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Gross motor skills in toddlers: Prevalence and socio-demographic differences

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Abstract

Objectives: Gross motor skills (GMS) are a vital component of a child's development. Monitoring levels and correlates of GMS is important to ensure appropriate strategies are put in place to promote these skills in young children. The aim of this study was to describe the current level of GMS development of children aged 11-29 months and how these levels differ by age, sex, BMI and socio-economic status. Design: Cross-sectional study. Methods: This study involved children from 30 childcare services in NSW, Australia. GMS were assessed using the Peabody Developmental Motor Scales Second Edition. Prevalence was reported using the gross motor quotient and both raw and standard scores for locomotor, object manipulation and stationary subtests. Socio-demographics were collected via parent questionnaires. Analyses included t-tests, chi-square tests, one-way ANOVA and linear regression models. Results: This study included 335 children (mean age = 19.80 ± 4.08 months, 53.9% boys). For the gross motor quotient, 23.3% of the children scored below average. For the GMS subtests, 34.3% of children scored below average for locomotion, 10.1% for object manipulation and 0.3% for stationary. Boys were more proficient in object manipulation than girls ($p = 0.001$). GMS were negatively associated with age and a higher socio-economic status (all $p < 0.05$). There were no associations for BMI. Conclusions: This is the first descriptive study to show the prevalence of below average at locomotor skills in toddlers is higher than reported in normative samples. Early commencement of GMS promotion is recommended with a focus on locomotor skills and girls' object manipulation skills.

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Gross motor skills in toddlers: Prevalence and socio-demographic differences

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Gross motor skills in toddlers: Prevalence and socio-demographic differences

ABSTRACT

Objectives: Gross motor skills (GMS) are a vital component of a child's development. Monitoring levels and correlates of GMS is important to ensure appropriate strategies are put in place to promote these skills in young children. The aim of this study was to describe the current level of GMS development of children aged 11 to 29 months and how these levels differ by age, sex, BMI and socio-economic status.

Design: Cross-sectional study.

Methods: This study involved children from 30 childcare services in NSW, Australia. GMS were assessed using the Peabody Developmental Motor Scales-2. Prevalence was reported using the gross motor quotient and both raw and standard scores for locomotor, object manipulation and stationary subtests. Socio-demographics were collected via parent questionnaires. Analyses included t-tests, chi-square tests, one-way ANOVA and linear regression models.

Results: This study included 335 children (mean age = 19.80±4.08 months, 53.9% boys). For the gross motor quotient, 23.3% of the children scored below average. For the GMS subtests, 34.3% of children scored below average for locomotion, 10.1% for object manipulation and 0.3% for stationary. Boys were more proficient in object manipulation than girls (p=0.001). GMS were negatively associated with age and a higher socio-economic status (all p<0.05). There were no associations for BMI.

Conclusions: This is the first descriptive study to show the prevalence of below average at locomotor skills in toddlers is higher than reported in normative samples. Early commencement of GMS promotion is recommended with a focus on locomotor skills and girls' object manipulation skills.

Key words: locomotor skills, object manipulation, stability skills, motor development, motor competence, early childhood, children

INTRODUCTION

Gross motor skills (GMS) are a vital component of a child's development[1]. GMS involve movements using the large muscles in the body and can be divided into locomotor skills, object control skills, and stability skills. Locomotor skills are movements that transport the body through space (e.g. run, jump and gallop), object manipulation skills are movements that control and manipulate an object through space (e.g. kick, throw and catch), and stability skills (stationary) involve the ability to sense and adjust to shifts in the relationship between body parts that alter one's balance[1].

Models on motor development have emphasized the importance of GMS competence during childhood to reach advanced motor behavior for specialized movements and sports throughout life[2,3]. The cognitive developmental theory by Piaget (1953) also emphasized the importance of movement for increased cognitive development in especially the early years of life[4]. Research has shown that poor GMS competency has been associated with lower levels of physical activity[5], reduced cognitive abilities[6], unhealthy weight status[5] and lower cardio respiratory fitness[5]. In order to develop gross motor skills, appropriate learning opportunities and practice, specific instruction, encouragement, and feedback are required as these skills do not develop naturally[1,7].

Levels of GMS competence in children have decreased over recent decades[8-10], which is concerning given the number of unfavorable health and developmental outcomes associated with poor GMS competency. It is therefore important to examine and monitor levels of GMS and associated correlates in children, to ensure appropriate strategies are put in place to prevent further decreases and promote GMS development.

To date, few studies have examined levels and correlates of GMS in young children (<5 years)[9-12]. An Australian study assessed gross motor skills in 330 children across 60 preschools (mean age = 4.4 ± 0.4 years; 52% boys)[9]. Results revealed almost 75% of the children mastered the run, but skill mastery was lower for other skills: gallop (31%), hop (25%), jump (22%), strike (14%), catch (20%), kick (35%), and throw (16%). In India, motor development scores reported among 300 children aged between birth and 60 months revealed 'average' scores for the stationary, locomotion and object control subtest compared to the US norms[11]. In Portugal, 540 children aged 36-71 months

were assessed[12]. Portuguese pre-schoolers performed above US norms on the stationary subtests, and below US norms on the locomotion and object control subtests. Studies in children (aged 3-12 years) show that GMS levels differ by sex and type of skills. Generally, boys perform better at object manipulation skills than girls[13,14], whereas findings are equivocal for locomotor skills[9,13,14]. Regarding balance skills, girls tend to outperform boys[14]. Other correlates identified in systematic reviews include age (increasing)[13,14], physical activity (more)[13,14], weight status (healthy)[13], pre-school based programs (presence)[14], and socio-economic status (higher)[13].

Promoting GMS in young children, e.g. toddlers, might be an important avenue to target poor GMS competence and promote healthy developmental trajectories for life. In these early years of life, the brain and central nervous system grow rapidly as new connections or synapses between cells are formed[15]. This makes these years critical for a child's overall as well as motor development[16]. Early commencement of interventions to promote GMS has also been recommended in systematic reviews on GMS interventions[7] and a previous pilot study has shown that interventions aimed at enhancing GMS development in toddlers can be effective, feasible and acceptable[17]. However, to design optimal and appropriate intervention programs, more information about GMS levels and correlates among toddlers is needed to identify those at most need of further intervention and how to intervene. The aims of the current study were to describe the current level of GMS of Australian toddlers aged 11 to 29 months and to describe how these levels differ by age, sex, BMI and socioeconomic status.

METHODS

This cross-sectional study was conducted concurrently with baseline data collection of the Get Up! Study. This was a 12-month 2-arm parallel group cluster randomized controlled trial evaluating the effects of reduced sitting time on toddlers' cognitive development[18].

Children were recruited from Early Childhood Education and Care (ECEC) services across New South Wales, Australia. Information on selection procedures and eligibility criteria for the ECEC services and participants are described elsewhere[18]. Data collectors participated in a two-day training involving instructions and practice sessions regarding the measurements. Prior to data collection, written informed consent was obtained from the participant's parents or caretakers. The study was

approved by the Human Research Ethics Committee of the University of Wollongong, Australia (HE15/236).

GMS were assessed using the GMS subtest of the Peabody Developmental Motor Scales Second Edition (PDMS-2)[19]. This assessment tool has been validated in children aged 0 through 5 years and consists of three subtests: stationary, locomotion and object manipulation. While performing the item, children were assessed on their performance according to the scoring options provided (i.e., "2 – The child performs the item according to the criteria specified for mastery", "1 – The child's performance shows a clear resemblance to the item mastery criteria but does not fully meet the criteria", or "0 – The child cannot or will not attempt to perform the item, or the attempt does not show that the skill is emerging"). Per item, children had three trials to receive a score of 2. The entry point of the test was determined by the child's age and the child receiving a score of 2 on the first three items. If a child was not able to meet these requirements, the test was administered backwards until the child reached three consecutive '2' scores. The assessment finished when a child received a score of 0 on three consecutive items. The total amount of points accumulated on a subtest (raw score) was converted into a standard score using the examiner's manual[19].

Standard scores were labelled 'Very superior', 'Superior', 'Above average', 'Average', 'Below average', 'Poor' and 'Very poor'. The Gross Motor Quotient (GMQ) was derived from the standard scores. Due to small numbers, children labelled 'Very superior', 'Superior' and 'Above average' were grouped as 'Above average' and children labelled 'Below average', 'Poor' and 'Very poor' were grouped as 'Below average' for analysis.

Standardized procedures were used to measure height and weight. The child was lightly dressed while heavy coats, pocket items, shoes and diapers were removed. Body Mass Index (BMI; weight (kg)/height (m^2)) was calculated using height and weight measures. More detail on the assessment procedures has been published elsewhere[18].

Information on the child's date of birth, sex and socio-economic status was collected via parent questionnaires. Socio-economic status was determined based on the Australian Socio-Economic Index for Areas (SEIFA Index), mother's education, mother's employment and family income. The SEIFA Index was developed by the Australian Bureau of Statistics and ranks areas

according to relative socio-economic disadvantage. This index ranges from 1; most disadvantaged, to 10; least disadvantaged, is based on the postcode and was categorized as low (decile 1-3), middle (decile 4-6) and high (decile 7-10). Mother's education was categorized as no schooling/did not complete primary school, primary school or equivalent, Year 10 or equivalent, Year 12 or equivalent, trade/apprenticeship/certificate, university degree, and post-graduate qualification. For the purpose of analyses, the groups 'no schooling/did not complete primary school', 'primary school or equivalent' and 'Year 10 or equivalent' were combined given the low numbers in those groups. Mother's employment was categorized as full-time employment, part-time employment and unemployed. Family income was categorized as one parent earning <A$580/week, both parents earning <A$580/week each, one parent earning <A$580/week and one parent earning A$580-A$1240/week, both parents earning A$580-A$1240/week or one parent earning <A$580 and the other parent earning >A$1240, one parent earning A$580-A$1240/week and other parent earning >A$1240, and both parents earning >A$1240/week.

SPSS version 21[20] and STATA version 13[21] were used for data analyses. Descriptive analyses were presented as mean ± standard deviation (SD) and percentages. Sex differences were examined using Mann-Whitney and two-tailed student's t-tests for not normally and normally distributed continuous variables, respectively. Chi-square tests were conducted for categorical variables. Given the rapid development of children at this young age and the age range of 1.5 years, GMS were also examined separately for children below and above 20 months (corresponds to mean and median for age). A one-way ANOVA with post-hoc Bonferroni analysis was conducted to examine differences between the four subgroups: girls and boys below 20 months, and girls and boys above 20 months. Standard scores were used for analysis to compare scores across sex and age.

The associations between socio-demographic factors and GMS were investigated using linear regression procedures in STATA accounting for clustering of ECEC services. The GMQ was used for this analysis as this is recommended in the manual[19]. All selected variables were independently entered into linear regression models to investigate associations with GMS. These models were then adjusted for sex and age. The significance level for all tests was set at $p<0.05$.

RESULTS

In total, 335 children aged 11 to 29 months (mean age = 19.80±4.08 months, 53.7% boys) completed all GMS measures and were therefore included in this study.

The prevalence of GMS and descriptive statistics are reported in Table 1. Results show 23.3% of the children scored below average, 69.8% of the children scored average and 6.9% of the children scored above average for the gross motor quotient. For the different subtests, the number of children scoring below average was 34.3% for locomotion and 10.1% for object manipulation. Only one child performed below average on the stationary subtest (0.3%).

Data on socio-economic variables were collected in 59%-100% of participants depending on the individual variable from the parent questionnaire. For mother's education, 10.0% reported a highest education of Primary school, Year 10 or equivalent; while 16.1% reported a highest education of level Year 12 or equivalent. Regarding mothers' employment status, 9.1% reported to be unemployed. Family income was reported to be below $580/week in 5.1% of the families.

---- Insert Table 1 here----

Table 2 (and figure S1) reports the prevalence of GMS for boys and girls separately by age. Boys performed significantly better than girls in object manipulation, both below and above 20 months ($p < 0.005$). Results of the ANOVA revealed differences between groups for locomotion ($F_{(3,331)} = 9.473$, $p<0.001$) and object manipulation ($F_{(3,331)} = 2.818$, $p = 0.39$). Post-hoc analysis revealed significant differences for locomotion, where girls below 20 months scored better than boys above 20 months (MD = 1.346; $d = 0.324$; $p < 0.001$), and boys below 20 months scored better than both boys and girls above 20 months (MD = 0.682; $d = 0.211$; $p < 0.05$ and MD = 0.876; $d = 0.391$; $p < 0.05$ respectively). For object manipulation, boys below 20 months scored better than girls above 20 months (MD = 0.898; $d = 0.216$; $p < 0.05$).

Socio-demographic factors associated with GMS are reported in Table 3. After adjusting for sex, GMS were negatively associated with age. GMS was also negatively associated with Socio-economic status (SEIFA index; $p < 0.05$) and mother's education ($p < 0.005$) after adjusting for age and sex.

---- Insert Tables 2 and 3 here----

DISCUSSION

Our results show that GMS development is below average in almost a quarter of the children assessed (23.3%). A comparable study in India among 121 toddlers (12-33 months)[11] showed similar results with only a small difference in locomotion (5% difference) in favor of the Indian sample. When comparing results to a Portuguese sample of 162 children (aged 3 years)[12], the current sample scored lower on all subtests of the PDMS-2. Results can also be compared to the US norm sample. The percentage of children scoring below average on the GMQ (23.3%) is comparable as 'below average' was set at the 25th percentile. Results from the locomotor subtest showed more children scored below average compared to the US norm sample (34.3%), whereas less children scored below average for object manipulation (10.1%) and stationary skills (0.3%). Comparing the number of children who scored 'average' to the US norm sample (50%), this number is higher for the GMQ (69.8%) and the different subtests (ranging from 63.6% to 96.4%). The number of children scoring 'above average' (ranging from 2.1% to 8.7%) is lower compared to the US norm sample (25%).

Research has shown several factors have an influence on GMS and might therefore explain differences in results between studies. Child characteristics such as sex and age seem to play an important role in GMS[13,14] and aforementioned studies were conducted in slightly different age groups and sex distributions. Other child characteristics include intrinsic motivation and cognitive development[1,4], and the physical readiness of a child to move and develop GMS[1]. Family-related characteristics that could have an influence on GMS include cultural background and parental physical activity and sports participation, and environmental factors potentially influencing GMS include ECEC-related factors (e.g. well-developed curricula) as these have a positive influence on GMS[14,22]. As these factors were not assessed or reported in the current study or the other studies, no conclusions could be drawn regarding their influence on GMS. These factors need to be examined in more detail in further studies. More importantly, the relationships between GMS and different child-, family-, and environmental factors are likely to be more complex as these factors might influence each other. Therefore, there is also a need to examine the interactions between these factors and how

they change with age and development. Additionally, methodological differences such as sample size (e.g. 335 children in the current study vs 121 in Indian study) may explain differences in results.

Within our sample, boys scored significantly higher than girls in the object manipulation. This trend is also seen in preschoolers[9,10], showing sex differences are consistently present in young children. For locomotion, several differences were found between different sex and age groups. Young girls scored better than older boys and young boys scored better than both older boys and girls. This is line with previous research showing mixed results as some studies showed results in favor of girls[8,9], while others found no sex differences[10,23]. Sex differences in gross motor development in young children are likely to be associated with social and environmental influences, such as family, peers and teachers, and cultural background rather than biological or physiological factors[24]. Therefore, it is important that parents, ECEC educators and policy makers are aware of these differences to ensure that girls are provided with the most appropriate GMS opportunities, instruction and feedback with the aim of fostering skill development. Additionally, sufficient opportunities should be provided to boys with high object manipulation skills to ensure continuous skill development.

Age was negatively associated with the GMQ, meaning that with increasing age children scored lower. A similar result was seen examining sex and age differences for different subtests. For locomotion, younger children (<20 months) scored better than older children (>20 months). For object manipulation, younger boys scored better than older girls. Children increase their raw scores over time (see Table 2), however, standardized scores (age- and sex adjusted scores) are lower for the older age group. This reinforces the need for early intervention to prevent children from being at risk of developmental delay and to promote healthy developmental trajectories. Most previous studies used raw scores to examine age effects on GMS[13,23]. Raw scores have a larger range compared to standardized scores, making them more sensitive to change and therefore commonly used in intervention studies. However, the use of standardized scores is important for comparing differences in GMS levels across age and sex.

Children with a low SEIFA Index scored higher than children with a middle or high SEIFA Index. This is in contrast with the literature suggesting childhood poverty and a lower socio-economic

status have a negative influence on overall child development and GMS[14,25]. A potential explanation includes more free play opportunities for children with a low SEIFA Index which can lead to some skill enhancement even though actual teaching is needed for skill mastery[7]. Other potential explanations include the distribution between socio-economic status (SEIFA Index) groups or the fact that this generalized index, based on postcode of residence, is perhaps not accurate enough as individual or preschool-related factors are not considered. More research will be needed to confirm a relationship between socio-economic status and gross motor skills in toddlers.

A mother's higher education was negatively associated with GMS; however, this was only significant in half of the categories. Previous studies have found mixed results[22,26]. No significant associations between mother's education and GMS have been seen in children aged 18 months[26], whereas they are present in children aged 4 to 6 years[22]. These results imply that this association might be influenced by the child's age which is consistent with a longitudinal study on correlates of poor development in preschoolers[27].

Strengths of this study include the young age of participants, the relative large sample size and the use of a validated GMS assessment. A limitation of this study is the use of US norms in Australian toddlers, which means that our results should be carefully interpreted due to cultural influences. There are currently no Australian norms available. Limitations regarding the methodology include the cross-sectional design of the study which precludes causality, the selection of variables to associate with GMS and the lack of inter- and intra-rater reliability assessments. Additionally, our sample is not representative of Australian toddlers and therefore our results are not generalizable beyond the population from which they were sampled.

Future studies should include longitudinal designs to track children over time and identify at what age gross motor skills levels might be most sensitive to intervention. Research needs to examine and identity what factors (including parental/family and environmental factors) explain potential changes in GMS levels to identify where and how to potentially intervene. Additionally, country- and cultural-specific norms for GMS assessments should be developed to increase the validity of outcomes.

CONCLUSIONS

In this sample of Australian toddlers, the levels of GMS are associated with age and socio-economic status. To our knowledge, this was the first study to examine the prevalence of GMS in Australian toddlers and one of the first internationally. This study showed just over a third of the children scored below average on the locomotion subtest and it is therefore recommended to include a special focus on locomotion skills in GMS interventions. Additionally, girls scored significantly lower than boys in object manipulation skills. Given that these sex differences are seen throughout childhood[13] and childhood object manipulation skills might be related to adolescent physical activity[28], a focus on object manipulation skills in girls is also recommended. Two recent papers have examined an object manipulation intervention targeting girls[29,30]. Results were promising but more interventions in this area are needed to target the sex differences observed and potentially target physical activity.

The authors recommend early commencement of GMS promotion as young children are willing to learn and practice, before poor techniques have developed and as differences in skill levels are still small. These interventions should have a special focus on locomotor skills and girls' object manipulation skills. Early intervention can prevent children from being behind in their GMS development when entering school and can promote a positive developmental trajectory.

Practical implications

- GMS promotion should commence as early as possible.
- GMS are associated with age, sex and socio-economic status.
- The use of standardized scores are recommended for prevalence studies.

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References

1. Payne VG, Isaacs LD. *Human Motor Development: A Lifespan Approach,* 8th ed, McGraw-Hill Education; 2011. 11-21 p.
2. Seefeldt V. Developmental motor patterns: Implications for elementary school physical education., in *Psychology of motor behavior and sport.* Nadeau C, Holliwell W, Newell K, Roberts G, ed^eds. Champaign, IL, Human Kinetics, 1980.
3. Clark JE, Metcalfe JS. The mountain of motor development: A metaphor., in *Motor development: Research and reviews.* Clark JE, Humphrey JH, ed^eds. Reston, VA, National Association of Sport and Physical Education., 2002.
4. Piaget J, Cook M. *The origins of intelligence in children*, International Universities Press New York; 1952. 145-330 p.
5. Lubans DR, Morgan PJ, Cliff DP, et al. Fundamental Movement Skills in Children and Adolescents: Review of Associated Health Benefits. *Sports Med.* 2010; 40(12):1019-1035.
6. van der Fels IM, Te Wierike SC, Hartman E, et al. The relationship between motor skills and cognitive skills in 4-16 year old typically developing children: A systematic review. *J Sci Med Sport.* 2015; 18(6):697-703.
7. Veldman SLC, Jones RA, Okely AD. Efficacy of gross motor skill interventions in young children: an updated systematic review. *BMJ Open Sport Exerc Med.* 2016; 2(1):e000067.
8. Hardy LL, Reinten-Reynolds T, Espinel P, et al. Prevalence and correlates of low fundamental movement skill competency in children. *Pediatrics.* 2012; 130(2):390-398.
9. Hardy LL, King L, Farrell L, et al. Fundamental movement skills among Australian preschool children. *J Sci Med Sport.* 2010; 13(5):503-508.
10. Bardid F, Huyben F, Lenoir M, et al. Assessing fundamental motor skills in Belgian children aged 3-8 years highlights differences to US reference sample. *Acta paediatrica (Oslo, Norway : 1992).* 2016; 105(6):e281-290.
11. Tripathi R, Joshua AM, Kotian MS, et al. Normal motor development of Indian children on Peabody Developmental Motor Scales-2 (PDMS-2). *Pediatr Phys Ther.* 2008; 20(2):167-172.

12. Saraiva L, Rodrigues LP, Cordovil R, et al. Motor profile of Portuguese preschool children on the Peabody Developmental Motor Scales-2: a cross-cultural study. *Res Dev Disabil.* 2013; 34(6):1966-1973.
13. Barnett LM, Lai SK, Veldman SL, et al. Correlates of Gross Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Med.* 2016; 46(11):1663-1688.
14. Iivonen S, Sääkslahti AK. Preschool children's fundamental motor skills: a review of significant determinants. *Early Child Dev Care.* 2013; 184(7):1107-1126.
15. Shonkoff JP, Phillips DA. *From neurons to neighborhoods: The science of early childhood development*, Washington: National Academy Press; 2000. 275-80 p.
16. Gale CR, O'Callaghan FJ, Godfrey KM, et al. Critical periods of brain growth and cognitive function in children. *Brain.* 2004; 127(2):321-329.
17. Veldman SLC, Okely A, D.,, Jones RA. Promoting Gross Motor Skills in Toddlers: The Active Beginnings Pilot Cluster Randomized Trial. *Perceptual and motor skills.* 2015; 121(3):857-872.
18. Santos R, Cliff DP, Howard SJ, et al. "GET-UP" study rationale and protocol: a cluster randomised controlled trial to evaluate the effects of reduced sitting on toddlers' cognitive development. *BMC pediatrics.* 2016; 16(1):182.
19. Folio MK, Fewell R. *Peabody Developmental Motor Scales: Examiner's Manual*, 2nd ed, Austin, Tex, PRO-ED, Inc.; 2000. 1-125 p.
20. IBMCorp. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp; 2012.
21. StataCorp. Stata Statistical Software: Release 13. In: Station C, ed. TX: StataCorp LP.; 2015.
22. Cools W, De Martelaer K, Samaey C, et al. Fundamental movement skill performance of preschool children in relation to family context. *J Sports Sci.* 2011; 29(7):649-660.
23. Saraiva L, Rodrigues LP, Cordovil R, et al. Influence of age, sex and somatic variables on the motor performance of pre-school children. *Ann Hum Biol.* 2013; 40(5):444-450.
24. Thomas JR, French KE. Gender differences across age in motor performance: a meta-analysis. *Psychol Bull.* 1985; 98(2):260-282.

25. McPhillips M, Jordan-Black JA. The effect of social disadvantage on motor development in young children: a comparative study. *J Child Psychol Psychiatry.* 2007; 48(12):1214-1222.
26. Koutra K, Chatzi L, Roumeliotaki T, et al. Socio-demographic determinants of infant neurodevelopment at 18 months of age: Mother-Child Cohort (Rhea Study) in Crete, Greece. *Infant behavior & development.* 2012; 35(1):48-59.
27. To T, Cadarette SM, Liu Y. Biological, social, and environmental correlates of preschool development. *Child: care, health and development.* 2001; 27(2):187-200.
28. Barnett LM, van Beurden E, Morgan PJ, et al. Childhood motor skill proficiency as a predictor of adolescent physical activity. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine.* 2009; 44(3):252-259.
29. Robinson LE, Veldman SLC, Palmer KK, et al. A Ball Skills Intervention in Preschoolers: The CHAMP Randomized Controlled Trial. *Med Sci Sports Exerc.* 2017; 49(11):2234-2239.
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.

390 Table 1: Participants' characteristics.

		All (n = 335) mean ± SD	Girls (n=155) mean ± SD	Boys (n=180) mean ± SD	*p*[a]
Age (months)		19.80 ± 4.08	19.69 ± 4.05	19.89 ± 4.12	0.645
Height (cm)		82.36 ± 5.27	81.40 ± 5.53	83.19 ± 4.90	**0.002**[b]
Weight (kg)		12.10 ± 1.58	11.72 ± 1.59	12.42 ± 1.50	**0.000**[b]
Body Mass Index (kg/m^2)		17.84 ± 1.69	17.71 ± 1.75	17.96 ± 1.63	0.179[b]
Gross Motor quotient		96.41 ± 9.84	96.30 ± 9.66	96.50 ± 10.03	0.455
Locomotion Raw score (range 0 - 178)		88.58 ± 11.87	88.32 ± 12.88	88.81 ± 10.97	0.483
Locomotion Standard Score (range 1 -20)		8.42 ± 2.21	8.52 ± 2.20	8.33 ± 2.21	0.348
Object Manipulation Raw score (range 0 - 48)		14.30 ± 5.90	13.32 ± 6.11	15.14 ± 5.60	**0.003**
Object Manipulation Standard Score (range 1 -20)		9.86 ± 2.20	9.53 ± 2.31	10.15 ± 2.06	**0.001**
Stationary Raw score (range 0 - 60)		38.84 ± 1.89	38.97 ± 2.18	38.73 ± 1.59	0.757
Stationary Standard Score (range 1 -20)		10.12 ± 1.24	10.23 ± 1.32	10.02 ± 1.17	0.295
		n (%)	n (%)	n (%)	
Gross motor skills (n = 335)	Below average	78 (23.3%)	35 (22.6%)	43 (23.9%)	
	Average	234 (69.8%)	110 (71.0%)	124 (68.9)	0.885
	Above Average	23 (6.9%)	10 (6.5%)	13 (7.2%)	
Locomotion (n = 335)	Below average	115 (34.3%)	49 (31.6%)	66 (36.7%)	
	Average	213 (63.6%)	104 (67.1%)	109 (60.6%)	0333[c]
	Above Average	7 (2.1%)	2 (1.3%)	5 (2.8%)	
Object Manipulation (n = 335)	Below average	34 (10.1%)	19 (12.3%)	15 (8.3%)	
	Average (n, %)	272 (81.2%)	125 (80.6%)	147 (81.7%)	0.422
	Above Average	29 (8.7%)	11 (7.1%)	18 (10.0%)	
Stationary (n = 335)	Below average	1 (0.3%)	0	1 (0.6%)	
	Average	323 (96.4%)	146 (94.2%)	177 (98.3%)	-
	Above Average	11 (3.3%)	9 (5.8%)	2 (1.1%)	
SEIFA index[d] (n=335)	Low (decile 1 – 3)	146 (43.6%)	61 (39.4%)	85 (47.2%)	
	Middle (decile 4 - 6)	135 (40.3%)	69 (44.5%)	66 (36.7%)	0.293
	High (decile 7 – 10)	54 (16.1%)	25 (16.1%)	29 (16.1%)	

Mothers' Education (n=230)	Primary school or Year 10 or equivalent	23 (10.0%)	14 (9.0%)	9 (5.0%)	0.389
	Year 12 or equivalent	37 (16.1%)	17 (11.0%)	20 (11.0%)	
	Trade/apprenticeship/certificate	79 (34.3%)	43 (27.7%)	36 (19.9%)	
	University degree	59 (25.7%)	24 (15.5%)	36 (19.3%)	
	Post-graduate qualification	32 (13.9%)	17 (11.0%)	15 (8.3%)	
Mothers' Employment (n=231)	Full-time	92 (39.8%)	46 (40.0%)	46 (39.7%)	0.979
	Part-time	118 (51.1%)	59 (51.3%)	59 (50.9%)	
	Unemployed	21 (9.1%)	10 (8.37%)	11 (9.5%)	
Family Income[e] (n=198)	1 or 2 (low)	10 (5.1%)	7 (7.1%)	3 (3.0%)	0.408
	3	41 (20.7%)	22 (22.2%)	19 (19.2%)	
	4	90 (45.5%)	44 (44.4%)	46 (46.5%)	
	5	42 (21.2%)	17 (17.2%)	25 (25.3%)	
	6 (high)	15 (7.6%)	9 (9.1%)	6 (6.1%)	

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[a] Two-tailed Student's t-test for continuous variables and Chi-square test for categorical variables.

[b] Mann Whitney test.

[c] Chi-square test was performed after collapsing the categories average and above average.

[d] SEIFA Index: Australian Socio-Economic Index for Areas

[e] Categories Family Income: 1 – one parent <A$580/week; 2 - both parents <A$580/week each; 3 - one parent <A$580/week and other between A$580 and A$1240/week; 4 - both parents between A$580 and A$1240/week OR one parent <A$580 and other >A$1240; 5 - one parent between A$580 and A$1240/week and other parent >A$1240; 6 - both parents >A$1240/week

406 Table 2: Prevalence of Gross Motor Skill Development by age.

Variable		**Age <20 months (n = 178)**			**Age >20 months (n = 157)**		
		Girls (n = 81)	**Boys (n = 97)**	***p*[a]**	**Girls (n = 74)**	**Boys (n = 83)**	***p*[a]**
Gross Motor skills	Gross Motor Quotient (range 35-165)	96.91 ± 8.34	98.26 ± 11.02	0.057	95.62 ± 10.93	94.45 ± 8.34	0.503
Locomotion	Raw score (range 0 - 178)	79.91 ± 8.60	82.05 ± 8.13	0.083	97.51 ± 10.24	96.70 ± 8.25	0.899
	Standard Score (range 1 -20)	8.84 ± 1.97	9.05 ± 2.15	0.727	8.18 ± 2.40	7.49 ± 1.99	0.087
Object Manipulation	Raw score (range 0 - 48)	9.89 ± 5.27	11.69 ± 4.58	**0.003**	17.08 ± 4.58	19.17 ± 3.67	**0.001**
	Standard Score (range 1 -20)	9.62 ± 2.34	10.33 ± 2.25	**0.003**	9.43 ± 2.29	9.94 ± 1.80	0.196
Stability	Raw score (range 0 - 60)	37.91 ± 0.74	37.98 ± 1.14	0.551	40.14 ± 2.61	39.61 ± 1.61	0.641
	Standard Score (range 1 -20)	10.11 ± 0.76	10.06 ± 1.04	0.745	10.35 ± 1.73	9.98 ± 1.31	0.269

407 [a] Mann-Whitney Test

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Table 3: Socio-demographic factors associated with Gross Motor Skill Development (GMQ)

Variable		Unadjusted Models		Adjusted Models[a]	
		B	**95% CI**	**B**	**95% CI**
Age		-0.486*	[-0.754, -0.217]	-	-
Sex	Girls (reference)				
	Boys	0.203	[-1.842, 2.249]	0.300	[-1.731, 2.331][b]
BMI		0.415	[-0.244, 1.075]	0.061	[-0.529, 0.651]
SEIFA Index	Low (reference)				
	Middle	-2.334	[-4.982, 0.313]	-2.740*	[-5.244, -0.236]
	High	-3.416*	[-6.637, -0.194]	-3.589*	[-6.812, -0.365]
Mothers' Education	Primary school or Year 10 or equivalent (reference)				
	Year 12 or equivalent	-5.213*	[-10.410, -0.015]	-5.216*	[-10.340, -0.092]
	Trade/apprenticeship/certificate	-3.069	[-7.492, 1.354]	-3.298	[-7.710, 1.114]
	University degree	-4.229	[-8.488, 0.029]	-4.170*	[-8.324, -0.017]
	Post-graduate qualification	-4.567	[-9.706, 0.573]	-4.775	[-10.213, 0.664]
Mothers' Employment	Employed full-time (reference)				
	Employed part-time	-2.878*	[-5.500, -0.256]	-2.575	[-5.239, 0.089]
	Not employed	-2.465	[-6.872, 1.943]	-1.785	[-6.211, 2.641]
Family Income[c]	1 and 2 (low) (reference)				
	3	-1.068	[-8.200, 6.063]	-0.781	[-7.562, 6.001]
	4	-0.700	[-6.218, 4.817]	-0.935	[-6.234, 4.363]
	5	-0.514	[-6.633, 5.605]	-0.176	[-6.033, 5.682]
	6 (high)	-3.533	[-11.238, 4.165]	-2.775	[-9.956, 4.406]

[a] Adjusted for sex and age

[b] Only adjusted for age.

[c] Categories Family Income: 1 – one parent < 580 $ / week, 2 - both parents < 580 $ / week each, 3 - one parent < 580 $ / week and other > 580 $ / week, 4 - both parents between 580 $ and 1240 $ / week OR one parent < 580$ and other > 1240 $, 5 - one parent between 580 $ and 1240 $ / week and other parent >1240 $, 6 - both parents > 1240 $ / week

* $p < 0.05$