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Associations between gross motor skills and physical activity in Australian toddlers

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ABSTRACT

Objectives: Physical activity can be promoted by high levels of gross motor skills. A systematic review found a positive relationship in children (3–18 years) but only few studies examined this in younger children. The aim of this study was to examine the association between gross motor skills and physical activity in children aged 11–29 months.
Design: Cross-sectional study.
Methods: This study involved 284 children from 30 childcare services in NSW, Australia (Mean age = 19.77 ± 4.18 months, 53.2% boys). Physical activity was measured using accelerometers (Actigraph GT3X+). Gross motor skills were assessed using the Peabody Developmental Motor Scales Second Edition (PDMS-2). Multilevel linear regression analyses were computed to assess associations between gross motor skills and physical activity, adjusting for sex, age and BMI.
Results: Children spent 53.08% of their time in physical activity and 10.39% in moderate to vigorous physical activity (MVPA). Boys had higher total physical activity ($p < 0.01$) and MVPA ($p < 0.01$) than girls. The average gross motor skills score was 96.16. Boys scored higher than girls in object manipulation ($p < 0.001$). There was no association between gross motor skills and total physical activity or MVPA.
Conclusions: Although gross motor skills were not associated with physical activity in this sample, stronger associations are apparent in older children. This study therefore highlights a potential important age to promote gross motor skills.

Introduction

Physical activity is essential for healthy growth and development, and has been associated with physical, psychosocial, and cognitive health throughout childhood.[1,2] However, physical inactivity is a growing public health concern[3] and in addition to the increased morbidity,[3] is responsible for a large economic burden.[4] Therefore, promoting physical activity, especially across the lifespan, is a key public health priority.

One way of increasing physical activity might be through promoting high levels of gross motor skill competence. Gross motor skills are seen as the building blocks and foundation of movement and physical activity, and are therefore a vital component throughout life.[5] Models on motor development have also highlighted the importance of gross motor skill competence for advanced motor behavior.[6,7] For example, the "proficiency barrier" suggests a certain level of gross motor skill competence is necessary to be able to engage in games and sports.[6] Gross motor skills comprise locomotor skills, object control skills and stability skills, and include jumping, running, kicking and throwing.[5] They have been associated with several health-related and developmental outcomes across childhood and adolescence such as weight status,[8,9] self-perceptions,[8] cognition[10] and cardio-respiratory fitness.[8,9]

Two recent systematic reviews found a positive relationship between gross motor skill competence and physical activity in children and adolescents.[11,12] However, only a few studies have examined this relationship in the early years of life (<5 years), with results inconclusive. Some studies found significant positive but weak associations[13–15] while other studies found no associations.[16–18] Of these studies, three examined sex differences

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within this association in preschool-aged children (ages 3–5 years) and one also examined age differences. Williams et al. found weak, but significant positive associations between total motor performance and moderate-to-vigorous physical activity (MVPA; r = 0.20, $p < 0.01$) and vigorous physical activity (VPA; r = 0.26, $p < 0.001$) in children aged 3–4 years.[16] When stratifying this sample by age, they found significant associations between total motor skill performance and physical activity in children aged 4 years but not for children aged 3 years. The only sex difference found was in VPA, with boys spending more time in VPA compared to girls. Fisher et al. also found weak, but significant correlations between total movement skills score and total physical activity (r = 0.10, $p = 0.039$) as well as MVPA (r = 0.18, $p < 0.001$) in 4-year-old children.[14] These correlations were similar when examining boys and girls separately. Cliff et al., in contrast with the other two studies, did find sex differences in the association between motor skills and physical activity. They found a positive association between ball skills and time spent in MVPA (r = 0.52, $p = 0.008$) and total physical activity (r = 0.37, $p = 0.015$) among preschool-aged boys, while locomotor skills and MVPA among preschool-aged girls were inversely associated (r = −0.52, $p = 0.015$).[19] Reasons for the inconclusive evidence on the relationship between gross motor skills and physical activity may be explained by differences in samples (e.g. size, age group, socio-economic status) and methodologies. Indeed, gross motor skills were measured using different assessment tools (e.g. performance criteria used, process versus product-oriented assessment, norms used) and physical activity was measured in different ways (e.g. questionnaires vs accelerometers, cut-points used, epoch length).

Currently, few studies have examined the associations between gross motor skill development and physical activity in children under the age of three and these studies have several methodological limitations. They examined the association in toddlers using either an observational motor assessment mostly used to identify neurological dysfunctions ("neurological examination technique for toddler-age" according to Hempel)[17] or a parent questionnaire to screen for gross motor delay (the Minnesota Infant Development Inventory).[18] The methods used to measure physical activity were not all validated in toddlers (e.g. step counts from wrist placement or cut-points used for analyses). The present study will attempt to overcome the limitations of previous research and increase the knowledge and understanding of gross motor skill development and physical activity in young children. The aim of this study was to examine the associations between the gross motor skills outcomes (locomotor, object manipulation and stability) and objectively measured physical activity in children aged 11–29 months. Addressing this gap might contribute to strategies for health promotion.

Methods

This cross-sectional study was conducted concurrently with the baseline data collection of the 'Get Up' study. The rationale and protocol for the GET UP! STUDY can be found elsewhere.[20] The 'Get Up' study was a 12-month two-arm parallel group cluster randomized controlled trial which is currently evaluating the effects of reduced sitting time on toddlers' cognitive development. Reporting was done following the STROBE Statement.[21]

Children were recruited via Early Childhood Education and Care (ECEC) services across New South Wales, Australia. Services were eligible if they had at least one classroom of toddlers from a low- to medium-socioeconomic background. Children were considered ineligible if they had any disabilities, were born very preterm or were diagnosed with a medical condition. More information on the selection procedures for these services as well as eligibility criteria for participants are described in the previously published methods paper.[20] Recruitment started in October 2015 and took eight months. The initial aim was to recruit 16 centers with an average of 20 children per center. However, the number of children per center was lower than expected and therefore 30 ECEC services were recruited with an average of 12 children per center. This was done to ensure adequate statistical power for the original study (GET UP Study). Data collection took place between March and August 2016 through week-long visits in the participating centers by trained data collectors. Training for data collectors took place over two days at the University of Wollongong and involved instructions and practical sessions. Prior to data collection, written informed consent was obtained from the participant's parents or carers. The study was approved by the Human Research Ethics Committee of the University of Wollongong, Australia (HE15/236) and was registered in the Australian New Zealand Clinical Trials Registry: ACTRN12616000471482, 11/04/2016 (retrospectively registered).

Physical activity was measured using tri-axial accelerometers (Actigraph GT3X+).[22] An epoch of 30 Hz was used, and then files were reintegrated in 15 s epochs. Children were asked to wear the accelerometers 24 h/day over seven consecutive days except for water-based activities. All data were checked for wear time. Sleep- and nap-time were excluded from the present analyses. Valid wear time was defined as a minimum of 1 day, with at least 4 h of recorded data given the exclusion of naps and sleep.[23] Non-wear time was defined as 20 min of consecutive zeros. Physical activity was analyzed using the following classifications: percentage of total wear time spent in sedentary (≤100 counts/min), light physical activity (LPA, 101–1680 counts/min), and moderate-to-vigorous physical activity (MVPA, >1680 counts/min). These cut points have been recommended for toddlers.[22] For the purpose of analysis, LPA and MVPA was grouped together as total physical activity. Accelerometer data were analyzed using the Actilife software (Version 6).

Gross motor skills were assessed using the gross motor skill subtest of the Peabody Developmental Motor Scales Second Edition (PDMS-2).[24] This assessment consists of three subtests: locomotion, object manipulation and stationary and has been validated in children aged 0 through 5 years. All PDMS-2 subtests showed good internal consistency ($\alpha = 0.76$–0.95) and test-retest reliability (ICC = 0.85–0.95).[24] Items were administered by trained data collectors by demonstrating the item correctly. The entry point of the test was based on the decimal age of the child and a child was required to perform the first three items correctly (e.g. a score of 2). If a child was not able to meet these requirements, the test was administered backwards until requirements were met. The assessment finished when a child received a score of 0 on three consecutive items. Children were assessed on their performance by a single trained data collector according to the scoring options provided per item (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 the item, or the attempt does not show that the skill is emerging"). Up to three trials per item were allowed to receive a score of 2. The total amount of points accumulated by a child on a subtest (raw score) was converted into a standard score using the examiner's manual and software provided.[24] Using the standard scores of the three subtests, the Gross Motor Quotient (GMQ) was determined.

Height and weight were measured following standard procedures.[20] Height was measured to the nearest 0.1 cm using a Seca 254 portable stadiometer (Hamburg, Germany). The child was positioned standing upright in bare feet or socks and with their head in the Frankfort Plane. Weight was measured to the nearest 0.1 kg using a portable electronic Seca 254 Scale (Hamburg, Germany). The child was lightly dressed while heavy coats, heavy