group, in the *superior* or *very superior* category. In the intervention group, there was a significant decrease in the proportion of children in the *poor* category ($p < .001$) following the intervention. This decrease resulted in increases in the proportion of children classified as *average* (from 58% to 69%), *above average* (from 2% to 11%), and *superior* (from 0% to 2%), although these increases were not significant. In the control group, the proportion of children in the *poor* group significantly increased ($p < .05$), with significant decreases evident in the proportion of children in the *average* category ($p < .001$).

Gross Motor Quotient (GMQ)

Data relating to the TGMD-2 categories for GMQ at baseline and follow up are presented in Table 5. Following the intervention, while 47% of children in the intervention group remained in the same category as pre-intervention 2, 30% of children improved into a GMQ category one level higher than pre-intervention 2, while 14% improved by two categories, and a further 3% improved by three categories. In contrast, despite 46% of the control group remaining in the same category as pre-intervention 2, 47% dis-improved into a category at least one level lower, with only 7% improving into a higher category. In the intervention group, following the intervention, there were no longer any children classified in the *very poor* category. The proportion of children in the *poor* and *below average* categories also decreased by over 5% and 20% in the respective categories following the intervention. The proportion of children in the *above average* category significantly increased from 0% to over 15% in the *above average* category ($p < .001$). Following the intervention, there were also children categorised in the *superior* and *very superior* categories, in contrast to baseline. Among the control group, the proportion of children in the *poor* and *above average* categories significantly increased while the proportion in the *average* group significantly decreased ($p < .001$).

Discussion

In Ireland, FMS proficiency and PA levels have been reported to be low among primary school aged children. As FMS have been found to be associated with PA levels and numerous health benefits, it is imperative that approaches to improve FMS are adopted among this cohort. This is the first study to examine the effect of specifically tailored interventions at improving FMS proficiency among Irish primary school children.

Intervention 1

Findings from this study suggest that although locomotor proficiency improved and object-control proficiency was maintained among the intervention group, the PA intervention was not significantly more effective than the Irish Physical Education curriculum carried out in the control school (in which no improvements in FMS proficiency were observed). Even though FMS instruction and feedback was not provided, improvement in locomotor proficiency among the intervention group may have resulted from the increased PA opportunities provided through lessons delivered by the qualified specialist, daily PA and weekly Physical Education provided by teachers. During this PA time, children engaged primarily in *huff and puff* activities and games which placed greater emphasis on locomotor skills such as running, jumping, galloping, and hopping as opposed to object-control skills. No significant change in object-control (and overall proficiency) indicates that increased PA opportunities alone may not be sufficient to improve object-control proficiency. Previous research has evaluated the effectiveness of PA interventions on motor skills, with a variety of definitions, skills and measures used across studies (Morgan et al., 2013). Therefore, this is the first study to investigate the effectiveness of a PA intervention (i.e. without an FMS focus) on FMS proficiency, and thus further research is warranted. In light of our findings and based on previous suggestions that FMS are not acquired naturally (Barnett et al., 2016; Gallahue et al., 2012; Payne & Isaacs, 2002),

interventions aimed at improving FMS should include quality instruction, feedback, encouragement and practice opportunities.

Intervention 2

The multicomponent FMS intervention (Year 2) resulted in significant group-time interactions for locomotor, object-control, and overall FMS proficiency, in favour of the intervention group. Significant increases were found in locomotor standard score, object-control standard score, and GMQ score among the 6-year-old and 10-year-old intervention groups, while significant decreases were observed among the respective control groups. Results from this multicomponent school-based intervention provides further evidence for the effectiveness of FMS interventions among primary school children. Our findings are consistent with recent meta-analyses (Morgan et al., 2013), which has found significantly greater locomotor, object-control, and overall FMS proficiency levels among children following school-based FMS interventions.

Analysis of the proportion of the children achieving mastery in each of the 12 FMS provided an in-depth insight into the effectiveness of this intervention. Among the 6-year-old intervention children, following the intervention, there were increases in the proportion of children achieving mastery in 11 of the 12 FMS (with mean improvement ranging from 1.1% improvement in the leap to 34.8% in the slide). The increase in eight of the FMS were significant (run, hop, gallop, slide, jump, throw, roll, kick, and dribble) ($p < .05$) (see Table 4).

The mean increase in the proportion of children achieving mastery across all FMS among the 6-year-old intervention cohort was 13%, in contrast to a 7% decrease among the control group. The skills which resulted in the greatest percentage improvement in mastery levels were the slide (35%), jump (34%) as well as both the kick and the hop (22%). Surprisingly, there was a significant decrease in the proportion of children achieving mastery in the gallop. It is possible that this may be due to the young children's over enthusiasm in

performing the skill at post-intervention testing, as the gallop was no longer a skill unfamiliar to them. This may have manifested in increases in the speed at which children attempted the gallop. In addition, as testing was conducted in small groups, children's patience while waiting their turn as well as the performance of their peers which preceded their own attempts may also have influenced performances. Component analysis supported this observation, with a significant decrease in the proportion of this group proficient in the component ($p < .001$, *Cochrane's Q* = 12.600), requiring '*a step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot*' (Ulrich, 2000).

Among the 10-year-old intervention group following the intervention, there were increases in the percentage achieving mastery in 11 of the 12 FMS (with mean improvement ranging from 3.8% in the run to 47.6% in the jump). The increase in the percentage achieving mastery in seven of the FMS was found to be significant (hop, slide, jump, catch, throw, roll, kick, and dribble) ($p < .05$) (see Table 4). At pre-intervention 2, the least proficient skills were the jump (3%) and roll (9%), with only 7 skills exceeding 50% mastery. However, at post-intervention 2, 10 skills exceeded 50% mastery, with the strike (25%) and the throw (46%) identified as the least proficient skills. The proportion of children achieving mastery across all FMS among the 10-year-old intervention group was 18% compared to a 5% decrease among the control group. The greatest percentage improvements in mastery levels were observed in the jump (48%), roll (47%), and dribble (39%). Surprisingly, an unexpected significant decrease in the proportion of 10-year-old children achieving mastery in the catch was found. Component analysis conducted revealed that among this group, there was a significant decrease in the proportion of children who demonstrated proficiency in the component requiring a *'preparation phase where hands are in front of the body and elbows are flexed'* (Ulrich, 2000), from 99% to 78% ($p < .001$, *Cochrane's Q* = 20.167). This may demonstrate the older

children's over-confidence in their ability to catch the ball, reflected in the fact that 96% of this group did indeed catch the ball for both trials (another required component for mastery).

The positive improvements observed in the intervention groups relative to the control groups adds to the body of evidence suggesting the FMS are not acquired naturally (Barnett et al., 2016). Rather, learning, practice and reinforcement are required in order to become proficient, without which, developmental delays or deficits may occur (Gallahue et al., 2012). Furthermore, according to the motor learning theory (Shumway-Cook & Woollacott, 2007), FMS proficiency acquired through skill learning is proposed to be retained due to a relatively permanent change in one's ability to execute the skill, facilitating participation in PA and sport throughout life (McMorris, 2004; Shumway-Cook & Woollacott, 2007). Evidence supporting the retention in FMS proficiency has been found by Salmon et al. (2008) with improvements in FMS relative to the control, still evident one year after the intervention.

The significant intervention effects on FMS proficiency observed in this study may be attributed to the quality and interaction of the various FMS-based components of this intervention, including FMS-based lesson plans and posters, FMS professional development practical workshop, FMS homework as well as FMS activity breaks. Also, the quality of teaching and feedback received during sessions delivered by the qualified specialist and any additional teacher-led PA sessions (including PA and FMS initiatives) incorporating FMS-based activities and fun games, facilitated and promoted FMS development. It is through quality instruction and feedback from qualified individuals and through practice opportunities that children develop and improve movement skill patterns (Cohen et al., 2015; Gallahue et al., 2012).

Improvements in locomotor proficiency were evident based on the distribution across the TGMD-2 classifications (Ulrich, 2000) for locomotor standard score with a significantly lower proportion of children in the intervention group in the *poor*, *below average*, and *average*

categories following the intervention, in turn resulting in significantly greater proportions of children in the *above average* (almost 30% greater), and *superior* categories. Furthermore, at pre-intervention 2, there was no child in the *very superior* category. However, following the intervention there were children demonstrating this level of locomotor proficiency.

In terms of the improvements in object-control proficiency, the distribution of object-control standard score revealed that there was no longer any child in the intervention group in the *very poor* category and the proportion of children in the *poor* category was significantly lower ($p < .05$). This resulted in a higher proportion of children in the *average* and *above average* categories. Also, in contrast to pre-intervention, there were children categorised in the *superior* category following the intervention. In contrast to the locomotor standard score, there was less than 15% of the children in the *above average*, *superior,* or *very superior* categories post-intervention 2, demonstrating the greater practice, instruction and perceptual demands required to develop object-control skills. Nonetheless, these positive significant findings highlight the effectiveness of the multicomponent FMS intervention at improving both locomotor and object-control proficiency of children, regardless of baseline ability.

Following the intervention, 47% of children in the intervention group were classified in a higher GMQ performance category than before the intervention, in contrast to 7% of the control group. The overall improvement in FMS proficiency, following the multicomponent FMS intervention, is also reflected in a shift in the distribution of the Irish cohort across the TGMD-2 categories, to the right of the continuum.

At post-intervention 2, there was no longer any child in the intervention group in the *very poor* category and the proportion of children in the *poor* and *below average* categories decreased by over 5% and 20%. Consequently, there was a significant increase in the proportion of children in the *above average* category ($p < .05$). Also, prior the intervention, there was no child in the *above average*, *superior,* or *very superior* categories. However,

following the intervention, these categories accounted for over 25% of the intervention group. These findings highlight, although children may not yet have attained 'mastery' (i.e. all components present across both trials), improvements have been made in FMS proficiency across the intervention. This indicates that, despite significant improvement in GMQ, the cohort of Irish children require further instruction, practice and feedback to allow for continued development and improvement and to attain superior FMS levels. Based on the positive findings of this study, the implementation of the multicomponent FMS intervention delivered by a qualified specialist for a longer duration may be one such mechanism to aid this further development.

Limitations

- A limitation of this study includes the use of unmatched intervention and control schools, in terms of both geographical location and the sex of attending children. However, it should be noted that all three schools (two urban single-sex intervention schools and one rural mixed-sex school) were in close proximity (approximately 10km) to each other. In relation to the existing sex-differences of participants across included schools, there may be developmental differences between children who attend all boys and all girls' schools and a mixed-sex school, in terms of PA choices and participation levels. It is recommended for future research that matched schools are selected based on geographical location and sex of participants, allowing for a more accurate comparison of groups.
- FMS testing, was conducted in small groups within each class group (up to 30 children) at the same time, through the use of a rotational station system. While this protocol was effective and time-efficient, it is possible that children may have been distracted during the demonstration of a skill, due to the presence of other children in their group or due to the movement of other children and testers throughout the hall. Also, as

children were required to wait for their own turn to attempt the skill, children may have forgotten the visual demonstration and may also have been influenced by the attempts to perform the skill made by their peers which preceded their own attempts. Children's concentration and attention levels and their ability to be patient while waiting their turn may also have influenced performances. Therefore, it is recommended for future research that FMS testing should be carried out individually with minimal external distraction to allow a most accurate measure of FMS proficiency.

- Sessions delivered by the qualified specialist replaced the allotted weekly Physical Education time in the girls' school, while the boys' school also received a 30-minute weekly Physical Education class delivered by the classroom teacher. This difference was due to individual school preferences and was not controllable by the *Project Spraoi* Research Team. However, as each teacher was permitted and encouraged to facilitate 20 minutes MVPA daily, this may not have influenced findings but nonetheless must be considered. For future research, it is recommended that all intervention groups received similar allocated PA time to maximise the quality of study design, findings and conclusions.
- PA facilitated by classroom teachers was not monitored during the PA intervention. However, PA and FMS opportunities were monitored through the use of the FMS/PA break charts during the FMS intervention. Findings revealed that on average, classroom teachers facilitated 14.3 minutes of PA per school day (excluding two x 25 minute lessons delivered by the qualified specialist weekly). It must be noted that while teacher and students were instructed to complete the FMS and PA charts to the best of their ability, the accuracy of reporting, due to the self-measure nature of the charts, is not known.

- Although FMS practice was monitored through the FMS homework manuals, it was not possible to ascertain how many practice attempts were made by each child at performing each skill throughout the intervention period (i.e. during sessions delivered by the qualified specialist, additional PA opportunities during school time and outside of school time including weekend activity as well as during organised sport/PA). Also, as FMS homework was recorded by self-report by children (and parents) and children often misplaced homework manuals, the accuracy and reliability of data relating to FMS practice conducted is unknown and has not been included.
- The order in which skills were practiced across the intervention during the sessions delivered by the qualified specialist, which was determined by each school, may be a further limitation influencing skill improvement from several perspectives. Firstly, additional opportunities to attempt the skills and technique(s) learned may be possible for children for those skills taught at the early stages of the intervention. On the other hand, the skills (and the correct technique) taught later in the intervention may be more easily remembered. However, the recap lessons at the end of the intervention reinforced the correct technique required for each of the FMS and provided further practice opportunities for each of the skills.
- Much research has previously used GMQ as a measure of FMS proficiency (Bardid et al., 2016; Burrows et al., 2014; Johnstone et al., 2017). As GMQ is based on normative data collected from a sample of 1,208 US children (Ulrich, 2000), the use of GMQ allows comparison to be made between the Irish and US samples. While classifying FMS performance based on GMQ may detect changes in FMS performance over time, it may not be a true representation of actual FMS proficiency among the Irish cohort as GMQ is based on a US sample. Future research to develop a GMQ scale for Irish children based on normative data collected among children in Ireland is recommended.

Conclusion

The PA intervention (without an FMS focus) improved locomotor proficiency and maintained object-control proficiency among a cohort of 6- and 10-year-old Irish primary school children, assessed using the TGMD-2. However, changes in FMS proficiency following the PA intervention were no greater than those made by the control group following the Irish Physical Education Curriculum only. The multicomponent FMS intervention delivered by qualified specialists across an academic year resulted in significant intervention effects for locomotor, object-control and overall FMS proficiency among 6- and 10-year-old Irish primary school children, when compared to the control treatment group. Aligned with recommendations by Tompsett et al. (2017), the 26-week intervention involving bi-weekly FMS and PA sessions delivered by a qualified specialist (Energizer), on-going teacher professional development, as well as an at-home practice component encouraging parental participation, was successful at improving FMS proficiency among Irish youth. The implementation of the FMS intervention, of longer duration and delivered by physical education specialists throughout the primary school years, may also promote further FMS development among children.

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Table 1: Descriptive statistics and mean pre- and post-intervention subset scores (SD), for both interventions

Variable	Year 1				Year 2			
	Intervention (*n*=96)		Control (*n*=91)		Intervention (*n*=195)		Control (*n*=162)	
	6-year-olds (*n*=45)	10-year-olds (*n*=51)	6-year-olds (*n*=50)	10-year-olds (*n*=41)	6-year-olds (*n*=92)	10-year-olds (*n*=103)	6-year-olds (*n*=77)	10-year-olds (*n*=85)
Age (years)	5.9 (.4)	9.9 (.4)	6.1 (.3)	10.0 (.4)	6.3 (.6)	10.4 (.6)	6.6 (.6)	10.5 (.5)
Height (cm)	114.8 (6.0)	140.4 (6.6)	116.4 (4.4)	140.5 (5.3)	117.9 (6.8)	142.7 (7.2)	119.6 (5.9)	143.2 (5.5)
Mass (kg)	21.4 (3.2)	36.0 (7.7)	21.3 (2.7)	34.7 (5.8)	23.2 (4.2)	37.6 (8.8)	23.1 (3.2)	37.1 (6.3)
Body Mass Index (BMI)	16.2 (1.8)	18.2 (2.9)	15.7 (1.3)	17.5 (2.3)	16.6 (2.1)	18.3 (3.1)	16.1 (1.4)	18.0 (2.3)
Pre Locomotor Score (range: 0-48)	38 (4)	42 (4)	40 (3)	41.7 (3)	39 (4)	42 (4)	40 (3)	42 (3)
Post Locomotor Score (range: 0-48)	41 (3)	43 (3)	42 (3)	42.5 (3)	43 (3)	46 (3)	39 (4)	41 (3)
Pre Object-control Score (range: 0-48)	28 (6)	39 (4)	30 (5)	39.8 (3)	31 (5)	38 (4)	34 (5)	40 (4)
Post Object-control Score (range: 0-48)	30 (6)	39 (4)	32 (5)	39.9 (3)	36 (4)	43 (3)	31 (5)	38 (4)
Pre TOTAL FMS Score (range: 0-96)	66 (8)	81 (6)	70 (5)	81.5 (4)	71 (7)	80 (6)	73 (7)	82 (5)
Post TOTAL FMS Score (range: 0-96)	71 (7)	82 (5)	74 (6)	82.4 (4)	79 (6)	88 (4)	70 (7)	80 (5)

FMS: fundamental movement skills

Table 2: Detailed description of the multicomponent fundamental movement skills (FMS) intervention

Component	Description
1. FMS-based Lesson plans	FMS-based lesson plans were developed and delivered in line with the Irish PE curriculum. These included (i) a warm up (incorporating a FMS previously learned), (ii) skill development and (iii) a moderate-vigorous intensity game, incorporating the skill. Variations and progressions were included.
2. Energizer-led Lessons	The Energizer delivered two x 25-minute weekly sessions which demonstrated FMS and PA activities which classroom teachers were encouraged to repeat during the week to help improve FMS and accumulate a target of 20 minutes of MVPA daily. This could be achieved in one activity session or with numerous activity breaks throughout the school day. Cross-curricular and classroom activities were also modelled and resources provided to the teacher. School FMS and PA initiatives and competitions were organised throughout the year.
3. FMS Posters	A series FMS posters were designed for each skill and hung on the walls in each classroom during the two-week period in which the said skill was the main focus during lessons. Posters depicted the correct technique as well as relevant teaching cues (as used in the lessons) for the given skill.
4. FMS Homework Manual	FMS homework manuals contained images depicting the correct technique and cues for each FMS and age-appropriate activities catering for varying skill levels. Many activities could be performed with a partner(s), encouraging parent involvement. FMS homework, distributed by the classroom teacher, reflected the FMS in focus during that period. Children/parents recorded the activities completed and the level of difficulty experienced in performing the skill/activities, in the manual to achieve 'homework points'. Prizes (e.g. ball, tennis racket) were distributed to the children based on homework points earned at term-end.
5. Professional Development	Teachers participated in an FMS practical workshop delivered by the Energizer. This workshop aimed to increase FMS knowledge and covered the following aspects: (i) developmentally age-appropriate cues and demonstration of correct FMS technique, (ii) identification and correction of common errors relevant to each FMS and (iii) developmentally age-appropriate FMS activities incorporating each of the FMS. Teachers received an FMS manual which included (i) a detailed description of how to perform each skill correctly, (ii) images depicting correct technique and cue words relevant to each FMS, (iii) common errors observed for each FMS, (iv) useful tips for teaching each skill and (v) skill-specific activities and variations, to allow differentiation for a broad age and skill range. In addition, teachers were provided with a classroom activity resource, which contained cross-curricular FMS activities and high-intensity dance routines (incorporating FMS), suitable for restricted space. Outdoor activity resources were also provided.
6. FMS Activity Breaks	FMS and PA Classroom Break Charts were introduced to aid teachers in the attempt to facilitate 20 minutes FMS practice (and PA) during the school days on which the Energizer was not present. These charts were designed to encourage short activity breaks (six per day) involving two activities; one *huff and puff* activity (such as high knees) and also the practice of an FMS (e.g. 10 ball catches with a partner), which varied daily. Each time the activities were completed, a tick was recorded on the chart, representing a score of 1 point. Any additional FMS practice or PA time was also recorded, with each minute corresponding to 1 point. Each week, total FMS practice and PA accumulated was calculated for each class and recorded on the school leaderboard in the sportshall. At term-end, small prizes (e.g. certificates (Appendix D.6), homework passes (Appendix D.7)) were distributed to the class and teacher with the highest points.
7. Other PA Initiatives	**Stride for 5:** The aim was for each class group to run continuously for five minutes. Children attempted to run continuously for one minute with the Energizer present. If successful, without any student stopping or walking, the class progressed and could attempt two minutes the following week. If any student stopped or walked during an attempt, the class could not progress to the next level. The progress of each

	class was recorded on the 'Stride for 5' ladder in the sportshall. When a class achieved five minutes running, their class name was placed above the ladder highlighting their achievement.
	Kilometre Challenge: The aim was to complete the 1km (e.g. 5 x 200m loop marked on yard) as fast as possible. Children received their run time after each attempt on an individual score card. Each time they attempted the 1km challenge, children attempted to improve their own individual time. Prizes (e.g. rulers, pens) were awarded to children for effort and improvements made and to teachers for attempts made to facilitate the practice of the 1km run. At the end of the challenge (five weeks), each child received a final score card showing their initial and final run times.
	Paper Rush: Children ran around a marked loop (approx. 40m) in the school yard/hall for a set time e.g. 1min/2min/3min. At opposite sides of the loop were two boxes; one empty and one filled with paper balls. Children raced around the route, attempting to move as many paper balls as possible from the full box to the empty box. Only one ball could be moved per student each loop/lap. At the end of the time, the balls were counted and the score recorded on the Paper Rush scoreboard in the PE hall.
	PE Student of the Week: At week-end, the classroom teacher awarded a 'PE Student of the Week', chosen based on effort made to improve their FMS, enthusiasm and willingness to learn during PE and PA sessions. The PE Student of the Week received a certificate which was placed on a large PE Student of the Week poster hung outside each classroom door and brought home the following week.
	Active Agent: The 'Active Agent' was the title given to the PE Student of the Week from the previous week. They had numerous roles including marking the PA Break Charts, moving the class marker on the Stride for 5 poster, reminding and encouraging the teacher to take classroom and outdoor PA breaks, reminding the teacher about FMS homework and also had responsibilities during lessons including assisting with and/or giving demonstrations and collecting and returning equipment.

FMS: fundamental movement skills, PA: physical activity, PE: Physical Education

Table 3: Changes in mean (SD) Locomotor Standard Score, Object-control Standard Score, and Gross Motor Quotient (GMQ)

Score	Baseline	Post-test	*p*-value[a]	Baseline	Post-test	*p*-value[a]	Adjusted Difference in Change (95% CI)[b]	p-value[c]	ICC[d]
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)				
Intervention 1	**Intervention (*n*=96)**			**Control (*n*=91)**					
Locomotor Standard Score	9.9 (2.5)	10.4 (2.0)	.041	10.2 (2.4)	10.5 (2.3)	.291	-.23 (-.5 to .4)	.498	.34
Object-control Standard Score	8.0 (2.0)	7.9 (2.2)	.362	8.4 (1.7)	8.3 (1.9)	.716	-.30 (-.8 to .2)	.708	.09
GMQ	93.9 (10.7)	94.8 (9.7)	.364	95.8 (9.6)	96.3 (9.9)	.594	-1.0 (-3.2 to 1.2)	.801	.33
Intervention 2	**Intervention (*n*=195)**			**Control (*n*=162)**					
Locomotor Standard Score	9.9 (2.2)	11.7 (2.1)	<.001	9.8 (2.0)	8.8 (1.9)	<.001	1.5 (1.2 to 1.9)	<.001	.08
Object-control Standard Score	8.2 (2.2)	9.8 (2.3)	<.001	8.4 (2.2)	6.9 (1.9)	<.001	1.3 (.9 to 1.7)	<.001	.05
GMQ	94.4 (11.0)	104.5 (10.5)	<.001	94.5 (10.7)	87.1 (9.3)	<.001	8.5 (6.8 to 10.3)	<.001	.08

GMQ: Gross Motor Quotient

a: Within-group change over time.

b: Adjusted mean difference and 95% CI between each respective intervention and control group (intervention minus control); results from linear mixed model with random effect for age group.

c: Group–time interaction from mixed model that included baseline and post-test data and covariates.

d: ICC for age group.

Table 4: Intervention 2: Percentage of children achieving mastery pre- and post-intervention in the 12 fundamental movement skills (FMS) of the Test of Gross Motor Development-2 (TGMD-2)

6-year-olds									10-year-olds								
Skill	**Intervention**				**Control**				**Skill**	**Intervention**				**Control**			
	Pre (%)	**Post (%)**	***Q***	***p*-value**	**Pre (%)**	**Post (%)**	***Q***	***p*-value**		**Pre (%)**	**Post (%)**	***Q***	***p*-value**	**Pre (%)**	**Post (%)**	***Q***	***p*-value**
Run	75.0	87.0	4.17	.041	79.2	76.6	.15	.695	**Run**	84.5	88.3	.80	.371	91.8	85.9	1.47	.225
Leap	69.6	70.7	.03	.869	71.4	61.0	2.29	.131	**Leap**	69.9	79.6	2.94	.086	57.6	76.5	7.53	.006
Hop	16.3	38.0	13.33	<.001	22.1	18.2	1.00	.317	**Hop**	51.5	66.0	5.77	.016	55.3	50.6	.62	.433
Gallop	73.9	45.7	16.90	<.001	77.9	22.1	39.34	<.001	**Gallop**	80.6	85.4	.86	.353	84.7	55.3	20.16	<.001
Slide	48.9	83.7	24.38	<.001	19.5	44.2	10.94	.001	**Slide**	60.2	89.3	20.46	<.001	51.8	43.5	1.69	.194
Jump	1.1	34.8	31.00	<.001	.0	2.6	2.00	.157	**Jump**	2.9	50.5	49.00	<.001	3.5	.4	.33	.564
Catch	20.7	23.9	.29	.590	23.4	13.0	3.56	.059	**Catch**	72.8	59.2	4.67	.031	84.7	40.0	32.82	<.001
Throw	8.7	25.0	9.00	.003	26.0	9.1	7.35	.007	**Throw**	25.2	45.6	10.76	.001	21.2	28.2	1.29	.257
Roll	2.2	14.1	9.31	.002	5.2	1.3	1.80	.180	**Roll**	8.7	55.3	44.31	<.001	22.4	8.2	7.20	.007
Strike	14.1	23.9	3.00	.083	18.2	10.4	2.57	.109	**Strike**	21.4	25.2	.44	.505	23.5	18.8	1.14	.285
Kick	35.9	57.6	11.77	.001	45.5	50.6	.80	.371	**Kick**	68.0	82.5	8.33	.004	83.5	94.1	5.40	.020
Dribble	4.3	20.7	11.84	.001	5.2	5.2	.00	1.000	**Dribble**	42.7	81.6	32.00	<.001	37.6	52.9	4.57	.033

Q = Cochrane's Q

Table 5: Intervention 2: Distribution of Locomotor Standard Score, Object-control Standard Score, and Gross Motor Quotient (GMQ) scores in each Test of Gross Motor Development -2 (TGMD-2) performance category, pre- and post-intervention

	Intervention				**Control**			
	Pre (%)	**Post (%)**	***Chi-square***	***p*-value**	**Pre (%)**	**Post (%)**	***Chi-square***	***p*-value**
Locomotor Standard Score								
Very Poor	.0	.0	-	-	.0	.0	-	-
Poor	3.6	1.0	5.0	.025	2.5	4.9	1.6	.206
Below Average	7.7	.5	14.0	<.001	5.6	20.4	18.0	<.001
Average	78.5	55.4	25.0	<.001	85.2	71.6	11.0	.001
Above Average	7.2	36.9	44.3	<.001	4.9	2.5	1.6	.206
Superior	3.1	5.6	1.5	.225	1.9	.6	2.0	.157
Very Superior	.0	.5	1.0	.317	.0	.0	-	-
Object-control Standard Score								
Very Poor	1.0	.0	-	-	1.2	1.9	.0	.845
Poor	10.8	2.1	6.5	.011	5.6	17.9	15.4	<.0001
Below Average	28.7	15.9	1.8	.180	30.9	46.3	2.7	.098
Average	57.9	68.7	1.9	.174	58.0	34.0	9.3	.002
Above Average	1.5	11.3	.4	.534	4.3	.0	-	-
Superior	.0	2.1	-	-	.0	.0	-	-
Very Superior	.0	.0	-	-	.0	.0	-	-
GMQ								
Very Poor	1.5	.0	-	-	.6	1.2	.0	.911
Poor	7.2	2.1	.3	.574	6.2	23.5	7.9	.005
Below Average	26.2	5.6	2.2	.134	24.1	37.0	1.8	.176
Average	57.9	66.7	2.1	.151	63.6	35.8	17.1	<.0001
Above Average	.0	17.4	11.2	.001	.0	2.5	5.2	.022
Superior	.0	7.7	2.8	.093	.0	.0	-	-
Very Superior	.0	.5	-	-	.0	.0	-	-

GMQ: Gross Motor Quotient