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Gross motor skills of South African preschool-aged children across different income settings

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ABSTRACT

Objectives: No studies have investigated gross motor skill (GMS) proficiency of preschool-aged children across different income settings in South Africa. Research from high-income countries suggests that children from low-income settings display poorer GMS proficiency compared to higher-income peers. This study aimed to (1) describe GMS proficiency of preschool-aged children in urban high-income (UH), urban low-income (UL) and rural low-income (RL) settings; and (2) explore differences in proficiency between income settings and sex.
Design: Descriptive cross-sectional study.
Methods: The Test of Gross Motor Development-Edition 2 (TGMD-2) was used to assess GMS. The TGMD-2 gross motor quotient, standardised scores and raw scores were used to describe proficiency.
Results: GMS proficiency was assessed in n = 259 3–6-year-old children (n = 46 UH, n = 91 UL, n = 122 RL). Overall, 93% of the children were classified as having 'average' or better GMS. According to TGMD-2 standardised scores, the RL children performed significantly better than UH and UL children ($p = 0.028$ and $p = 0.009$, respectively). RL children were significantly more proficient than UH and UL children in the strike and horizontal jump when comparing raw scores. Overall, boys performed significantly better than girls in the strike, stationary dribble, kick and leap when comparing raw scores (all $p < 0.001$).
Conclusions: This study reports high GMS proficiency in preschool-aged children across income settings in South Africa. The factors associated with higher GMS in low-income settings are not immediately obvious. Thus, future research should explore potential factors and identify opportunities to ensure that GMS proficiency is capitalised on as preschool-aged children enter formal schooling.

Practical implication

- High volumes of unstructured physical activity may, in some contexts and to a certain extent, displace the need for teaching, practice and reinforcement of GMS in preschool children in order to reach adequate levels of GMS proficiency.
- Preschool-aged girls in South Africa would benefit from efforts to improve their object control skills to match the object control skills of boys.
- Adequate GMS upon entry into primary school (from preschool) need to be developed into sport-specific skills as these could contribute to adequate physical activity levels later in childhood.

1. Introduction

Gross motor skills (GMS; known also as fundamental motor skills or fundamental movement skills), refer to locomotor, object

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control (or manipulative), and stability (or balance) skills.[1] Locomotor skills are those that include body projection skills such as running or leaping. Object control skills are sometimes referred to as ball skills, and include throwing or kicking a ball. Stability skills include balancing and are occasionally called non-locomotor stability skills. A recently published review of terminology has recommended the use of the terms 'fundamental movement skills' and/or 'fundamental motor skills'.[2] However, the term 'gross motor skills' tends to be the more commonly used term in South African practice and research.[3–5]

During the preschool years (3–5 years old), gross motor skills (GMS) play an integral role in the development of children's movement patterns[6,7] and is thus a critical period for GMS development. To date, the majority of studies reporting gross motor proficiency among preschool children have been from high-income countries.[8] In studies from high-income countries, GMS proficiency during the preschool years has been positively associated with healthy body weight,[9–11] higher levels of physical activity[12] and improved cognitive outcomes.[13] However, even during this short developmental period, some differences in children's abilities are evident. For instance, preschool-aged boys have generally been shown to be more proficient in object control skills, but not necessarily locomotor skills, than preschool-aged girls.[8]

Two reviews exploring the correlates of preschool-aged children's motor development and socioeconomic status (SES) have yielded different findings. The review published in 2010 reported a consistent association between SES and GMS,[14] where preschool-aged children from lower SES areas showed poorer GMS than children from higher SES areas. More recently, this association has been reported as inconsistent[8]; although there is still evidence from high-income countries that show that preschool children from low-income settings perform poorly compared to their high-income peers[15] and a greater proportion of children from low-income settings are classified as 'delayed' in their GMS development.[16,17] It is believed that preschool children in low-income settings have fewer developmentally appropriate motor opportunities and may therefore have limited exposure to the teaching, practice and reinforcement that are arguably necessary for the development of GMS.[18]

There are only a small number of studies that have investigated GMS proficiency of preschool children in low- and middle-income countries. One study of Indonesian pre-schoolers found that GMS proficiency was not high[19] (particularly in relation to perceived competence), but studies from Myanmar (southeast Asia)[20] and South Africa[3–5] have mostly reported adequate levels of GMS proficiency.[3–5] One study from South Africa reported similar locomotor skills between boys and girls,[5] while another reported better cognitive outcomes with greater GMS proficiency.[3] However, only one of the South African studies has made use of a validated tool to measure GMS,[3] and none have explored differences in GMS proficiency between preschool children from urban and rural settings (or income settings) in South Africa. Additionally, it is worth noting that objectively measured physical activity levels of preschool children in South African settings is reportedly high (462.0 ± 64.4 min per day).[21]

Considering the positive relationship between GMS proficiency and health and developmental outcomes in preschool-aged children, it is important to identify the levels of GMS proficiency in low- and middle-income countries, including South Africa, using validated tools. Furthermore, it is important to investigate GMS proficiency in different settings (i.e. rural and urban, and income setting) in low- and middle-income countries, as these settings differ vastly. South Africa is an upper middle-income country, although it is one of the most unequal societies in the world.[22] The uppermost decile of the South African population accounts for almost 60% of South Africa's income, while the lowest decile accounts for less than 1%.[22] Thus, income settings may potentially differ in ways that influence GMS development, such as pre-schooler's access to space and toys. Examining pre-schoolers' GMS proficiency will provide a starting point for future research into correlates of GMS proficiency in low- and middle-income countries which can potentially be targeted in interventions. Therefore, the aims of this study were to (1) describe GMS proficiency in urban high-income (UH), urban low-income (UL), and rural low-income settings (RL); and (2) explore differences in proficiency between income settings and sexes in a sample of South African preschool-aged children.

2. Methods

Data were collected from a UH setting (Cape Town, n = 46), an UL setting (Cape Town, n = 91) and an RL setting (Bushbuckridge municipal area in Mpumalanga Province in northern South Africa, n = 122). Data were collected in 2012 (UH and UL) and 2014 (RL). The study settings, sample and methods have been reported elsewhere.[21] Where necessary, specific methods have been repeated or described in more detail in this paper. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cohort studies was followed in the reporting of this study.[23]

Cape Town preschool children were selected using convenience sampling (two UL preschools were recruited, children from UH settings were recruited through word of mouth and snowball sampling in selected UH suburbs). In Bushbuckridge, recruitment was coordinated through the Public Engagement Office of the MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt). The RL preschool-aged children from the Bushbuckridge area were recruited from three preschools and two primary schools (from the Grade R/'Reception' year class which precedes Grade One).

Age and sex details for each preschool-aged child was provided by the parents (UH) and preschool teachers (UL and RL). The Test for Gross Motor Development – Edition 2 (TGMD-2) was used to assess GMS proficiency. This is a valid and reliable measure of GMS for children aged 3–10 years,[24] and has been used successfully in South Africa prior to this study.[3] The TGMD-2 involves the assessment of six locomotor skills (run, gallop, hop, leap, horizontal jump, slide) and six object control skills (catch, roll, throw, strike, stationary dribble, kick). Each skill is graded according to a set of performance criteria that represent specific components of the skill. There are between three and five performance criteria for each skill, For example, when performing the hop, the following five performance criteria apply: (1) non-support leg swings forward in pendular fashion to produce force, (2) foot of non-support leg remains behind the body, (3) arms flexed and swing forward to produce force, (4) takes off and lands three consecutive times on preferred foot, and (5) takes off and lands three consecutive times on non-preferred foot.[24] Performance criteria for each skill that are performed correctly are scored as 1 and performance criteria that are performed incorrectly or only partially are scored as 0.

In groups of four to seven, children watched the correct performance of each skill and then were asked to perform the skill to the best of their ability.[24] The researchers that conducted the testing were trained and later assisted by a researcher with experience in using the TGMD-2, following thorough studying of the TGMD-2 manual.[24] Children were given two opportunities to perform each skill. A local fieldworker translated the instructions of the demonstration into the local language for children who did not speak English. Each attempt was video-recorded and later scored (the Cape Town and Bushbuckridge data were scored by two different scorers, respectively). The scoring for 14 randomly selected TGMD-2 assessments (out of n = 137 of the urban sample, ±10% of

Table 1
Between- sex and setting differences of children in each TGMD-2 descriptive rating category.

Descriptive ratings	Total (n = 259)	Boys (n = 130)	Girls (n = 129)	*p*-Value	Urban high-income (n = 46)	Urban low-income (n = 91)	Rural low-income (n = 122)	*p*-Value
Very poor	(2) 0.8	0	(2) 1.6		0	(1) 1.1	(1) 0.8	
Poor	(3) 1.2	(2) 1.5	(1) 0.8		0	(1) 1.1	(2) 1.6	
Below average	(13) 5.0	(4) 3.1	(9) 7.0		(1) 2.2	(4) 4.4	(8) 6.6	
Average	(156) 60.2	(85) 65.4	(71) 55.0	0.215	(34) 73.9	(65) 71.4	(57) 46.7	0.016
Above average	(61) 23.6	(31) 23.9	(30) 23.3		(9) 19.6	(18) 19.8	(34) 27.9	
Superior	(20) 7.7	(7) 5.4	(13) 10.1		(2) 4.4	(2) 2.2	(16) 13.1	
Very superior	(4) 1.5	(1) 0.8	(3) 2.3		0	0	(2) 3.3	

Data presented as (n =) % per ranking; p-values shown for differences between sex and setting using Chi^2 analyses.

the sample) was repeated by one of the scorers. Lin's concordance correlation coefficient was used to assess agreement between the sum of the raw locomotor scores as well as the object control scores for sets of data.[25] Agreement between the scorers was 0.88 (95% CI: 0.63, 0.99) and 0.74 (95% CI: 0.41, 0.96) for the locomotor and object control raw scores, respectively.

Raw scores, standard scores and gross motor quotient (GMQ) scores were determined for each child. Raw scores for individual skills indicate proficiency in each skill. The GMQ score is derived from the locomotor and object control standard scores (standardised according to age and sex). It is a combined score for all skills that is age- and sex-normed and provides a reliable numeric score for GMS proficiency.[24] The GMQ score is further used to rank children according to descriptive categories of gross motor development on a 7-point scale, ranging from very poor to very superior.

Stata 13 for Mac (StataCorp, Texas, USA) was used to perform all statistical analyses. Descriptive statistics were produced to describe GMS proficiency in the children using the locomotor and object control raw and standard scores, and the GMQ. The data reporting on the number of children per TGMD-2 ranking, based on their proficiency, are reported as percentage per ranking and are stratified by sex and setting. Pearson's chi-squared analyses were used to determine differences between the settings for TGMD-2 ranking. Both raw and standard scores have been included in the analysis, since standard scores (and the GMQ) enable comparisons with other studies using the TGMD-2, but also imply differences in age and sex. Following tests for normality, between-sex differences were assessed using t-tests and Mann–Whitney U tests where appropriate; while between-setting differences were assessed using ANOVA and Kruskal–Wallis tests where appropriate. Where differences were observed between the three settings, separate Mann–Whitney U tests were used to assess between-setting differences. Linear regressions were run to determine the associations of sex, age and income setting with raw locomotor and raw object control skills, respectively.

Ethical approval for this research was obtained from the University of Cape Town Human Research Ethics Committee (HREC REF 237/2012), the University of the Witwatersrand (Wits) Human Research Ethics Committee (Medical) (M140250), and the Mpumalanga Provincial Departments of Health and Education. Written informed parental consent was obtained for all children who participated in the study, and children provided verbal assent.

3. Results

The mean age of participants was 5.2 ± 0.7 years. There were no differences in age for boys and girls, but UL children were significantly older than RL children (5.4 ± 0.7 vs. 5.0 ± 0.6 respectively, $p = 0.001$).

Table 1 illustrates the percentage of children per GMQ ranking (from very poor to very superior), by sex and setting. Overall, the children displayed good GMS, with only 7% of all children achieving a descriptive ranking below 'average'. The RL children performed significantly better than the UH and UL children according to these descriptive rankings ($x^2(6) = 6.943$, $p = 0.016$).

Between-setting differences for individual locomotor and object control raw skills, sum of raw scores, standard scores, and GMQ are shown in Table 2. Post-hoc analyses indicated that RL children had a significantly higher sum of standard scores and GMQ compared to UH children ($p = 0.028$ and $p = 0.029$ respectively) and UL children ($p = 0.009$ and $p = 0.006$ respectively). RL children had significantly better locomotor standard scores than UH children ($p = 0.018$), and significantly better object control standard scores than UL children ($p = 0.012$). However, when comparing raw scores for individual skills, RL children performed significantly worse in the run ($p < 0.001$ in comparison to both UH and UL), slide ($p = 0.002$ for UH, $p = 0.037$ for UL), and stationary dribble ($p = 0.001$ for UH, $p < 0.001$ for UL). For the horizontal jump, UH children performed significantly worse compared to UL children ($p = 0.032$) and RL children ($p < 0.001$). For the strike, the RL children performed significantly better than the UL children ($p = 0.009$).

Differences between boys and girls for individual locomotor and object control skills, sum of raw scores, standard scores, and GMQ are shown in Table 3. Boys performed significantly better than girls in the leap, strike, stationary dribble, and kick (all $p < 0.001$). Boys also had a significantly higher sum of raw scores for object control skills and for the total sum of raw scores ($p < 0.000$ for both). Differences between boys and girls were not evident when comparing standard scores or GMQ.

Regression results showed that pre-schoolers who scored better in object control raw scores were significantly less likely to be girls (95% CI = −4.68, −2.25; $p < 0.001$) and more likely to be older (95% CI = 2.19, 3.96; $p < 0.001$). In this model (n = 259, $r^2 = 0.247$, $p < 0.001$) income setting was not significantly associated ($p > 0.05$). For locomotor raw scores, only age was shown to be positively associated (95% CI = 3.01, 5.08; $p < 0.001$). Although the model was statistically significant (n = 259, $r^2 = 0.186$, $p < 0.001$), neither sex nor income setting were significantly associated with locomotor skills (both $p > 0.05$).

4. Discussion

This study suggests that preschool-aged children from South Africa predominantly have adequate GMS, with only a small percentage scoring below an 'average' GMQ ranking. The most significant finding from this study is that children from low-income areas (UL and RL) were equivalent in their skills to children from high-income areas which contradicts previous research from other countries.[16,17,26] Interestingly, the RL children outperformed children from UH and UL settings in several GMS components. This finding contradicts the assumption that children in low-income areas are typically at a disadvantage due to poorer access to equipment and instruction.[8] Considering that increased physical activity[7,27] has been reported to provide a child more opportu-

Table 2
Between-setting differences for individual locomotor and object control raw skills, sum of raw scores, standard scores, and GMQ.

	Urban high-income (n = 46)	Urban low-income (n = 91)	Rural low-income (n = 122)	*p*-Value
Individual locomotor skills				
Run (range 0–8)	7.8 ± 0.6 (8.0, 8.0–8.0)	7.9 ± 0.6 (8.0, 8.0–8.0)	7.0 ± 1.1 (7.0, 6.0–8.0)	<0.001
Gallop (range 0–8)	4.5 ± 1.2 (4.0, 4.0–6.0)	4.2 ± 2.2 (4.0, 2.0–6.0)	4.7 ± 2.7 (6.0, 2.0–7.0)	0.088
Hop (range 0–10)	7.9 ± 2.6 (8.5, 7.0–10.0)	8.4 ± 2.1 (9.0, 8.0–10.0)	8.2 ± 2.4 (9.0, 8.0–10.0)	0.418
Leap (range 0–6)	3.6 ± 0.9 (4.0, 3.0–4.0)	3.8 ± 0.7 (4.0, 4.0–4.0)	3.7 ± 1.8 (4.0, 3.0–5.0)	0.394
Horizontal jump (range 0–8)	4.4 ± 2.3 (4.0, 2.0–6.0)	5.3 ± 2.4 (6.0, 3.0–8.0)	6.0 ± 1.8 (6.0, 5.0–8.0)	<0.001
Slide (range 0–8)	7.0 ± 1.9 (8.0, 6.0–8.0)	6.6 ± 2.0 (7.0, 6.0–8.0)	5.5 ± 2.8 (7.0, 3.0–8.0)	0.003
Sum: locomotor raw scores (range 0–48)	35.2 ± 5.4 (36.0, 34.0–38.0)	36.2 ± 6.2 (38.0, 33.0–41.0)	35.2 ± 6.7 (36.0, 31.0–40.0)	0.252
Locomotor standard score	10.8 ± 1.5 (11.0, 10.0–12.0)	11.1 ± 2.2 (11.0, 10.0–13.0)	11.6 ± 3.0 (11.0, 10.0–14.0)	0.041
Individual object control skills				
Strike (range 0–10)	6.1 ± 2.2 (6.0, 4.0–8.0)	5.9 ± 2.4 (6, 4–8)	6.8 ± 2.1 (7.0, 5.0–8.0)	0.021
Stationary dribble (range 0–8)	4.9 ± 2.1	4.9 ± 2.3	3.7 ± 2.0	<0.001
Catch (range 0–6)	4.2 ± 1.0	3.8 ± 1.1	4.1 ± 1.1	0.138
Kick (range 0–8)	7.1 ± 1.3 (8.0, 6.0–8.0)	7.3 ± 1.0 (8.0, 7.0–8.0)	6.8 ± 1.6 (8.0, 6.0–8.0)	0.165
Throw (range 0–8)	3.9 ± 2.1 (3.0, 2.0–6.0)	3.7 ± 1.9 (4.0, 2.0–5.0)	4.2 ± 2.4 (4.0, 2.0–6.0)	0.312
Roll (range 0–8)	4.4 ± 1.3	4.2 ± 1.3	4.2 ± 1.7	0.679
Sum: object control raw scores (range 0–48)	30.6 ± 6.0	29.9 ± 5.1	29.7 ± 5.9	0.494
Object control standard score	10.5 ± 2.0 (10.0, 9.0–12.0)	10.1 ± 1.8 (10.0, 9.0–11.0)	11.0 ± 2.6 (11.0, 9.0–13.0)	0.040
Sum: locomotor and object control raw scores (range 0–96)	65.8 ± 10.0 (67.0, 62.0–72.0)	66.1 ± 9.6 (69.0, 62.0–72.0)	64.9 ± 10.4 (67.0, 58.0–71.0)	0.547
Sum: locomotor and object control standard scores	21.2 ± 3.0 (21.0, 19.0–23.0)	21.3 ± 3.1 (22.0, 20.0–23.0)	22.6 ± 4.7 (23.0, 20.0–25.0)	0.013
Gross motor quotient	103.7 ± 8.9 (103.0, 97.0–109.0)	103.4 ± 9.5 (103.0, 100.0–109.0)	107.7 ± 14.2 (109.0, 100.0–115.0)	0.010

Data presented as mean ± SD (median, IQR) for data not normally distributed, and as mean ± SD for normally distributed data; *p*-values shown for differences between settings using ANOVA or Kruskal–Wallis analyses.

Table 3
Between-sex differences for individual locomotor and object control raw skills, sum of raw scores, standard scores, and GMQ.

	Total (n = 259)	Boys (n = 130)	Girls (n = 129)	*p*-Value
Individual locomotor skills				
Run (range 0–8)	7.5 ± 1.0 (8.0, 7.0–8.0)	7.5 ± 0.9 (8.0, 7.0–8.0)	7.4 ± 1.0 (8.0, 7.0–8.0)	0.320
Gallop (range 0–8)	4.5 ± 2.3 (5.0, 2.0–6.0)	4.4 ± 2.2 (4.0, 2.0–6.0)	4.6 ± 2.4 (5.0, 4.0–6.0)	0.248
Hop (range 0–10)	8.2 ± 2.3 (9.0, 8.0–10.0)	8.3 ± 2.2 (9.0, 8.0–10.0)	8.2 ± 2.5 (9.0, 8.0–10.0)	0.915
Leap (range 0–6)	3.7 ± 1.3 (4.0, 3.0–4.0)	4.1 ± 1.1 (4.0, 4.0–5.0)	3.3 ± 1.4 (4.0, 3.0–4.0)	<0.001
Horizontal jump (range 0–8)	5.5 ± 2.2 (6.0, 4.0–7.0)	5.4 ± 2.2 (6.0, 4.0–7.0)	5.6 ± 2.2 (6.0, 4.0–7.0)	0.626
Slide (range 0–8)	6.2 ± 2.5 (7.0, 6.0–8.0)	6.4 ± 2.3 (7.0, 6.0–8.0)	5.9 ± 2.6 (7.0, 4.0–8.0)	0.208
Sum of locomotor raw scores (range 0–48)	35.5 ± 6.3 (37.0, 32.0–40.0)	36.1 ± 5.7 (37.0, 33.0–40.0)	35.0 ± 6.9 (36.0, 31.0–40.0)	0.257
Locomotor standard score	11.3 ± 2.5 (11.0, 10.0–13.0)	11.4 ± 2.3 (11.0, 10.0–13.0)	11.3 ± 2.7 (11.0, 10.0–13.0)	0.828
Individual object control skills				
Strike (range 0–10)	6.3 ± 2.3 (6.0, 5.0–8.0)	7.0 ± 2.1 (7.0, 6.0–8.0)	5.7 ± 2.2 (6.0, 4.0–7.0)	<0.001
Stationary dribble (range 0–8)	4.3 ± 2.2	5.0 ± 2.1	3.7 ± 2.1	<0.001
Catch (range 0–6)	4.0 ± 1.1	3.9 ± 1.1	4.1 ± 1.1	0.255
Kick (range 0–8)	7.1 ± 1.4 (8.0, 6.0–8.0)	7.4 ± 1.0 (8.0, 7.0–8.0)	6.7 ± 1.6 (7.0, 6.0–8.0)	<0.001
Throw (range 0–8)	4.0 ± 2.2 (4.0, 2.0–6.0)	4.1 ± 2.1 (4.0, 2.0–6.0)	3.8 ± 2.3 (3.0, 2.0–6.0)	0.119
Roll (range 0–8)	4.2 ± 1.5	4.4 ± 1.5	4.1 ± 1.5	0.138
Sum of object control raw scores (range 0–48)	29.9 ± 5.6	31.9 ± 5.3	28.0 ± 5.3	<0.001
Object control standard score	10.6 ± 2.3 (10.0, 9.0–12.0)	10.4 ± 1.9 (10.0, 9.0–12.0)	10.8 ± 2.5 (10.0, 9.0–12.0)	0.187
Sum of locomotor and object control raw scores (range 0–96)	65.5 ± 10.0 (68.0, 61.0–72.0)	67.9 ± 8.9 (70.0, 63.0–73.0)	63.0 ± 10.5 (65.0, 58.0–70.0)	<0.001
Sum of locomotor and object control standard scores	21.9 ± 4.0 (22.0, 19.0–24.0)	21.7 ± 3.4 (22.0, 20.0–24.0)	22.0 ± 4.5 (22.0, 19.0–25.0)	0.449
Gross motor quotient	105.5 ± 12.0 (106.0, 97.0–112.0)	105.1 ± 10.2 (106.0, 100.0–112.0)	105.8 ± 13.6 (106.0, 97.0–115.0)	0.497

Data presented as mean ± SD (median, IQR) for data not normally distributed, and as mean ± SD for normally distributed data; *p*-values shown for differences between sex using t-test or Mann–Whitney-U analyses.

nity to develop and refine their GMS, other research on preschool children from similar settings in South Africa could provide some potential explanations for the findings of this study. Total objectively measured physical activity levels of preschool children in these settings is 2.5 times the recommended 180 min.[21] In addition, directly observed physical activity levels have shown that RL children spend significantly more time in moderate- to vigorous-intensity physical activity during preschool time and that this physical activity is mostly unstructured with limited teacher facilitation.[21] This contradicts the argument that teaching, practice and reinforcement are necessary to support the development of GMS in preschool children.[18] It is therefore possible that high levels of unstructured activity could be contributing to GMS proficiency, although further research is needed to develop this hypothesis.

When individual raw scores were investigated, there were a number of individual skills in which RL children were significantly less proficient (run, slide and stationary dribble), although the RL children outperformed the UH and UL children in the horizontal jump and strike. This finding is difficult to explain as it is likely that the RL children have poorer access to equipment (which would favour the argument for being less proficient in the stationary dribble), but were superior in the strike. The strike is a skill that requires more specialised equipment and is quite specific to baseball and softball, two sports which are not commonly practiced in South Africa, especially in comparison to soccer, cricket or rugby.

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It is possible that certain skills require more attention and perhaps a greater level of direct instruction to achieve all components of the skill (such as the stationary dribble or run), while others require less instruction (in this case, the strike or horizontal jump) but are obtainable through adequate levels of physical activity and unstructured play. It is notable that the kick was the object control skill best performed by boys and girls. Proficiency in kicking is not unexpected in South African children, particularly in boys (of any age). There is a strong soccer culture among South Africans, particularly in low-income areas where the game is played widely,[28] both formally (in a league format) and informally (during leisure time). It is therefore possible that this soccer culture and being surrounded by other children, some of whom are older, in the community is a potential source of kicking 'coaching' and 'peer education'.[29]

This study reported superior object control raw skills for boys. When scores were normalised for sex (and age), these differences were no longer evident, since the TGMD-2 standard scores (and hence GMQ and descriptive ratings) assume boys to perform better than girls. Boys' superior object control skills are frequently reported in studies from high-income countries using the TGMD-2,[8] as well as in low- and middle-income countries including Myanmar [20] and Indonesia.[19] These findings have inspired researchers to develop interventions with the aim of improving proficiency in preschool-aged girls' object control skills.[30] Although it has not yet been established whether girls can 'catch up' to boys, the findings reported in our study suggest that girls in South Africa, irrespective of income setting, may benefit from an intervention targeting their object control skills.

While these findings reporting high levels of GMS proficiency in South African pre-schoolers are encouraging, the extent to which these skills are maintained into primary school has not been systematically established, which highlights a need for future research. A small number of regional studies with older South African children indicate that levels of GMS proficiency do not remain high as children get older.[31] It may be the case that in these older age groups, income differences begin to have a more noticeable impact due to the limited capacity for organised physical activity and sport in low-income South African primary schools, specifically with regards to equipment, facilities and human resources to offer extra-mural sport and physical education.[32] Low levels of participation in organised sport and poor implementation of physical education in schools have also been noted in low-income South African settings.[31] It is therefore possible that preschool children in low-income South African settings may start their formal schooling with adequate GMS, but their school environment is not equipped to capitalise on these skills. This could mean that these skills are not being developed into more sport-specific skills and correct motor patterns later in childhood.[33] Strategies for intervention could thus be better placed to target the development of sport-specific skills in older children to ensure that their earlier proficiency is not lost.

The limitations of this study include that the sample was a convenience sample, particularly in the UH setting, where recruitment proved to be far more challenging than in the low-income settings (UL and RL). This study only presents findings from selected regions in South Africa and it is possible that findings may be different across regions, where the social and economic circumstances in low-income settings may have a differential impact on GMS proficiency. However, this is the first study in South Africa to explore differences in GMS proficiency between preschool-aged children from different income settings. Another limitation is that only one process-oriented tool was used, thus certain GMS (not evaluated by the TGMD-2) were not examined. Further research should consider using more than one tool to evaluate all GMS. However, the TGMD-2 is a validated tool that has been used in numerous other international studies and despite having 2 different scorers, there was strong agreement between scorers.

It is important for further research to be conducted across income settings in South Africa to understand the contextual nature of associations between GMS proficiency and various health and developmental outcomes, including physical activity, body composition and cognitive outcomes. It is also necessary to investigate the impact of these correlates on the extent to which GMS proficiency levels are maintained into later childhood. Considering the high levels of GMS proficiency identified in this study, there is also potential for using gross motor activities to further improve the health and development of preschool children in South Africa.

5. Conclusion

This study reports adequate gross motor skill proficiency in preschool-aged children across income settings in South Africa. In low-income settings, particularly rural settings, it is feasible to suggest that the mechanism of learning gross motor skills is attributable to factors other than income. Future research should explore the contextual factors within low-income settings that contribute to gross motor skill proficiency. This could help to identify opportunities to maximise these factors in other urban settings to ensure that gross motor skill proficiency is capitalised on as preschool-aged children enter formal schooling.

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References

1. Gallahue DL, Ozmun JC, Goodway JD. *Understanding Motor Development: Infants, Children, Adolescents, Adults*, 7th ed. McGraw-Hill, 2011.
2. Logan SW, Ross SM, Chee K et al. Fundamental motor skills: a systematic review of terminology. *J Sports Sci* 2017; 2(2):1–16, 2nd ed.
3. Draper CE, Achmat M, Forbes J et al. Impact of a community-based programme for motor development on gross motor skills and cognitive function in preschool children from disadvantaged settings. *Early Child Dev Care* 2012; 182(1):137–152.
4. Toit Du D, Pienaar AE. Overweight and obesity and motor proficiency of 3- and 4-year old children. *South Afr J Res Sport Phys Educ Recreat* 2003; 25(2):37–48. University of Stellenbosch.
5. Pienaar AE, van Reenen I, Weber AM. Sex differences in fundamental movement skills of a selected group of 6-year-old South African children. *Early Child Dev Care* 2016; 186(12):1994–2008.
6. Stodden DF, Goodway JD, Langendorfer SJ et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest* 2012; 60(2):290–306. Taylor & Francis Group.
7. Hardy LL, King L, Farrell L et al. Fundamental movement skills among Australian preschool children. *J Sci Med Sport* 2010; 13(5):503–508. Sports Medicine Australia.

8. Barnett LM, Lai SK, Veldman SLC et al. Correlates of gross motor competence in children and adolescents: a systematic review and meta-analysis. *Sports Med* 2016; 46(11):1–26. Springer International Publishing.
9. Castetbon K, Andreyeva T. Obesity and motor skills among 4 to 6-year-old children in the United States: nationally-representative surveys. *BMC Pediatr* 2012; 12(1):28. BioMed Central.
10. Lubans DR, Morgan PJ, Cliff DP et al. Fundamental movement skills in children and adolescents. *Sports Med* 2010; 40(12):1019–1035. Springer International Publishing.
11. Morano M, Colella D, Caroli M. Gross motor skill performance in a sample of overweight and non-overweight preschool children. *Int J Pediatr Obes* 2011; 6(Suppl. 2 (S2)):42–46.
12. Tonge KL, Jones RA, Okely AD. Correlates of children's objectively measured physical activity and sedentary behavior in early childhood education and care services: a systematic review. *Prev Med* 2016; 89:129–139.
13. Diamond A. Effects of physical exercise on executive functions: going beyond simply moving to moving with thought. *Ann Sports Med Res* 2015; 2(1):1011. NIH Public Access.
14. Venetsanou F, Kambas A. Environmental factors affecting preschoolers' motor development. *Early Child Educ J* 2010; 37(4):319–327. Springer Netherlands.
15. Chow BC, Louie LHT. Difference in children's gross motor skills between two types of preschools. *Percept Mot Skills* 2013; 116(1):253–261, 3rd ed. SAGE PublicationsSage CA: Los Angeles, CA.
16. Pope ML, Liu T, Getchell N. Object-control skills in Hispanic preschool children enrolled in Head Start. *Percept Mot Skills* 2011; 112(1):193–200, 2nd ed. SAGE Publications. Sage CA: Los Angeles, CA.
17. Goodway JD, Robinson LE, Crowe H. Gender differences in fundamental motor skill development in disadvantaged preschoolers from two geographical regions. *Res Q Exerc Sport* 2013; 81(1):17–24. Taylor & Francis Group.
18. Robinson LE, Goodway JD. Instructional climates in preschool children who are at-risk. Part I: object-control skill development. *Res Q Exerc Sport* 2009; 80(3):533–542, 5th ed.
19. Famelia R, Tsuda E, Bakhtiar S et al. Relationships among perceived and actual motor skill competence and physical activity in Indonesian preschoolers. *J Motor Learn Dev* 2018; 6(s2):S403–S423.
20. Aye T, Oo KS, Khin MT et al. Gross motor skill development of 5-year-old Kindergarten children in Myanmar. *J Phys Ther Sci* 2017; 29(10):1772–1778. The Society of Physical Therapy Science.
21. Draper CE, Tomaz SA, Stone M et al. Developing intervention strategies to optimise body composition in early childhood in South Africa. *Biomed Res Int* 2017; 2017(1):5283457–5283513.
22. The World Bank. *Overview: South Africa*, World Bank, 2016 [cited 2017 Apr 11]. Available from: http://www.worldbank.org/en/country/southafrica/overview.
23. Elm von E, Altman DG, Egger M et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *PLoS Med* 2007; 4(10):e296. Public Library of Science.
24. Ulrich DA. *Test of Gross Motor Development-2*, 2nd ed. Austin, TX, Pro-Ed, 2000.
25. Lin LI-K. A concordance correlation coefficient to evaluate reproducibility. *Biometrics* 1989; 45(1):255.
26. McPhillips M, Jordan-Black J-A. The effect of social disadvantage on motor development in young children: a comparative study. *J Child Psychol Psychiatry* 2007; 48(12):1214–1222. Blackwell Publishing Ltd.
27. Colella D, Morano M. Gross motor development and physical activity in kindergarten age children. *Int J Pediatr Obes* 2011; 6(Suppl. 2 (S2)):33–36.
28. Bolsmann C, Parker A. Soccer, South Africa and celebrity status: Mark Fish, popular culture and the post-apartheid state. *Soccer Soc* 2006; 8(1):109–124, 2nd ed.
29. Abdi F, Simbar M. The peer education approach in adolescents — narrative review article. *Iran J Public Health* 2013; 42(11):1200–1206. Tehran University of Medical Sciences.
30. Veldman SLC, Palmer KK, Okely AD et al. Promoting ball skills in preschool-age girls. *J Sci Med Sport* 2017; 20(1):50–54.
31. Uys M, Bassett S, Draper CE et al. Results from South Africa's 2016 report card on physical activity for children and youth. *J Phys Act Health* 2016; 13(11 Suppl. 2):S265–S273.
32. de Villiers A, Steyn NP, Draper CE et al. HealthKick: formative assessment of the health environment in low-resource primary schools in the Western Cape Province of South Africa. *BMC Public Health* 2012; 12(1):794. BioMed Central Ltd.
33. Metcalfe J, Clark S. The mountain of motor development: a metaphor, In: *Motor Development Research and Reviews.* Reston, VA, NASPE Publications, 2002. p. 163–190.

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