Preventive Medicine Reports 11 (2018) 191–195

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Short Communication

Fundamental movement skills: Where do girls fall short? A novel investigation of object-control skill execution in primary-school aged girls

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ARTICLE INFO

Keywords:
Fundamental movement skills
Girls
Competency
Mastery
Object-control

ABSTRACT

Fundamental movement skill (FMS) proficiency is positively associated with a range of health outcomes, and is a predictor of lifelong participation in physical activities and sport. Yet low FMS proficiency levels in children prevail, particularly among girls performing object-control skills (e.g., kicking, catching). To identify where girls require the most support and inform future teaching resources and interventions, this cross-sectional study investigated proficiency levels of object-control skills and their specific performance components (subskills) in girls; and aimed to determine whether patterns in subskill mastery were evident in girls from two different developmental stages. This study included 153 girls (aged 4–12 years; mean age = 7.7, SD = 1.8) from the Hunter Region, Australia. Six object-control skills were video-assessed using the Test of Gross Motor Development (TGMD-2, TGMD-3); overall skill proficiency levels and mastery levels of subskills were determined. In summary, < 5% (of the total group, 4–8 years or 9–12 years) demonstrated mastery or advanced skill level in the strike, stationary dribble, overhand throw or kick. Mastery levels were also poor for the majority of the 24 subskills, with mastery levels below 40% for the total group for 17 of the 24 subskills. Deficiencies in specific subskills were evident in the preparation, action and recovery phases of the six object-control skills. Only 6 of the 24 subskills mastery levels were significantly higher in the older age-group. Our investigation provides new evidence that may be useful for practitioners and researchers looking to support the optimal development of FMS proficiency among girls.

Australian New Zealand Clinical Trials Registry: ACTRN12615000022561.

1. Introduction

Fundamental movement skills (FMS) have been described as the building blocks for movement, and form the foundation for many of the specialized movement skills needed to participate successfully in sport and physical activity (Gallahue and Ozmun, 2006). As FMS do not generally develop naturally, the skills need to be learned, practised and developed (Gagen and Getchell, 2006). Childhood is a critical time for FMS development as recent reviews have found FMS proficiency to be positively associated with a range of health, fitness and academic outcomes, participation in organised sports and sustained engagement in physical activity (Hardy et al., 2012; Jaakkola et al., 2015; Lubans et al., 2010; Stodden et al., 2014; Stodden et al., 2008).

FMS have been commonly categorized as locomotor skills (e.g., running, jumping, hopping) and object-control skills (e.g., catching, throwing, kicking) (Haywood and Getchell, 2009). The motor learning literature outlines that most children (girls and boys) are developmentally capable of mastering all FMS by Grade 4 (approximately 10 years old) through the provision of developmentally appropriate activities and equipment, appropriate visual demonstrations of skills, instruction and feedback, a variety of relevant, enjoyable and challenging practice activities, and a positive learning environment (Gallahue and Ozmun, 2006). Alongside these environmental factors, biological factors impacting girls and boys can also influence the rate at which FMS are mastered by boys and girls alike (Gallahue and Ozmun, 2006). Globally, young people are also failing to perform FMS to their expected developmental capability. For example: in Ireland only 11% of 12–13 year olds achieved either mastery or near mastery for nine FMS (O'Brien et al., 2016); in New Zealand < 40% of children 5–13 years old mastered the kick, throw or strike (Mitchell et al., 2013); less than a quarter of children aged 6–9 years old in Hong Kong achieved mastery across 12 FMS (Pang and Fong, 2009); in the UK a large proportion of

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https://doi.org/10.1016/j.pmedr.2018.06.005
Received 3 October 2017; Received in revised form 14 May 2018; Accepted 13 June 2018
Available online 18 June 2018

10–11 year old children rated as non-proficient in overall FMS competency levels (Foweather, 2010); and in Singapore the majority of children aged 6–9 years old score 'below average' or 'poor' on both locomotor and object control skills (Mukherjee et al., 2017). These studies also demonstrate that boys generally outperform girls in FMS assessments; of concern is that 14%, 38% and 34% more Australian boys (in Grade 6) demonstrate advanced skill levels in object control skill such as the catch, kick and over-arm throw (respectively), than their female peers (Hardy et al., 2017).

Researchers have attempted to explain the vast differences between sexes, especially in throwing, with some researchers suggesting that environmental and socio-cultural factors explain why boys generally outperform girls at object-control skills (as boys generally spend more time participating in different ball games and gross motor activities that utilise and develop these skills) (Pate et al., 2004). This hypothesis is supported by Hyde (2005), who reviewed the extensive 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 contrary and given that sex differences occur very early in life, other researchers claim 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).

The prevalence of FMS mastery among Australian children and adolescents is also very low (Hardy et al., 2017). In a recent national physical literacy report card, where an 'A' represented the highest score (81–100% mastery), Australian children received a D (21–40% mastery) for 'movement skills' (Active Healthy Kids Australia, 2016).This rating was based on assessments of both locomotor (sprint, vertical jump, side gallop and leap) and object-control (kick, over-arm throw and catch) skills, of Grade 6 children. Of further concern, Australian girls consistently demonstrate poorer FMS proficiency than boys, particularly for object-control skills. For example, only 14% of Australian girls have mastered the kick and over-arm throw upon entering secondary school, compared to 52% and 53% of boys (respectively) (Hardy et al., 2017). However, there have been no studies reporting the specific components of individual object-control skills that girls may be proficient or deficient, or whether these vary by age. In order to maximize learning experiences for girls, it is important that researchers not only identify FMS component mastery levels, but that evidence-based and age-appropriate FMS programs are developed that specifically target areas of need (Hardy et al., 2012).

Therefore, the aims of this paper were 1) to determine mastery levels of six common object-control skills; 2) to examine overall and individual subskill mastery levels; and 3) to determine whether subskill mastery rates varied in girls from two different developmental stages.

2. Materials and methods

2.1. Study design

Guided by the STROBE statement this investigation reports baseline data from a randomized controlled trial which evaluated an intervention designed to improve physical activity levels in fathers and their pre-adolescent daughters. In total, 153 daughters (mean (SD) age = 7.4 (1.6) years, range 4–12 years) were recruited from the broader Newcastle region, NSW, Australia (Morgan et al., under review). Families were eligible if the father or male guardian lived with his daughters at least 3 days per week. All FMS data were collected prior to randomization.

2.2. Assessment measures

Ethics approval for the study was provided by the University of Newcastle's Human Research Ethics Committee. Assessments occurred in January 2015 by trained researchers.

2.2.1. Measurement of fundamental movement skill (FMS)

Girls' FMS competency was assessed using the standardized object-control skill protocols described in the *Test of Gross Motor Development* (TGMD-2 and TGMD-3) (Ulrich, 2000; Valentini et al., 2016). This validated assessment was designed to measure the gross motor functioning in children aged 3–10 via the assessment of 3–5 key skill components for each FMS (Ulrich, 2000; Valentini et al., 2016). After watching a demonstration of each skill, girls were individually filmed (on an iPad) performing two attempts of the kick, catch, dribble, overhand throw, two-handed strike (TGMD-2), and underhand throw (TGMD-3). The performance components of each skill were scored as present ("1") or absent ("0") for both trials by independent coders. Scores for each trial were summed to give total component scores, which were then added to give total skill scores. Aligning with the methods used by Cliff and associates (Cliff et al., 2012), the proportion of girls exhibiting mastery were calculated (defined as exhibiting all skill components during both trials, e.g., kick = 8/8) and advanced skill proficiency (defined as exhibiting 'all' or 'all but one component' during both trials, e.g., catch ≥5/6) for each skill. Given that low FMS competency levels prevail among Australian children (especially in girls) despite increased efforts to target this issue in the past decade, our research team took a novel approach by investigating what specific aspects of object-control skills are problematic for girls, and reported sub-skill mastery. Included in Table 2 are the *TGMD* performance criteria for each of the six object-control skills tested. The six skills were selected due to their inclusion in the Australian health and physical education curriculum and their relevance to a wide variety of sports commonly played by children in Australia. The skills were categorized as either power skills (strike, kick and overhand throw) or control skills (stationary dribble, underhand throw, catch) for this study. The TGMD-2 was used for all but one object-control skill, with the TGMD-3 used for the underarm throw, as it was a new inclusion to the assessment tool (replacing the underarm roll).

2.3. Statistical analysis

The statistical analyses were conducted in IBM SPSS Statistics for Windows (Version 20) (SPSS, INC 2010, IBM Company, Armonk, NY). Overall mastery rates for each skill subcomponent are presented as counts and percentages. Chi-square tests were used to determine if significant differences in subskill mastery existed between girls in the 'infant' (4–8 years) and 'primary' (9–12 years) school stages. To account for the multiple analyses, the alpha was adjusted with a Bonferroni correction and the significance level was set at $p < 0.001$.

3. Results

The mean (SD) ages of girls was 7.7 years (SD 1.8) with 22% of girls meeting daily physical activity recommendations of 12,000 steps/day (Tudor-Locke et al., 2011). Based on estimates from the SEIFA Index of Relative Socio-economic Advantage and Disadvantage (Australian Bureau of Statistics, 2011) (1 = most disadvantaged, 10 = most advantaged), girls were represented from socio-economic postal areas (3–4 = 24%, 5–6 = 42%; 7–8 = 17%; 9–10 = 17%). Results were analysed based on the schooling stage of participants and on the two levels of Primary School that exists in Australian schools (Infants: Kindergarten to Grade 2 = ages 4–8; Primary: Grade 3–6 = aged 9–12) given that object-control skills are typically taught, learned, practiced and developed from Kindergarten to Grades 2, and explored, practised and applied in different contexts during Grades 3–6 within the

Table 1
Results by age-group for overall skill mastery/near mastery skill (Australia, 2015).

Object control skill	Achieved mastery/near mastery (n, %)			
	Total (n = 153)	4–8 yrs (n = 108)	9–12 yrs (n = 45)	p-Value
Strike	1 (1)	1 (1)	0 (0)	0.52
Kick	6 (4)	4 (4)	2 (4)	0.83
Overhand throw	2 (1)	1 (1)	1 (2)	0.51
Stationary dribble	2 (1)	0 (0)	2 (1)	0.37
Underhand throw	15 (10)	7 (6)	8 (18)	0.03
Catch	49 (34)	33 (32)	16 (36)	0.64

mandatory physical education curriculum (NSW Department of Education and Training, 2000).

3.1. Object-control skills mastery levels

Table 1 details all results for mastery levels and advanced skill level for each of the six object-control skills for both age-groups. The mastery of object-control skills were generally very low with the vast majority of girls unable to demonstrate mastery or near-mastery for almost all skills. Specifically, < 5% of girls (range 0–4%) in all age-groups exhibited mastery/near mastery in the strike, dribble, kick and overhand throw. Similarly for the underhand throw, only 6% of girls in the 4–8 age group and 18% of girls in the 9–12 age group demonstrated skill mastery. Although levels of competency did not exceed 36%, higher levels of competency were evident for the catch in both age-groups (4–8 year olds: 32%, 9–12 year olds: 36%).

3.2. Overall and individual subskill mastery levels

Table 2, appendix Table A.1 and Fig. A.1 detail subskill components of each skill. Mastery levels for the total group were low (0–40%) for subskills within the strike (1, 2,3,4), kick (3,4), overhand throw (1,2,3,4), dribble (1), underhand throw (2, 4) and catch (1) and involved the side-on positioning of the body, body rotation, transfer of body weight, appropriate limb actions during windup, or follow through actions during power skills, and appropriate positioning of the hands or feet. The girls tended to perform better on the subskill components requiring locomotion (e.g., running, striding, leaping), ball contact and arm actions during skill execution. There were significant differences between age-groups for subskill components for the kick (2), dribble (2,4), underhand throw (1,3) and catch (3), with the older age group displaying higher mastery levels ($p < 0.001$).

4. Discussion

The main aim of this study was to assess the object-control skill levels of primary school-aged girls and in doing so, highlight the skills that girls mastered the most and mastered the least. Our findings demonstrate that the vast majority of girls failed to master any of the object-control skills irrespective of age-group, and although mastery levels for the catch were highest, only 34% of girls mastered or displayed near mastery skill level in this skill. These results add to the growing body of research highlighting low FMS levels in girls – especially object-control skills (Foweather, 2010; Hardy et al., 2017; Mitchell et al., 2013; Mukherjee et al., 2017; O'Brien et al., 2016; Pang and Fong, 2009). To complement previous research, this study also examined the subskill mastery of the six object-control skills and identified a range of key areas where girls require particular support.

Our results reveal that FMS mastery levels were poor across all skills (and particularly the power skills) and for the majority of subskill components. Notably, of the 24 subskill components, 17 had been mastered by < 40% of the sample. The most problematic components involved the side-on positioning of the body, body rotation, transfer of body weight, appropriate limb actions in power skills during windup or follow-through, and appropriate positioning of the hands or feet. These deficiencies in subskill components did not occur uniformly within a specific phase of the skills, but included components of the preparation, action and recovery phases. Successful object control-skill execution generally requires the individuals to perform unique biomechanical functions within each phase (Bartlett, 2007). Our results also showed

Table 2
Results by age-group for skill component mastery (Australia, 2015).

Object control skill	Subskill		Total (n = 153)	4–8 yrs (n = 108)	9–12 yrs (n = 45)	p-Value
	#	Description	n (%) mastered	n (%) mastered	n (%) mastered	
Strike	1	Dominant hand grips bat above non-dominant hand	32 (21)	16 (15)	16 (36)	< 0.01
	2	Non-preferred side of body faces the imaginary tosser with feet parallel	14 (9)	7 (6)	7 (16)	0.08
	3	Hip and shoulder rotation during swing	7 (5)	3 (3)	4 (9)	0.10
	4	Transfers body weight to front foot	22 (14)	11 (10)	11 (24)	0.02
	5	Bat contacts ball	123 (80)	85 (79)	38 (84)	0.42
Kick	1	Rapid continuous approach to the ball	94 (61)	62 (57)	32 (71)	0.11
	2	[a]An elongated stride or leap immediately prior to the ball contact	91 (59)	52 (48)	39 (87)	< 0.001
	3	Non-kicking foot placed even with or slightly to the back of the ball	41 (27)	23 (21)	18 (40)	0.02
	4	Kicks ball with instep of preferred foot (shoelaces) not toe	28 (18)	24 (22)	4 (9)	0.05
Overhand throw	1	Windup is initiated with downward movement or hand/arm	20 (13)	9 (8)	11 (25)	< 0.01
	2	Rotates hips and shoulders to a point where the non-throwing side faces wall	29 (19)	15 (14)	14 (32)	0.01
	3	Weight is transferred by stepping with the foot opposite the throwing hand	40 (26)	22 (21)	18 (41)	0.01
	4	Follow-through beyond release diagonally across body toward non-preferred side	17 (11)	8 (7)	9 (20)	0.02
Stationary dribble	1	Contacts ball with one hand about belt level	5 (3)	4 (4)	1 (2)	0.65
	2	[a]Pushes ball with fingertips	57 (38)	24 (22)	33 (75)	< 0.001
	3	Ball contacts surface in front of or to the outside of foot on the preferred side	28 (18)	16 (15)	12 (27)	0.07
	4	[a]Maintains ball control for four consecutive bounces without moving feet to retrieve	58 (38)	28 (26)	30 (68)	< 0.001
Underhand throw	1	[a]Preferred hand swings down and back, reaching behind the trunk	84 (55)	48 (44)	36 (80)	< 0.001
	2	Steps forward with the foot opposite the throwing hand	30 (20)	15 (14)	15 (33)	< 0.01
	3	[a]Ball is tossed forward hitting the wall without a bounce	83 (54)	43 (40)	40 (89)	< 0.001
	4	Hand follows through after ball release to chest level	43 (28)	25 (23)	18 (40)	0.04
Catch	1	Preparation phase where hands are in front of the body and elbows are flexed	50 (34)	38 (37)	12 (27)	0.24
	2	Arms extend while reaching for the ball as it arrives	125 (86)	87 (85)	38 (86)	0.87
	3	[a]Ball is caught by hands only	99 (68)	58 (57)	41 (93)	< 0.001

[a] Significant differences between age-groups accounting for bonferroni correction.

that poor mastery levels in the preparation phase of several skills, generally indicated a pattern of poor mastery for the subsequent subskills from the action and recovery phases. As adequate preparation is important to ensure the body is in an optimal position for skill execution, targeting these subskills may provide girls with the foundations required to perform the action phases of each skill with better technique, more success and with more power (in the case of the power skills).

Surprisingly, our results showed that only 6 out of 24 subskill components were rated significantly higher for the older age group, and highlights that low proficiency levels prevail in many subskills throughout the primary school years. Given that children are developmentally capable of mastering all FMS through the provision of age-appropriate learning opportunities (Gallahue and Ozmun, 2006), this is a concern, and implies that the FMS programs currently being implemented in schools or the community are not meeting the specific needs of young girls. Clearly, girls of all ages need more specific instruction, demonstration and practice of the subskills that were poorly performed, and more targeted opportunities to further develop or extend upon the subskills girls performed accurately.

4.1. Implications

In order to maximize learning opportunities and increase skill proficiency levels of girls, our findings suggest that educators, coaches and researchers should move away from a 'blanket approach' to teaching FMS and 1) spend more time developing the object-control skills that girls are least competent in performing at; 2) use age-appropriate programs; and 3) use teaching programs and strategies (such as instruction and feedback) that are focused on the specific subskill components of the skill that the majority of girls struggle to master (rather than spending time on the skills and the key components that most girls are able to perform). These suggestions also align with common motor learning theory, suggesting that the learning of motor skills can be maximized when instruction, feedback and attention focus on only a few key elements of a performance at a time, rather than presenting the learner with a broad range of variables to attend to in the learning environment (Gallahue and Ozmun, 2006).

In practice, this would imply that learning of object-control skills may be better taught in phases, where the skill is presented and practiced in full during the awareness and exploratory stages of skill acquisition (i.e., learners are introduced to new skills and are provided with opportunities to explore and practice skills in isolation), and followed by instruction and practice targeting only the more problematic components of a skill during the discovery stage (i.e., learners are provided with opportunities to refine and practice skills in varied contexts) (Gallahue and Ozmun, 2006). By targeting problematic areas children are not overloaded with information and key points that they have already mastered.

4.2. Strengths and limitations

This investigation explores FMS proficiency levels in Australian primary-school aged girls, with a novel focus on identifying and comparing key performance deficits in a range of object-control skills in girls aged 4–8 years and 9–12 years using an objective, reliable and valid measure of FMS competency. For practical purposes (time, space and resources), we were unable to assess all FMS (e.g. locomotor skills). Additionally, the sample was relatively small so we were unable to compare all developmental age-groups, and the two sub-groups determined by school stage were uneven in size. Despite this, the current findings are novel and provide an impetus for further investigation.

5. Conclusion

To the authors' knowledge this is the first study to explore the performance components of six object-control skills in girls. Our investigation demonstrated low mastery levels in most object-control skills and in many of the associated key skill components in girls 4–12 years old. We were also able to identify a number of patterns within each of the six object-control skills and across age-groups, which will help to inform the design and delivery of future school- and community-based FMS programs for girls.

Acknowledgments

This study was funded by the Hunter Medical Research Institute (HMRI: G1301335) with research grants from Port Waratah Coal Services and the Hunter Children's Research Foundation. David R Lubans is funded by an Australian Research Council Future Fellowship (ARC: G1301163). The authors thank all families for their valued contributions to this research. We would also like to thank University of Newcastle undergraduate students Alice Ianni, Angus Leahy, Jasmin Courtenay, Joel Redman, Kirsten Murray, Kristen Pryor, Laura Harrison, Louisa Patel, Melanie Maslin, Sarah Nieuwenhuise, Sophie Martin and Teliah Buckton for their valued contributions to the study during data collection. The authors declare there is no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2018.06.005.

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