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A four-week fundamental motor skill intervention improves motor skills in eight to 10-year-old Irish primary school children

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Abstract: Aim: To determine if a four-week fundamental motor skills intervention improves fundamental motor skills in Irish school children. Methods: 100 Primary School boys (n = 58) and girls (n = 42) participated in this study (Age 9 ± 1 years, equally divided into a control and intervention group. Proficiency was assessed qualitatively using the Fundamental Motor Skills Quotient (FMSQ) pre and post intervention, and between gender. Results: There was no change in the control group over time (p = 0.54; Mean change = 0.06 [−0.14 to 0.26]; Cohen's d = 0.01 [Trivial]). In the intervention group, both the male (p ≤ 0.001; Mean diff = 0.893 [7.79 to 10.08]; Cohen's d = 2.24 [V. Large]), and female group (p ≤ 0.001; Mean diff = 11.85 [10.45 to 13.25]; Cohen's d = 3.54 [V. Large]) significantly improved fundamental motor skills scores. A four-week intervention is effective at improving FMSQ.

Subjects: Sports and Leisure; Social Sciences; Education

Keywords: physical literacy; movement; skill development; youth; movement screening

ABOUT THE AUTHORS

Keith Costello Keith has worked as a Primary School Teacher for 19 years. He also lectures in the area of Physical Education with Hibernia College. Keith has a particular interest in the area of Children's Fundamental Movement Skills and hopes to do further research in this area in the future. He is also certified strength and conditioning coach and holds a master's degree in performance coaching. He works with athletes from all different sports.

Joe Warne Joe is an elite athlete, coach and scientist. He specialises in data analytics, biomechanics and physiology. His focus is very much on high performance, where he has coached and currently coaches several international athletes. Academically, Joe has numerous publications in the area of running biomechanics and physiology. He is recognised as one of the world's leading experts in the transition of minimalist footwear with respect to performance and injury as a result of his PHD research.

PUBLIC INTEREST STATEMENT

An ongoing health concern is the prevalence of overweight and obese children. While fast food and poor nutrition play a role in this, another important contributor is that children today are less active than they have been in the past. A potential reason for this lack of activity is because children lack fundamental motor skills. However, our research has shown that a four-week fundamental motor skill intervention of just two 30-minute lessons a week can significantly improve 8- to 10-year-old male and female proficiency of the Fundamental Motor Skills. Teachers can use the methods in the study to teach these focused fundamental motor skills classes, using the different game discussed to reinforce the skills. The intervention is feasible within the confines of a limited school PE curriculum so that focused fundamental motor skills literacy becomes a key part of the child's education in the future.

1. Introduction

Fundamental motor skills are important in the long-term development of children physically, socially and cognitively (Lloyd, Saunders, Bremer, & Tremblay, 2014). Barnett, Van Beurden, Morgan, Brooks, and Beard (2008) define The Fundamental Movement Skills as "basic learnt movement patterns that do not occur naturally and are suggested to be foundational for more complex physical and sporting activities". They are generally broken into three categories: Locomotor skills—such as walking, running, hopping, skipping, jumping, dodging, and side stepping, stability skills—such as Balancing and landing and Manipulative skills—such as catching, throwing, kicking, the underarm roll, and striking (Hands & McIntyre, 2015). These fundamental skills have been suggested to influence long-term adherence to physical activity (Barnett et al., 2008; Lloyd et al., 2014) and may also be related to obesity (Okely, Booth & Chey, 2004; Lubans, Morgan, Cliff, Barnett, & Okely, 2010).

Within Ireland, an ongoing health concern is the prevalence of overweight and obese children; Whelton et al. (2007) found that almost one in four Irish boys (23%) between the ages of 4 and 16 and just over one in four Irish girls (28%) aged between 4 and 16 were either overweight or obese. While fast food and poor nutrition may play a role in obesity (Rosenheck, 2008), another important contributor is that children today are less active than they have been in the past (Fisher et al., 2005). Woods, Moyna, and Quinlan (2010) found that just 19% of the primary and 12% of the post-primary school children in Ireland met the minimum physical activity recommendations of at least 60 minutes of moderate to vigorous physical activity daily. A potential reason for this lack of activity is because children lack fundamental motor skills (Lubans et al., 2010). Bremer and Cairney (2018) believe a number of factors such as sedentary lifestyles, inactivity, weight problems/obesity and problems in learning amongst some children are factors that explain their poor fundamental motor skills. Lubans et al. (2010) maintain that the mastery of fundamental motor skills contributes not just to a child's physical development but also to their cognitive and social development as well as providing the foundation for an active lifestyle. Balyi and Hamilton (2004) believe that if the fundamental motor skills are not mastered between the ages of eight and 11 for boys and nine to 12 for girls the ability of the young child to reach their full potential may be compromised. Therefore, if we can teach fundamental motor skills to young children we not only give them the confidence and skills to take part in physical activity and sport (Hume et al., 2008), but we may also help in combating obesity and the related risk of disease in later life (Okely et al., 2004).

The Department of Education and Skills recommend that 60 minutes a week is allocated to Physical Education in Irish Primary schools, usually consisting of two 30-minute sessions (Woods et al., 2010). However, just 46 minutes was found to be the average time spent in Physical Education and in fact, only 35% of the children are getting the required 60 minutes a week as recommended (Woods et al., 2010). Curriculum online.ie, (1999) lists six different Physical Education strands on its website: Athletics, Dance, Gymnastics, Games, Outdoor, and Adventure Activities and Aquatics. While the curriculum lists the skills, the child should be "enabled to learn" for each of the strands, it does not mention expected motor skill development as the child progresses from Junior Infants to sixth class. Also, Woods et al. (2010) found that children are not being exposed enough to each of the six curriculum strands. They noted that Basketball was the most common activity undertaken by children (68%), followed by Gaelic football (64%), soccer (61%), rounders (55%), and swimming (50%). They also noted that most of these activities are from the games strand of the Primary School Physical Education Curriculum and that 89% of the children reported to not having participated in any outdoor and adventure activities, 70% didn't participate in gymnastics, 57% had no participation in dance, 50% didn't participate in aquatics and 42% had no exposure to athletics during their physical education class in the past year. Therefore, not only are Irish Primary School Children not getting enough exposure to Physical Education weekly, they are not being exposed enough to each of the different Curriculum strands. The importance of exposure to other stands such as gymnastics and dance in the Physical Education curriculum for promoting Fundamental Motor Skills has been well highlighted (Ross &

Butterfield, 1989; Rudd et al., 2017). This lack of exposure to other strands may help explain the poor current fundamental motor skill standards.

Several studies have examined the Fundamental Motor Skills of Children. For example, Booth et al. (1999) assessed the performance of six Fundamental Motor Skills amongst Australian children and adolescents (Years 4–10), the findings indicated the mastery or near mastery of these fundamental motor skills were low particularly amongst Year 4 children (8 and 9-years old). The authors found that only 24% of the boys and girls showed mastery in Running, 20% in the vertical jump and just 18% in the Overhand Throw (Booth et al., 1999). In addition, a U.S. study by Erwin and Castelli (2008) assessed 180 childres aged 8- to 12-year-old children on their competency in a number of basketball (Locomotor/Manipulative skills), gymnastic (stability skills) and throwing skills (Manipulative skills). The results showed that just 47% of the children were making satisfactory progress toward motor competency. To date, very limited research has been conducted in Irish Primary School Children. One study that we are aware of is that of O'Brien, Belton, and Issartel (2016) where nine Fundamental Motor Skills were assessed amongst 12 to 13-year-old Irish children during Physical Education classes; Alarmingly only 11% of the children assessed displayed mastery of near mastery of these basic movement patterns (O'Brien et al., 2016). As far as we are aware no study has been done dealing specifically with the Fundamental Motor Skills of eight to 10-year-old Irish Primary School Children, and it is during these years that children are developmentally ready to learn fundamental motor skills that will give them the best chance of engaging in lifelong, health enhancing physical activity (Balyi, Way & Higgs, 2013). A secondary concern is that females have been found to consistently underperform in fundamental motor skills, when compared to males (Booth et al., 1999; Erwin & Castelli, 2008; O'Brien et al., 2016; Spessato, Gabbard, Valentini, & Rudisill, 2013). Boys generally display superior scores for object control and locomotor skills (Spessato et al., 2013). Researchers have tried to explain the differences between boys and girls, especially in the area of throwing. Some researchers suggest that socio-cultural and environmental factors explain why boys are generally better than girls at object-control skills (as boys generally spend more time participating in different gross motor activities and ball games that utilise and develop these skills) (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). This proposed explanation is supported by Hyde (2005), who reviewed the comprehensive meta-analyses evidence relating to sex differences and reported that males and females are alike on most psychological variables at all ages (Hyde, 2005)—implying that differences in motor abilities in children are influenced by the learning environment. On the other hand and given that sex differences occur at a very young age, other researchers maintain that sex differences, especially in throwing, cannot simply be attributed differential experiences, and that innate psychological capacities relating to spatial targeting may influence performance in girls and boys (Watson, 2001). Consequently, low FMS proficiency levels and sex-differences in performance levels highlight the need for further investigation into FMS proficiency in young people (especially girls). This underperformance has implications for female health and physical activity in the future (Barnett et al., 2008; Farmer, Belton, & O'Brien, 2017).

Whilst there is a need for FMS development through all juvenile age groups we are at a potential crisis point for children of this age (8–10 years old), to be exposed to opportunities to develop Fundamental Motor Skills (Woods et al., 2010) and hence the focus on this age group in the present study. Timetabled Physical Education (PE) lessons a week in week out of the school year in a suitable facility (hall/playground) are an ideal opportunity to improve these skills. A dedicated intervention may be useful in schools to develop Fundamental Motor skills within the current Irish PE infrastructure, where limited opportunity for physical activity exists. It is not intended that the development of Fundamental Motor Skills replaces the Physical Education (PE) lesson. Rather, it is intended that this skill development is integrated into the PE lesson in line with the overall school plan. In this way, the teacher focuses a lens on skill development within a lesson that is based on one of the strands of the PE curriculum. It is suggested that the teacher introduces a maximum of two teaching points per skill during each PE lesson. For example, van Beurden et al. (2003) carried out a study to see if over a 1000 Australian Primary School Children could be taught fundamental

motor skills through Primary School PE lessons and concluded that yes, by modifying existing PE lessons, significant improvements in fundamental motor skills mastery can be gained. Likewise, a systematic review and meta-analysis by Morgan et al. (2013) and Logan, Robinson, Wilson, and Lucas (2012), which guided decisions made in our study, indicate that motor skill interventions are effective. Therefore, there is evidence that the short window of opportunity afforded during PE schedules can be used to effectively master fundamental motor skills, and this needs to be examined in an Irish population.

Thus, the aim of the present study was to determine if a four-week-instructed fundamental motor skills intervention, applied in two 30-minute sessions, is effective in improving fundamental motor skills in Irish school male and female children between eight and 10 years of age, when compared to a control group. A four-week intervention was used as schools often focus on a topic each month (four weeks) and therefore we felt this was an useable approach for primary schools". According to the Australian Fundamental Motor Skills Manual, (1996), it takes between 240 and 600 minutes of instruction time to become proficient in one FMS and providing 1 hr a week will ensure sufficient learning experience. We wanted to challenge this time-frame and see if just two well-planned and structured 30-minute lessons a week over four-weeks could improve a child's proficiency in the FMS. We hypothesize that the intervention group will significantly improve fundamental motor skills scores as a result of the intervention, when compared to the control group. Second, we hypothesize that females will demonstrate lower fundamental motor skill scores when compared to males throughout testing.

1.1. Materials and methods

1.1.1. Participants

A total of 100 third- and fourth-class Primary School boys (n = 58, Age 8.6 ± 0.7) and girls (n = 42, Age 8.8 ± 0.7) participated in the study. All children lived in an urban or suburban setting. To be included in the study, the children had to be healthy; any child suffering from neurological or musculoskeletal condition was excluded (n = 4). Parents and Guardians were provided with information regarding the testing and written informed consent was obtained from all prior to any testing taking place. The primary investigator held both a Bachelor of Education Degree (BEd) as well as a Master's in Performance Science Degree (MSc) and had many years' experience of working with children and testing athletes. The intervention was delivered by the primary investigator at all times. The primary investigator was vetted by An Garda Síochana. Procedures and ethics were approved by the college and Primary School involved in the study.

1.1.2. Experimental design

Following an explanation of the testing procedures, the 100 children were divided per class grouping into a control group (n = 49) which consisted of one third class (n = 25), one fourth class (n = 24) and an intervention group (n = 51), which consisted of the other third class (n = 26) and the other fourth class (n = 25). Each child was assessed using the Fundamental Motor Skills Quotient (FMSQ) criteria which have been shown to be a valid measure of motor competence in young children (Hands & McIntyre, 2015). Unlike more popular methods of FMS assessment such as the TGMD-2 which assesses 12 skills in total, the FMSQ tests just four. Therefore, testing of larger groups is a far quicker process. It's simple scoring system means children's scores can be tallied in real-time observation, making it a practical resource.

To examine the inter-rater reliability of the scoring method, both authors independently assessed 10 children on a separate occasion using the same methods as described below and without knowledge of the other author's scores. These separate scores were then compared for analysis.

The children were demonstrated the skills once before completing them individually. Following testing the control group partook in their normal Physical Education classes which consisted of

ball-handling skills and station teaching from the "Games" strand of the curriculum, two 30-minute classes a week for four weeks while the Intervention group partook in a four-week movement literacy Intervention. Both groups were then re-tested for FMSQ. Re-testing took place in the same testing order, in the same setting, and at the same time of day. All testing took place in controlled conditions in an indoor sports hall and at the same time of day. The testing area was set up identically for both the pre- and post-tests. Participants wore the same footwear and their school tracksuit on both testing days.

1.1.3. Instruments and procedures

1.1.3.1. Fundamental motor skills quotient (FMSQ) testing. The indoor sports hall used for testing measured 26 metres by 16 metres and was floored using a standard indoor vinyl finish. Due to the simple scoring system used by the FMSQ, all scoring was undertaken by the primary investigator as the children performed each skill. The procedure for each of the tests was as follows and the scoring criteria are also presented in Table 1 (Hands & McIntyre, 2015).

(1) Single leg Hop: Two Parallel lines using red duct rape were aligned five metres apart. The child was instructed to stand on the first red line and to hop using only their right leg to the second red line a distance of five metres. Upon reaching the second red line, the child was asked to turn around and to single leg hop back a further five metres to the first line again only using their right leg. The same procedure was repeated by the child using their left leg. The tester observed the child's upper body while hopping from the first line to the second line each time and the child's lower body while hopping back from the second line to the first line each time.

Table 1. Skills criteria for each fundamental motor skill

Hop (right and left leg). 11 criteria	**Overarm throw. 7 criteria**
(1) The support leg bends on landing and straightens again when pushing off (R and L).	(1) The child stands side on in the direction of the throw.
(2) The child takes off and lands on the forefoot (R and L).	(2) The throwing arm moves in an arc that is downward and backward.
(3) The swing leg moves rhythmically with the support leg (R and L).	(3) The child steps forward with the opposite foot to the throwing arm.
(4) The child can hop on both legs.	(4) Hips rotate first, followed by the shoulders.
(5) The head and trunk are stable and the child's eyes are looking ahead (R and L)	(5) The elbow is bent as the throwing arm moves behind the head.
(6) The arms are bent and they move to assist leg action (R and L).	(6) The forearm and hand lag behind the upper body.
	(7) The throwing arm follows through across the body.
Broad jump. 7 criteria	**Sprint run. 6 criteria**
(1) The ankles, knees, and hip bend.	(1) Feet land along a narrow path.
(2) The child is looking forward.	(2) Foot close to the buttocks and high knee lift.
(3) The arms swing behind the body.	(3) The head and trunk are stable.
(4) The legs straighten.	(4) The child is looking ahead.
(5) Both of the child's feet leave the ground at the same time.	(5) The elbows are bent (approx. 90 degrees).
(6) The arms swing forward and upward.	(6) Arm drive (forward and backwards vigorously).
(7) Both feet touch the ground at the same time on landing.	

R, right; L, Left (Hands & McIntyre, 2015).

Note: A point is given for each criteria that are deemed present.

(2) Standing Broad Jump: The child was instructed to stand on the first red line with their feet parallel, shoulder width apart, and facing the second red line. They were then instructed, when ready, to jump as far forward as they could. Upon landing the child was asked to return once more to the first red line and in their own time complete a second standing broad jump. The tester observed the child's upper body movements during the first jump and their lower body movements during the second jump.

(3) Overarm Throw: The child was instructed to stand on the first red line and to face the second red line. The child was handed a tennis ball. He/she was instructed when ready to throw the ball using an overarm throw as far as they could. The child was handed a second ball and repeated the same procedure. The tester observed the child's upper body movements during the first throw and their lower body movements during the second throw.

(4) Sprint Run: A third red line was aligned parallel using red duct tape 20 metres from the first line. The child was instructed to stand on the first red line and face the third red line. When ready they were instructed to run as fast as they could over 20 metres. On reaching the third red line they were instructed to turn around and to run back another 20 metres to the first red line as fast as they could. The tester observed the child's upper body movements while sprinting from the first red line to the third and the child's lower body movements while sprinting back again from the third red line to the first.

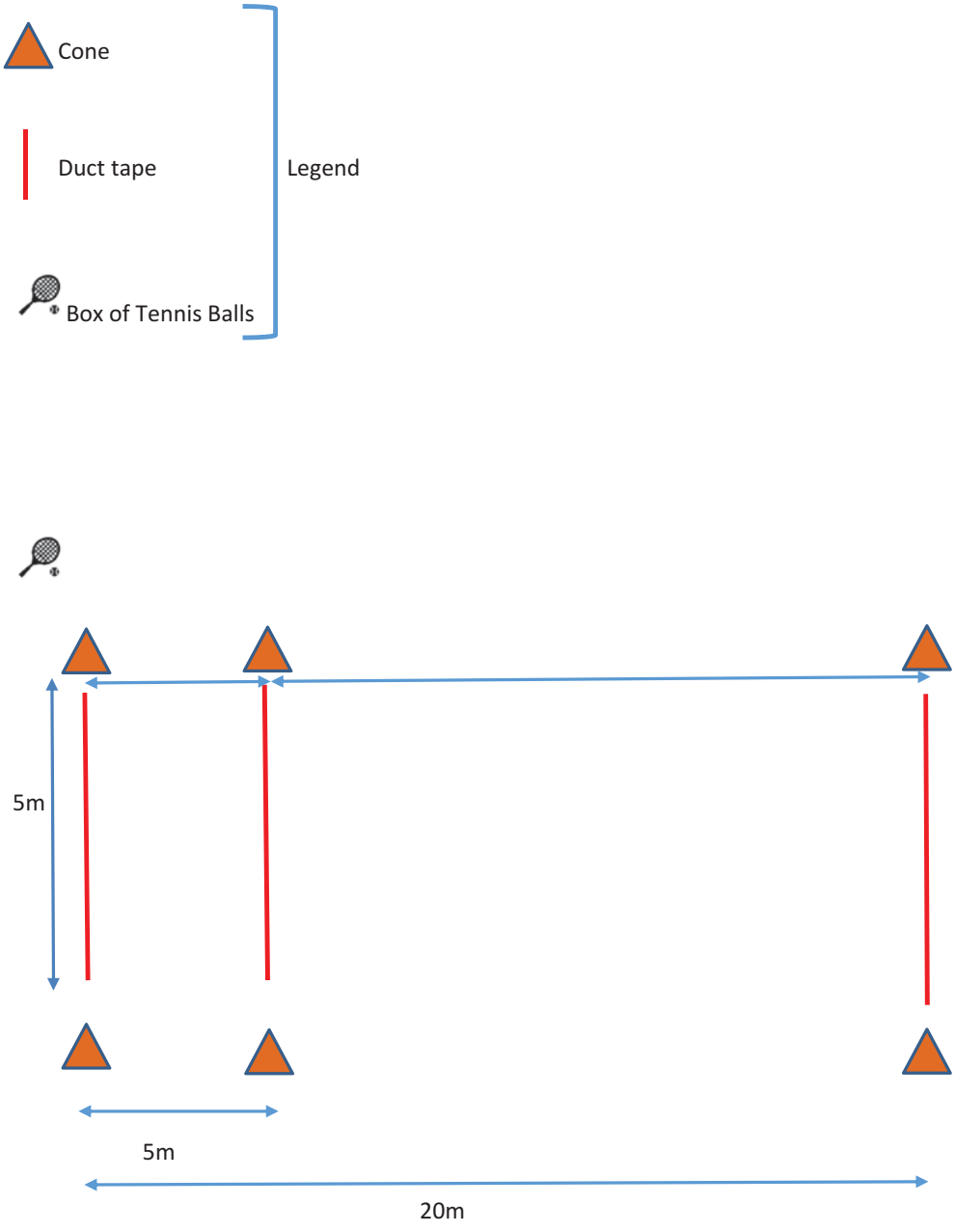
Each child was marked on their proficiency in completing each movement using a simple scoring system based on the FMSQ criteria. As recommended by Hands and McIntyre (2015) each criterion demonstrated successfully by the child received a score of one and for each criterion not successfully displayed by the child, he/she received a score of zero. The observation record for the "run" comprised of six criteria, the "overarm throw" seven criteria, the standing "broad jump" eight criteria, and the single leg "hop" 11 criteria. The skills criteria for each of the fundamental motor skills assessed can be found in Table 1. The maximum score a child can receive is 32 when the sum of all four skills is totalled (Hands & McIntyre, 2015). Prior to testing, 100 sheets were photocopied (one for each child) with each of the criteria on it and each child's score was marked as they were observed completing each of the fundamental motor skills.

After pre-tests, the intervention group (n = 51) began a four-week fundamental motor skills intervention. The intervention group was split into two smaller groups, Group one (n = 27) and Group two (n = 24), based on class allocations. Sixty minutes a week is currently the recommended time donated to PE in the Irish Primary School Curriculum (Woods et al., 2010). Therefore, for the next four weeks both Group one and two were taken for two 30-minute fundamental motor skills lessons each a week. Each lesson focused on a specific fundamental motor skill and began with a 5-minute dynamic warm-up (Figure 1). A 5-minute revision of skills learned from previous lessons followed this. This was followed by 10 minutes of teaching the specific Fundamental Motor Skill being taught that week, namely the criteria mentioned in Table 1. Primary Physical Education lists a number of Games from the "Move Well, Move Often" Physical Literacy Program. Each lesson finished with 10 minutes of these Games. These games are designed to improve children's fundamental motor skills. The four-week intervention is detailed in Table 2.

2. Data management

Each pupils' Age, Gender, and individual score for their single leg hop, standing broad jump, overarm throw, and Sprint Run was entered in Microsoft Excel. A total overall score was calculated for each pupil. Both groups' mean and standard deviation were calculated for each individual Fundamental Movement skill as well as each group's total score.

Figure 1. A floor plan of the gymnasium layout for testing.



3. Data analysis

A three-way mixed ANOVA (between, between, within-subject factors) was conducted to examine differences in time (pre vs. post-test), group (intervention vs. control), and gender (male vs. female). Three way-interactions were examined using two-way mixed ANOVAs and simple main effects (Statistical Package for the Social Sciences data analysis software V22.0, SPSS Inc., Chicago, Illinois, USA). Statistical significance was accepted at $\alpha \leq 0.05$. The smallest standardised change that is considered meaningful was assumed to be an effect size of 0.20 for Cohen's d. (Cohen, 1988). The effect was also expressed as 95% confidence limits (mean change [lower to upper confidence interval]). Where tests failed Mauchly's test of Sphericity, a Huynh-Feldt correction was applied for main effects.

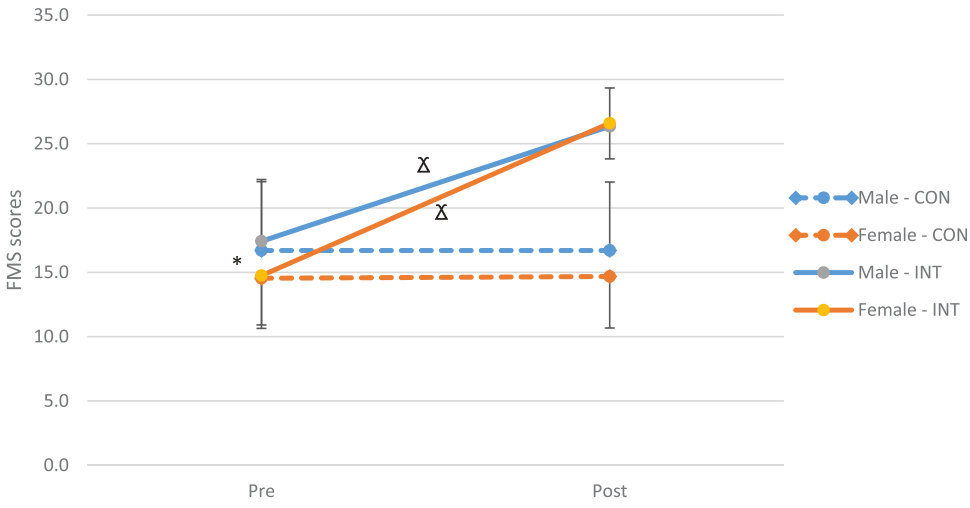


Figure 2. A line graph identifying changes in fundamental motor skills (FMS) scores in males and females in the two groups (control—CON, intervention—INT) over the four-week intervention period (pre, post). Error bars are SD.

Note: *Sig. difference ($p \leq 0.05$) between groups (INT group only); Ⱦ = sig. change ($p \leq 0.05$) between time points for specific group.

Inter-tester reliability was assessed utilising the two-way mixed interclass correlation coefficient (+95% confidence interval [CI]) and typical error (TE), as well as a paired t-test to examine systematic error between raters.

4. Results

There was no participant dropout during the research. Analysis identified no significant differences between the intervention and control group at pre-test for fundamental motor skills scores ($p = 0.50$). Descriptive statistics for the total fundamental motor skills tests can be observed in Table 3, and individual test scores are presented in Table 4.

There was a significant, but small three-way interaction (time*group*gender) ($p = 0.003$) for fundamental motor skills scores. Therefore, we first examined overall effects of the intervention comparing the intervention and control group, and then proceeded to examine any differences in gender specific to each group.

There was a statistically significant interaction between the groups (Intervention & Control) and time (Pre and Post) on fundamental motor skills scores ($p \leq 0.001$). Results of the interaction can be observed in Figure 2. Mean (±SD) data for total scores for each group are presented in Table 3.

We examined this interaction using simple main effects. When examining differences between groups, there was no significant difference in fundamental motor skills scores at the pre-test ($p = 0.50$; Mean diff = 0.64 [−1.23 to 2.51]; Cohen's d = 0.14 [Trivial]); however, a significantly higher fundamental motor skills score was identified at the post-test in the intervention group when compared to the control ($p \leq 0.001$; Mean diff = 10.65 [9.06 to 12.25]; Cohen's d = 2.68 [V. Large]).

When examining changes over time, the intervention group significantly improved fundamental motor skills scores ($p \leq 0.001$; Mean change = 10.08 [9.13 to 11.02]; Cohen's d = 2.63 [V. Large]). However, the control group did not change fundamental motor skills scores ($p = 0.54$; Mean change = 0.06 [−0.14 to 0.26]; Cohen's d = 0.01 [Trivial]).

When examining the effect of gender throughout the study, we examined both the control and intervention group separately. For the control group, we observed no interaction effect between time and gender ($p = 0.49$), as well as no main effects for time ($p = 0.49$), or gender ($p = 0.13$). However, in the intervention group, a significant interaction between time and gender was observed ($p = 0.002$). Simple main effects identified a significantly higher fundamental motor skills score in males compared

Table 2. Details of the four-week fundamental motor skills intervention

Week 1	Week 2	Week 3	Week 4
Dynamic warm-up (5 minutes)	Dynamic Warm-up (5 minutes)	Dynamic Warm-up (5 minutes)	Dynamic Warm-up (5 minutes)
	Revision of Learned Skills (5 minutes)	Revision of Learned Skills (5 minutes)	Revision of Learned Skills (5 minutes)
Skills on how to perform a Single Leg Hop (10 minutes) The children proceeded when instructed to single leg hop on their right foot the length of the hall, focusing on a different teaching point every two lengths of the hall. Teaching points: (1) Taking off and landing on the same foot. Ensuring to push from the ball of the foot on take-off. (2) Moving the support leg rhythmically with the jumping leg. (3) Slightly bending the support leg on landing and straightening on take-off. (4) Bending the arms at the elbow and swinging them back and forth together assisting the leg action. (5) Eyes focused forward, keeping the head and trunk stable. Each step was repeated for the left leg. The children were then allowed 2 minutes to practice their single leg hopping on each leg in their own time. The teacher observed the children and teaching points were given when required.	Skills on how to perform a Standing Broad Jump (10 minutes) The children were lined up side by side at one end of the hall and faced the opposite end. The standing Broad Jump was taught as several steps that everybody completed together one step at a time. Steps: (1) Eyes focused forward. Feet parallel and shoulder width apart. (2) Squat deeply onto the heels while bringing the arms back. (3) Explode forward, bringing the arms forwards and up. Hips, knees, and ankles extend simultaneously. The toes are last part of the body to leave the ground. (4) As the feet hit the ground together, absorb the impact by bending the knees, hips and ankles. Having completed several Standing Broad Jumps step by step with the teacher, the children were allowed 2 minutes to practice some in their own time. During this time the teacher observed the children. Teaching points were given when required.	Skills on how to perform an Overarm Throw (10 minutes) Each child was given a tennis ball and then lined up side by side at one end of the hall, facing the opposite end. The skill was taught step by step as follows: (1) Stand side on. (2) Hold the tennis ball in the dominant hand. Nondominant hand and shoulder point towards a target. (3) Eyes focused on the target throughout the throw. (4) The throwing arm is brought back behind the body, moving in an arc that is downwards and backwards. (5) Step towards the target with the opposite foot to the throwing arm (transferring weight from the back foot to the front foot). (6) Hips rotate first, followed by the shoulders. (7) Throwing arm moves forward, releasing the tennis ball and follows through in the direction of the target and down across the body. The children were then allowed 2 minutes to practice in their own time.	Skills on how to perform a Sprint Run (10 minutes) The children were lined up side by side at one of the hall and faced the opposite end. The children then proceeded, when instructed, to sprint the length of the hall, focusing on a different teaching point every two lengths of the hall: The teaching points included (1) Head stable, eyes looking straight ahead. (2) Elbows bent at 90 degrees. (3) The arms drive forwards and backward vigorously (drive comes from the shoulders) in opposition to the legs while remaining close to the body. Maintain the 90-degree elbow bend. (3) High knee lift (The thigh is almost parallel with the ground). (4) The foot is close to the buttocks on kickback. (5) Run on the balls of the feet. The children were then allowed 2 minutes to practice in their own time.

(*Continued*)

Table 2. (*Continued*)

Week 1	Week 2	Week 3	Week 4
Game 1: "Find someone who?" (5 minutes) Each child finds a space in the hall. The game begins with the teacher saying: "Find someone who … has the same eye colour as you". The children must single leg hop around the hall, find a partner with the same eye colour and make a shape (e.g. rolling into a ball or spreading their arms to look like a star). They hold the shape for 5 seconds and then begin single leg hopping around the hall again. On the teacher's whistle the children freeze and the teacher repeats the activity using a different instruction such as "find someone who has the same hair colour as you".	**Game 1: "Jumping Spots" (5 minutes)** Each child is given a spot marker which they place on the ground ensuring they have enough space from other children. When the music plays, the children walk around the hall. When the music stops the children must jump onto the closest spot marker using a standing broad jump. When the music plays again, the children use a different locomotor skill to move around the hall, e.g. running, skipping, hopping and once again on hearing the teacher's whistle the child must jump onto the closest sport marker using a standing broad jump.	**Game 1: "Litterbug" (5 minutes)** The indoor hall is split in half using cones. The children are split into two equal teams and each team is assigned one half of the hall. Each child is given a small, soft, sponge ball. On the teacher's whistle both groups begin throwing the sponge balls, using an overarm throw, out of their half into the other teams' half. The children continue throwing for a set period, throwing back any sponge balls that land in their half of the hall. The winning team is the team that has the least number of sponge balls in their half at the end.	**Game 1: "Go Grab it" (5 minutes)** The children are split into four teams. Each team lines up behind a hula hoop at one end of the hall. A large number of bean bags, cones, tennis racquets, balls etc. are placed at the other end of the hall. On the teacher's whistle the first child from each team sprint runs to the other end of the hall, grabs a piece of equipment and returns to their team as quickly as possible. The piece of equipment is placed in the hula hoop and only then is the next team member allowed to go. The team with the most amount of equipment in their hula hoop at the end is the winning team. Each game lasts a set period of time.
Game 2: "Rabbit in the Burrow" (5 minutes) Each child finds a space in the hall. The teacher places 20 hula hoop randomly on the hall floor. On hearing "Run Rabbits!" the children single leg hop around the hall. On hearing 'Burrow!" they single leg hop into any Burrow (Hula Hoop) as quickly as possible. Any child without a burrow must do 10 Jumping Jacks and then re-joins the game. A hula hoop is removed and the game is played again. The game finishes when there are 10 hula hoops left. Children are encouraged to alternate legs to avoid fatigue.	**Game 2: "Creature Alley" (5 minutes)** Using cones, the teacher sets up two alleys (3 metres wide) the length of the hall. Bean bags, spot markers, bollards and other obstacles (creatures) are scattered close together inside each of the alleys. The class is split into two groups and each group is assigned an alley. The child must jump from the start of the alley to the end using standing broad jumps without stepping on any of the creatures. If a child steps on a creature they must return to the start and wait their turn before attempting, it again. When the child gets to the end of the alley they must run back to the start, tag the next person to go and join the end of the line. The two groups finish by having a race against each other. Each child that makes it to the end of the alley successfully, sits down. The first group to have all their team sitting down, wins.	**Game 2: "How far can you throw?" (5 minutes)** The children are split into groups of two. Each pair is given a bean bag and some chalk. The children line up in their pairs, one behind the other, along one side of the hall, behind the throwing line (a line of cones). On the teacher's whistle, using an overarm throw, the first child from each pair throws the bean bag as far as possible. The child walks to where it lands and using a piece of chalk writes his/her initials beside it, before picking up the beanbag and returning to the throwing line. The activity is repeated until each child has had five attempts, each time trying to increase the distance of their throw.	**Game 2: "Lifesaver Tag" (5 minutes)** Each child finds a space in the hall. Two children are given a bib to wear and nominated as the "taggers". A third pupil is nominated as the "lifesaver" and is given a hula hoop to carry. On the teacher's whistle the rest of the children run freely around the hall. When a child is "tagged" they must freeze on the spot. In order to be freed the "lifesaver" must place the hula hoop over the child's head and move it down their body until it touches the ground. The freed child now becomes the "lifesaver". The game is played for a set period of time. For each new game, a different "lifesaver" and "taggers" are nominated.

Notes: Each week plan was conducted twice per week over 30-minute period. Each lesson concluded with two quick games where children were encouraged to remember the teaching points learned in the previous section while playing the games.

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Table 3. Mean (± SD) for total fundamental motor skills (FMS) scores comparing the two groups (control, intervention) over the four-week intervention period (pre, post)

Group	*N*	Pre (FMS score)	Post (FMS Score)
Control—Male	27	16.71 (± 5.34)	16.71 (± 5.31)
Control—Female	22	14.55 (± 3.9)	14.68 (± 4.0)
Intervention—Male	31	17.42 (± 4.79)	26.35 (± 2.98)
Intervention—Female	20	14.75 (± 3.84)	26.6 (± 2.78)

to females at the pre-test ($p = 0.04$; Mean diff = 2.67 [0.11 to 5.23]; Cohen's d = 0.61 [Medium]), but no difference between genders at post-test ($p = 0.77$; Mean diff = −0.25 [−1.92 to 1.43]; Cohen's d = 0.09 [Trivial]). Both the male ($p \leq 0.001$; Mean diff = 0.893 [7.79 to 10.08]; Cohen's d = 2.24 [V. Large]), and female group ($p \leq 0.001$; Mean diff = 11.85 [10.45 to 13.25]; Cohen's d = 3.54 [V. Large]) significantly improved fundamental motor skills scores as a result of the intervention.

When examining the inter-tester reliability of the scoring method, we observed excellent agreement (two-way mixed ICC = 0.86; 95% CI [0.53 to 0.96]; TE = 1.7 points; P [difference] = 0.798) for the total points scored.

5. Discussion

The primary outcome of the present study is that children who completed the four-week Fundamental Motor Skills Intervention increased their proficiency in the fundamental motor skills significantly when compared to a control group, and therefore we accept the research hypothesis. Specifically, we noted a mean increase of 10.08 on overall FMS score when we examine the effectiveness of the intervention. We believe the study is novel as this area of research specifically is very underutilised. The fact the children's PE lessons for the week were modified as opposed to adding additional physical activity sessions/lessons or completely changing the Physical Education Curriculum shows not only the effectiveness of the intervention but also the possibility that such an intervention could be introduced to other Primary Schools quite easily.

The results of our study were similar to the systematic review and meta-analyses by Morgan et al. (2013) and Logan et al. (2012) where results indicated that motor skill interventions are effective. Teachers can use the methods in the present study to teach these focused fundamental motor skills classes, using the different games to reinforce the different skills. Anecdotally we observed that this adds an element of fun to the lessons and helps to keep the children engaged. However, this is certainly not supported by evidence from testing. The authors believe the intervention was successful because not only were lessons well planned and fun, instructions were easy to follow and kept to a minimum. Having taught the majority of the children, the children were familiar with the primary researcher which created an environment where the children were at ease, more inclined to listen and comfortable in asking questions if needed.

Interestingly, whilst we did observe significantly higher fundamental motor skills scores in males vs. females at the pre-test for the intervention group, in line with Booth et al. (1999); Spessato et al. (2013); Erwin and Castelli (2008) which all contained boys and girls of similar age to our present study, we observed no difference in fundamental motor skills scores between genders following the intervention. This observation rejects our research hypothesis. The intervention appears to have narrowed the gap between FMS competency in males vs females, but the reasons for this are not entirely clear. Anecdotally, the primary researcher observed groups of girls practicing the taught fundamental motor skills at lunch times while the boys tended to partake in small sided soccer and basketball games. Regardless of the reason, given the abundance of literature identifying girls as the "at-risk" population for fundamental motor skills and lifelong physical activity (Evans, 2008; Goodway, Famelia, & Bakhtiar, 2014; Slater & Tiggemann, 2010), this finding

Table 4. Individual FMS tests descriptives

Test	Control - Male		Control - Female		Intervention - Male		Intervention - Female	
Time	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Hop	6.37 (± 2.50)	6.37 (± 2.51)	5.27 (± 2.31)	5.32 (± 2.36)	6.61 (± 1.98)	9.13 (± 1.45)	5.70 (± 2.08)	9.35 (± 1.09)
Jump	3.89 (± 1.99)	3.93 (± 1.90)	3.50 (± 2.11)	3.55 (± 1.92)	4.39 (± 2.29)	6.58 (± 1.18)	4.00 (± 1.95)	6.60 (± 1.05)
Throw	3.52 (± 2.15)	3.48 (± 2.08)	2.91 (± 1.54)	2.91 (± 1.51)	3.52 (± 1.59)	5.45 (± 0.68)	2.80 (± 1.01)	5.45 (± 0.83)
Run	2.93 (± 1.41)	2.93 (± 1.41)	2.86 (± 1.73)	2.91 (± 1.63)	2.90 (± 1.22)	5.19 (± 0.65)	2.25 (± 0.97)	5.20 (± 0.52)

can only be seen as positive if it balances the fundamental motor skills competencies of young children between gender. The types of activity in the intervention may have greater appeal to girl's participation and potential sustainability to participating in general Physical Activity and not sport-specific activity.

The initial testing of the school children highlighted their Fundamental Motor Skills incompetence. If we define proficiency as possessing all, or all but one required criteria of a skill, we see that pre-intervention, zero children in our study (0%) were proficient in the single leg hop, 10 children (20%) were proficient in the standing broad jump, four children (8%) were proficient in the overarm throw and four children (8%) were proficient in the sprint run. The authors believe there are several reasons for this illiteracy. The Department of Education and Skills in Ireland recommends that children get 60 minutes a week of Physical Education (Woods et al., 2010). However, just 46 minutes was found to be the average time spent in Physical Education and in fact, only 35% of the children are getting the required 60 minutes a week as recommended (Woods et al., 2010). Interestingly the average weekly PE time in the European Union is 109 minutes a week (Hardman, 2008). In fact, the average time donated to PE a year in Ireland is a mere 37 hours compared to France at 108 hours (Hardman, 2008). Therefore, Irish Primary School Children are not getting enough exposure to Physical Education weekly, although it could be argued that it is the quality of the instruction and design that is more important. Also, Woods et al. (2010) noted that most of the activities children are being exposed to are from the games strand of the Primary School Physical Education Curriculum, where others may be neglected. Therefore, not only are Irish Primary School Children potentially not getting enough exposure to Physical Education weekly, they are certainly not being exposed enough to each of the different Curriculum strands which may help explain the poor current levels in physical literacy. Finally, in secondary schools in Ireland PE is taught by a specialist teacher; however, at Primary Level, it is taught (along with all the other subjects) by a generalist teacher. Even though there is an element of Physical Education training in teacher training colleges in Ireland, many teachers believe that the time donated to it is inadequate and therefore some class teachers feel they haven't the confidence or competence to teach PE (Broderick & Shiel, 2000). Also, there is evidence that schools struggle to find the time to teach the basic curriculum (English, Irish, Mathematics, etc., Connor, 2003; Woods et al., 2010). Therefore, PE lessons are possibly being rushed or unfortunately sacrificed entirely.

Given the links between fundamental motor skills and numerous factors, such as lifelong physical activity (Stodden et al., 2008), sports participation, and competence (Lubans et al., 2010), and obesity (Okely et al., 2004) to name a few, a national surveillance system to monitor changes in Physical Education needs to be in place so that changes and progress can be evaluated (Bryant, Duncan, Birch, & James, 2016). Most Irish Primary Schools participate in an "Active Schools" week once a year (www.activeschoolflag.ie). During this week, class teachers make a far greater effort to get their children active, whether it is participating in the "Daily Mile" challenge, 30 seconds of activity such as jogging on the spot in between lessons or adding a physical activity element to the homework such as star jumps or laps of the garden. Instead of "Active Schools" week being an annual event it could easily be a termly event or even more regular. It must be remembered that Physical Literacy is just as important as "Literacy Literacy". Investment is needed nationwide, and indeed worldwide, to combat this issue in the future. Regardless, we have demonstrated that even within the current physical education infrastructure, significant positive changes can be made to fundamental motor skills for children using focused, fun activities (Logan et al., 2012; Morgan et al., 2013).

There are some limitations noted in this study: as children from only one school were used in the study, the generalisability of the results observed is limited. It is therefore unknown if similar results would be observed nationwide. Furthermore, one may argue that testing of just four fundamental motor skills does not provide a good representation of FMS. However, the authors feel that the four skills tested represent the three fundamental motor skill categories of body management (hopping on one leg), locomotor (running and jumping) and object control (throwing)

(Hands & McIntyre, 2015). For the purpose of our study, the fundamental skills were taught in the following order: Singe Leg Hop, Standing Broad Jump, The overarm Throw, and Sprint Run, which may be a limitation. The Education Department of Western Australia (2013) recommends that the fundamental motor skills should be taught in the following order: Sprint Run, Standing Broad Jump, Single Leg Hop, and The overarm throw. They maintain that even though the fundamental motor skills are not necessarily mastered in this order, by ordering them as such, there is a progression from the easiest skill to the most difficult (Education Department of Western Australia, 2013). This is something that should be examined further in future research. Even though the results of our intervention were promising, typically, most of the literature on FMS has focused on longer intervention to determine the impact of an intervention (Logan et al., 2012). However, given that schools focus on topics per month (four weeks) or per term (6 weeks), we believe that a four-week intervention is a feasible approach and presents an useable approach for primary schools. Finally, retention of the fundamental motor skills was not measured in this study, and future research should examine if the children maintain fundamental motor skills competency after an extended period of regular physical education classes.

Conclusion

It can be concluded that a four-week fundamental motor skills intervention of two 30-minute lessons a week can significantly improve eight to 10-year-old male and females in their proficiency of the Fundamental Motor Skills. Teachers can use the methods in the present study to teach these focused fundamental motor skills classes, using the different games to reinforce the different skills. We believe this intervention is feasible within the confines of a limited school PE curriculum in 8- to 10-year-old children so that focused fundamental motor skills literacy becomes a key part of the child's education for the future.

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References

Balyi, I., & Hamilton, A. (2004). Long-term athlete development: Trainability in childhood and adolescence. *Olympic Coach*, *16*(1), 4–9.

Balyi, I., Way, R., & Higgs, C. (2013). *Long-term athlete development*. Human Kinetics. Champaign, USA.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2008). Does childhood motor skill proficiency predict adolescent fitness? *Medicine & Science in Sports & Exercise*, *40*(12), 2138. doi:10.1249/MSS.0b013e31818160d3

Booth, M. L., Okely, T., McLellan, L., Phongsavan, P., Macaskill, P., Patterson, J., … Holland, B. (1999). Mastery of fundamental motor skills among New South Wales school students: Prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport*, *2*(2), 93–105. doi:10.1016/S1440-2440(99)80189-3

Bremer, E., & Cairney, J. (2018). Fundamental movement skills and health-related outcomes: A narrative review of longitudinal and intervention studies targeting typically developing children. *American Journal of Lifestyle Medicine*, *12*(2), 148–159. doi:10.1177/1559827616640196

Broderick, D., & Shiel, G. (2000). *Diet and activity patterns of children in primary schools in Ireland*. Dublin: St: Patrick's College.

Bryant, E. S., Duncan, M. J., Birch, S. L., & James, R. S. (2016). Can fundamental movement skill mastery be increased via a six-week physical activity intervention to have positive effects on physical activity and physical self-perception? *Sports*, *4*(1), 10. doi:10.3390/sports4010010

Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. New York, NY: Academic press.

Connor, S. (2003). *Youth sport in Ireland: The sporting, leisure, and lifestyle patterns of Irish adolescents. Dublin, Ireland: Liffey Press.*

Education Department of Western Australia. (2013). *Fundamental movement skills learning, teaching and assessment book 1: Preparing children for an active and healthy lifestyle* (1st ed.). Perth, WA.

Erwin, H. E., & Castelli, D. M. (2008). National physical education standards: A summary of student performance and its correlates. *Research Quarterly for Exercise and Sport*, *79*(4), 495–505. doi:10.1080/02701367.2008.10599516

Evans, K. (2008). Dropping out and hanging out: Girls and organised sports participation. *Australasian Parks and Leisure*, *11*(2), 44.

Farmer, O., Belton, S., & O'Brien, W. (2017). The relationship between actual fundamental motor skill proficiency, perceived motor skill confidence and

competence, and physical activity in 8–12-year-old Irish female youth. *Sports*, *5*(4), 74. doi:10.3390/sports5040074

Fisher, A., Reilly, J. J., Kelly, L. A., Montgomery, C., Williamson, A., Paton, J. Y., & Grant, S. (2005). Fundamental movement skills and habitual physical activity in young children. *Medicine & Science in Sports & Exercise*, *37*(4), 684–688. doi:10.1249/01.MSS.0000159138.48107.7D

Fundamental Motor Skills. (1996). *In fundamental motor skills: A manual for classroom teachers* (pp. 1–58). Victoria: Community Information Service.

Goodway, J. D., Famelia, R., & Bakhtiar, S. (2014). Future directions in physical education & sport: Developing fundamental motor competence in the early years is paramount to lifelong physical activity. *Asian Social Science*, *10*(5), 44. doi:10.5539/ass.v10n5p44

Hands, B., & McIntyre, F. (2015). Assessment of fundamental movement skills in Australian children: The validation of a Fundamental Motor Skills Quotient (FMSQ). *Malaysian Journal of Sport Science and Recreation*, *11*(1), 1–12.

Hardman, K. (2008). Physical education in schools: A global perspective. *Kinesiology: International Journal of Fundamental and Applied Kinesiology*, *40*(1), 5–28.

Hume, C., Okely, A., Bagley, S., Telford, A., Booth, M., Crawford, D., & Salmon, J. (2008). Does weight status influence associations between children's fundamental movement skills and physical activity? *Research Quarterly for Exercise and Sport*, *79*(2), 158–165. doi:10.1080/02701367.2008.10599479

Hyde, J. S. (2005). The gender similarities hypothesis. *American Psychologist*, *60*(6), 581. doi:10.1037/0003-066X.60.6.581

Lloyd, M., Saunders, T. J., Bremer, E., & Tremblay, M. S. (2014). Long-term importance of fundamental motor skills: A 20-year follow-up study. *Adapted Physical Activity Quarterly*, *31*(1), 67–78. doi:10.1123/apaq.2013-0048

Logan, S. W., Robinson, L. E., Wilson, A. E., & Lucas, W. A. (2012). Getting the fundamentals of movement: A meta-analysis of the effectiveness of motor skill interventions in children. *Child: Care, Health and Development*, *38*(3), 305–315. doi:10.1111/j.1365-2214.2011.01307.x

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., & Okely, A. D. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine*, *40*(12), 1019–1035. doi:10.2165/11536850-000000000-00000

Morgan, P. J., Barnett, L. M., Cliff, D. P., Okely, A. D., Scott, H. A., Cohen, K. E., & Lubans, D. R. (2013). Fundamental movement skill interventions in youth: A systematic review and meta-analysis. *Paediatrics*, *132*(5), e1361–e1383.

O'Brien, W., Belton, S., & Issartel, J. (2016). Fundamental movement skill proficiency amongst adolescent youth. *Physical Education and Sport Pedagogy*, *21*(6), 557–571. doi:10.1080/17408989.2015.1017451

Okely, A. D., Booth, M. L., & Chey, T. (2004). Relationships between body composition and fundamental movement skills among children and adolescents. *Research Quarterly for Exercise and Sport*, *75*(3), 238–247. doi:10.1080/02701367.2004.10609157

Pate, R. R., Pfeiffer, K. A., Trost, S. G., Ziegler, P., & Dowda, M. (2004). Physical activity among children attending preschools. *Pediatrics*, *114*(5), 1258–1263. doi:10.1542/peds.2003-1088-L

Physical Education. (1999). Retrieved from http://www.curriculumonline.ie/Primary/Curriculum-Areas/Physical-Education

Rosenheck, R. (2008). Fast food consumption and increased caloric intake: A systematic review of a trajectory towards weight gain and obesity risk. *Obesity Reviews*, *9*(6), 535–547. doi:10.1111/obr.2008.9.issue-6

Ross, A. N. N., & Butterfield, S. A. (1989). The effects of a dance movement education curriculum on selected psychomotor skills of children in grades K-8. *Research in Rural Education*, *6*(1), 51–56.

Rudd, J. R., Barnett, L. M., Farrow, D., Berry, J., Borkoles, E., & Polman, R. (2017). Effectiveness of a 16-week gymnastics curriculum at developing movement competence in children. *Journal of Science and Medicine in Sport*, *20*(2), 164–169. doi:10.1016/j.jsams.2016.06.013

Slater, A., & Tiggemann, M. (2010). "Uncool to do sport": A focus group study of adolescent girls' reasons for withdrawing from physical activity. *Psychology of Sport and Exercise*, *11*(6), 619–626. doi:10.1016/j.psychsport.2010.07.006

Spessato, B. C., Gabbard, C., Valentini, N., & Rudisill, M. (2013). Gender differences in Brazilian children's fundamental movement skill performance. *Early Child Development and Care*, *183*(7), 916–923. doi:10.1080/03004430.2012.689761

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, *60*(2), 290–306. doi:10.1080/00336297.2008.10483582

van Beurden, E., Barnett, L. M., Zask, A., Dietrich, U. C., Brooks, L. O., & Beard, J. (2003). Can we skill and activate children through primary school physical education lessons? "Move it Groove it"—a collaborative health promotion intervention. *Preventive Medicine*, *36*(4), 493–501. doi:10.1016/S0091-7435(02)00044-0

Watson, N. V. (2001). Sex differences in throwing: Monkeys having a fling. *Trends in Cognitive Sciences*, *5*(3), 98–99. doi:10.1016/S1364-6613(00)01595-3

Whelton, H., Harrington, J., Crowley, E., Kelleher, V., Cronin, M., & Perry, I. J. (2007). Prevalence of overweight and obesity on the island of Ireland: Results from the North South survey of children's height, weight and body mass index, 2002. *BMC Public Health*, *7*(1), 187. doi:10.1186/1471-2458-7-187

Woods, C.B., Tannchill D. Quinlan, A., Moyna, N., & Walsh, J. (2010). *The children's sport participation and physical activity study (CSPPA study)*. Research No.1. Dublin, Ireland: School of Health and Human Performance, Dublin City University and The Irish Sports Council.

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