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Child, family and environmental correlates of children's motor skill proficiency

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Publication Details

Barnett, L. M., Hinkley, T., Okely, A. D. & Salmon, J. (2013). Child, family and environmental correlates of children's motor skill proficiency. *Journal of Science and Medicine in Sport*, 16 (4), 332-336.

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Abstract

To identify factors associated with children's motor skills. Cross-sectional. Australian preschool-aged children were recruited in 2009 as part of a larger study. Parent proxy-report of child factors (age, sex, parent perception of child skill, participation in unstructured and structured activity), self-report of parent factors (confidence in their own skills to support child's activity, parent-child physical activity interaction, parent physical activity) and perceived environmental factors (play space visits, equipment at home) were collected. Moderate to vigorous physical activity (MVPA) (ActiGraph GT1M accelerometer) and motor skills (Test of Gross Motor Development-2) were also assessed. After age adjustment, variables were checked for association with raw object control and locomotor scores. Variables with associations of $p < 0.20$ were entered into two multiple regression models with locomotor/object control as respective outcome variables. Motor skills were assessed for 76 children (42 female), mean [SD] age-4.1 [0.68]: 71 completed parent proxy-report and 53 had valid MVPA data. Child age, swimming lessons, and home equipment were positively associated explaining 20% of locomotor skill variance, but only age was significant ($\beta = 0.36$, $p = 0.002$). Child age and sex, unstructured activity participation, MVPA%, parent confidence, home equipment (all positively associated), and dance participation (inversely associated) explained 32% object control variance. But only age ($\beta = 0.67$, $p < 0.0001$), MVPA% ($\beta = 0.37$, $p = 0.038$) and no dance ($\beta = -0.34$, $p = 0.028$) were significant. Motor skill correlates differ according to skill category and are context specific with child level correlates appearing more important.

Keywords

era2015, proficiency, children, skill, correlates, environmental, family, child, motor

Disciplines

Education | Social and Behavioral Sciences

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1 **Abstract**

2 **Objectives:** To identify factors associated with children's motor skills. **Design:** Cross-sectional.

3 **Methods:** Australian preschool-aged children were recruited in 2009 as part of a larger study. Parent
4 proxy-report of child factors (age, sex, parent perception of child skill, participation in unstructured
5 and structured activity), self-report of parent factors (confidence in their own skills to support child's
6 activity, parent-child physical activity interaction, parent physical activity) and perceived
7 environmental factors (play space visits, equipment at home) were collected. Moderate to Vigorous
8 Physical activity (MVPA) (Actigraph GT1M accelerometer) and motor skills (Test of Gross Motor
9 Development-2) also assessed. After age adjustment, variables were checked for association with raw
10 object control and locomotor scores. Variables with associations of $p < .20$ were entered into two
11 multiple regression models with locomotor/object control as respective outcome variables. **Results:**
12 Motor skills were assessed for 76 children (42 female), mean [SD] age = 4.1 [0.68]; 71 completed
13 parent proxy-report and 53 had valid MVPA data. Child age, swimming lessons, and home equipment
14 were positively associated explaining 20% of locomotor skill variance; but only age was significant (β
15 = 0.36, $p = 0.002$). Child age and sex, unstructured activity participation, MVPA%, parent confidence,
16 home equipment (all positively associated), and dance participation (inversely associated), explained
17 32% object control variance. But only age ($\beta = 0.67$, $p < 0.0001$), MVPA% ($\beta = 0.37$, $p = 0.038$) and
18 *no* dance ($\beta = -0.34$, $p = 0.028$), were significant. **Conclusion:** Motor skill correlates differ according
19 to skill category and are context specific with child level correlates appearing more important.

1 **Introduction**

2 Motor skill competence (e.g. the ability to throw, kick and jump proficiently) is linked to physical
3 activity in both children and adolescents ¹. Understanding more about motor skill competence in
4 young children (three to five years old) may be particularly important, as only 3% to 5% of their time
5 is spent in moderate to vigorous activity ²⁻⁴, and this early period has been identified as crucial in the
6 establishment of physical activity behaviours and motor skills ^{5,6}.

7 Ecological systems theory conceptualises child behaviour as stemming from interactions between the
8 various influences that impact on a child ⁷. The contextual influences as applied to physical activity
9 behaviour, are characteristics associated with the child, the family, and the environment ⁸. Whilst
10 contextual influences on children's physical activity have been explored, little has been
11 undertaken with respect to motor skill proficiency.

12 Given the association between physical activity and motor competence, it is possible that the
13 contextual factors that are associated with motor skill proficiency may be similar to those for
14 physical activity. For instance, participation in outdoor unstructured play was associated with
15 pre-schoolers' physical activity ⁹ and may also be linked to children's motor skill. In another
16 study, parent perception of their child's motor skill was associated with their child's physical
17 activity level ¹⁰.

18 Family socio-cultural factors (such as parental physical activity and interaction) are associated with
19 physical activity in pre-school aged children ⁹ and there is some evidence they may also influence
20 motor skill. For instance, Cools et al. recently found in a large sample (n = 846), that fathers' physical
21 activity level was positively associated with fundamental motor skills in preschool boys ¹¹.

22 Physical environmental influences such as time and frequency in play spaces outside the home are
23 associated with pre-schoolers' physical activity ⁹, but there is little information as to whether these
24 factors are associated with motor skill in this age group. Possessing toys at home might be

1 hypothesised to positively impact on motor skill because of the increased opportunity for
2 children to practice certain skills (e.g. ball for practising the throw). Conversely, children who
3 have better skills may be likely to request new sports or physical activity related equipment.
4 In fact, the Cools et al. study did find that the frequency which parents bought new equipment
5 for their child was positively associated with their motor skills ¹¹.

6 The purpose of the current study was to determine the contextual correlates of children's
7 motor skills. In particular, which child, family and environmental factors were related to
8 locomotor and object control skills in preschool aged children.

9 **Methods**

10 Children were recruited as part of the Healthy Active Preschool Years (HAPPY) study. All
11 metropolitan councils (n = 29) were divided into quintiles, based on the 2001 Socio-economic Indices
12 for Areas index of advantage and disadvantage ¹². Two local government areas (LGAs) from each of
13 the lowest, middle and highest quintiles were randomly selected. Within each of these LGA's,
14 preschools/childcare centres were recruited from a randomly ordered list of centres. Recruitment and
15 data collection occurred during 2008/09. In total, 156 childcare centres and 137 preschools were
16 approached. Following centre approval, all parents of children three years or older were invited.
17 Parent consent rate was 11% (n = 1032/9825). A subset of children recruited in 2009 (11%, n = 76/707
18 from 12 centres) were asked to consent to their children's motor skills assessment, in addition to other
19 measures conducted as part of HAPPY described below. Ethics approval was received from Deakin
20 University and Department of Education and Early Childhood Development.

21 To objectively assess child physical activity, children were fitted with an ActiGraph GT1M
22 accelerometer and instructed that the accelerometer was to be worn on the right hip, from waking for
23 the entire day, removed only for sleeping and aquatic activities. Data were collected in 15-second
24 epochs to maximise opportunities to more accurately capture the sporadic nature of young children's
25 physical activity ^{4, 13}. Children wore accelerometers for an eight-day period. Each monitor was

1 initialised on the first day to commence recording at 9 am, and data management adjusted for actual
2 wear-time. Participants' data were included if they had a minimum of three week and one weekend
3 days of data, with data for at least 50% of their usual wake time on each day. Spearman-Brown
4 analysis¹⁴ on the larger HAPPY sample indicated that up to 2.5 weekdays, and 0.7-1.4 weekend days,
5 were required to achieve generally accepted reliability of 0.8¹⁵. Percentage of time spent in moderate
6 and vigorous physical activity (MVPA) was determined for each day individually, and across the
7 entire wear period, using age specific cut-points¹⁶. After checking for normality, child percentage of
8 time in MVPA was log transformed before analysis.

9 Parents completed a survey in which they reported their child's date of birth and sex, their own sex,
10 country of birth, highest level of education, and employment, and whether they or their partner (where
11 relevant) had a health care or pension card (an indication of low income status). The survey included
12 child, family and environmental factors hypothesised to be associated with motor skills. Test-retest
13 reliability (14-50 days, mean 24) was conducted on a separate parent sample (n = 47) on these survey
14 factors. All categorical variables used in the current study had a kappa > 0.4 and % agreement > 0.6,
15 and all continuous variables had an ICC > 0.50.

16 Child skill (as perceived by the parent) was assessed by asking whether they agreed or disagreed that
17 their child *doesn't have good enough motor skills to participate in physical activity*. Response options
18 were on a five point scale from Strongly Disagree (1) to Agree (5). Structured activity participation
19 was determined by whether their child participated (yes, no) in swimming, dance and kindy-gym in
20 the last month. Unstructured activities referred to how often their child *usually: rode a bike /scooter*
21 *for fun, played in the backyard, played on a trampoline/swing/other equipment, used toys and*
22 *equipment such as bats and balls in his/her play, and/or swam in a pool*. The six point scales for each
23 item were summed with a possible score ranging from 5 to 30.

24 Parents were asked if they felt *confident they had the skills to support their child to be active*. Options
25 were collapsed into 'not confident' and 'confident'. Parental interaction in child's physical activity
26 was assessed by two items: *How often are you and/or your partner physically active with your child?*

1 Response options were on a six point scale ranging from never (1) to daily (6). The two items were
2 summed (except for four parents without partners who were excluded) to create a score ranging from 2
3 to 12. Respondent parents were also asked to report their own moderate- and vigorous-intensity
4 physical activity (engaged in for at least 10 minutes at a time) in a typical week; item taken from the
5 Active Australia Survey¹⁷. Parent time (mins/week) in moderate, and also vigorous, activity were each
6 log transformed before analysis.

7 Frequency of visits to a play space was assessed by asking *how often your preschool child would*
8 *usually go to: local playground, playground in another area, parks/ovals with no play equipment,*
9 *sports venue, specialist outdoor activity centre, indoor play centre.* Response options for the six items
10 were on a seven point scale ranging from never (1) to five or more times a week (7) and were summed
11 to range from 6 to 42. Parents were also asked to specify toys/equipment at home suitable for physical
12 activity. Equipment items considered to be related to motor skills were: *balls, basketball ring, bats*
13 *racquets or golf clubs, bowls, climbing equipment/trees suitable for climbing, frisbee, pool or beach*
14 *toys, roller blades or skates, scooter, skateboard, skipping rope, slide, soft balls for indoor play,*
15 *swings, swimming/wading pool, table tennis table bats and balls, trampoline and volleyball/badminton*
16 *net, and/or a tricycle/bicycle.* Availability of items was summed into a composite with possible scores
17 ranging from 0 to 18.

18 The Test of Gross Motor Skill Development – 2nd Edition (TGMD-2) was used to assess six locomotor
19 skills (running, galloping, hopping, leaping, horizontal jumping, sliding) and six object control skills
20 (striking a stationary ball, stationary dribble, kicking, catching, overhand throwing, and underhand
21 rolling)¹⁸. The TGMD-2 is a process oriented measure, assessing the components of each skill rather
22 than the outcome or product of the skill execution.

23 Children were given a demonstration of the proficient technique before being asked to perform the
24 skill twice. Encouragement was given but no verbal feedback provided on skill performance. Each
25 attempt was scored with each component of the skill receiving a '1' if correctly executed or a '0' if
26 not. Each skill had a number of components (ranging from 3 to 5) that needed to be demonstrated for

1 the skill to be performed proficiently. Scores of the two trials were summed to obtain a raw score for
2 each skill. The six locomotor skill scores for each child were then summed for the locomotor subset
3 and the six object control scores for each child were summed for the object control subset.

4 All children were assessed in the preschool/childcare setting using live observation by observers
5 trained for that purpose. The training of four observers (12 hours) was conducted in 2009 by an expert
6 trainer. Accuracy was assessed by comparing observer scores (0-10 depending on skill) to the expert
7 trainers' ratings of videotapes of children performing each skill. Training was completed when
8 observer scores were no more than one point difference to the expert trainers' ratings. In the field,
9 inter-rater reliability was assessed opportunistically with each observer matched with each other
10 observer at least once. Interrater reliability for raw totals for the object control and locomotor subsets
11 were assessed using an intraclass correlation (ICC) with a one way model for absolute agreement for
12 single measures. Inter-rater reliability was assessed on 16 children (21% of sample). Inter-rater
13 reliability was strong for both the locomotor raw subtotal scores (ICC = .92, 95% CI .80 to .97) and
14 for the object control raw subtotal (ICC = .90, 95% CI .74 to .96).

15 SPSS version 17.0 was used for analyses. Variables were firstly entered one at a time into respective
16 regression models to check for associations with a) locomotor skills (raw subtest score) or b) object
17 control skills (raw subtest score). As age is a known determinant of motor skills, associations were
18 adjusted for age in days. Those variables with associations of $p < 0.20$ with object control or
19 locomotor skill (after age adjustment) were entered into two standard multiple regression models. This
20 less stringent significance level ($p < 0.20$) was chosen for variable inclusion in the model/s, because
21 variables may contribute to a regression model in unexpected ways due to the potentially complex
22 interrelationships among the variables¹⁹. There was no evidence of multicollinearity for either model,
23 with the tolerance for each predictor variable in both models over 0.6; indicating that each variable
24 could not be well accounted for by other variables. Also, the variance inflation factors were all under
25 10, indicating the standard errors for the coefficient were unlikely to be inflated²⁰. The determined
26 significance level for variables in the final models was $p < 0.05$.

1 **Results**

2 Slightly more than half (n= 42; 55%) of the 76 children were girls. Age ranged from three to six years
3 (mean 4.1, *SD* =0.68). All had complete motor skill assessments, 71 parents completed the proxy-
4 report survey, and 53 children met the inclusion criteria for valid physical activity. The sample of
5 respondent parents were almost all female (n = 68, 95.8%) with 66.2% Australian born and the
6 remainder born in 15 other countries. Most were working full- or part-time (69.0%) with 28.2%
7 engaged full-time in home duties, (87.3%) had a University degree or Year 12/Diploma/trade
8 certificate (8.5%), and five (7.0%) families had a health care card. See Table 1.

9 INSERT TABLE 1

10 Nearly all parents disagreed with the statement that their child *doesn't have good enough motor skills*
11 *to participate in physical activity*, with only one agreeing and a further three neither agreeing nor
12 disagreeing; therefore this variable was not included in further analyses. After age adjustment, the only
13 child factor associated with locomotor skill was participation in swimming lessons. Child factors
14 associated with object control skill, included sex, participation in unstructured physical activity,
15 MVPA (%) and *not* participating in dance classes. Of the family factors, none were associated with
16 locomotor skills and parents' confidence in their own skills was associated with the child's object
17 control skills. In terms of environmental factors, the number of pieces of equipment at home was
18 associated with both locomotor and object control skills (Tables 2 and 3).

19 In the final locomotor model, child age, participation in swimming lessons, and equipment explained
20 20% of locomotor skill variance; but participation in swimming lessons and equipment did not reach
21 significance (Table 2). In the final object control model, child age and sex, unstructured physical
22 activity, MVPA (%), *not* participating in dance classes, parent confidence of own skill, and number of
23 of toys/equipment in the home explained 32% of object control variance; although only child age,
24 MVPA (%) and *not* participating in dance classes remained significant (Table 3).

25

1 INSERT TABLE 2, and 3

2

3 **Discussion**

4 This is one of few studies to use an ecological systems framework to explore factors associated with
5 children's motor skills¹¹. Our results are important because understanding which factors are
6 associated with motor skills may be key in helping young children develop motor skill competency. A
7 range of factors at the child, family and environment levels were initially associated with motor skill,
8 supporting the use of the ecological framework in understanding correlates of motor skill. However,
9 there were some differences between the factors associated with locomotor and object control skills.
10 In the final models, only factors at the child level were associated with either skill type, indicating that
11 whilst factors supporting the development of motor skill competency appear to be multidimensional,
12 factors specific to the child are most important.

13 Child age, child MVPA and *not* participating in dance classes were all statistically significant in the
14 final object control model. Our finding that child MVPA was positively associated with object control
15 skill and not locomotor skill support those in an adolescent sample in which MVPA explained more
16 variance in object control skills than locomotor skills (12% compared to 2%)²¹. Our finding is also
17 consistent with Cliff et al. who reported that object control skills were related to time in MVPA in
18 preschool boys (n = 25)²².

19 The inverse association with participating in dance classes and object control skills is interesting. This
20 may signify that those children who participate in dance are spending less time developing their object
21 control skills due to interest, time or other factors. Another explanation is that more girls participated
22 in dance and the girls had poorer object control skills, in which case dance participation could be seen
23 as a proxy for being female; similarly the converse is also relevant. Studies in older children have
24 found sex differences in motor skill type with boys generally more proficient in object control skills
25 than girls²³⁻²⁵. To test this explanation, further investigation of the data was undertaken. Of the 26
26 children who participated in dance around a quarter were boys (n = 7). When we split the file by sex
27 and ran a regression with structured dance participation as a predictor and object control skill as an

1 outcome, structured dance participation was significant and negatively associated for girls only. This
2 indicates that the girls who dance, were less likely to have good object control skills.

3 Child age was the only factor significantly positively associated with locomotor skill in the final
4 model although participation in swimming classes was close to significant ($p = .05$). A study in older
5 children also found participation in structured sporting activities was associated with higher motor
6 skill proficiency²⁶. However, we found that participation in dance and kindy-gym classes had no
7 association with locomotor skills. It is unclear why swimming appeared to have more association with
8 locomotor skills than dance and kindy-gym, as it would appear that all three activities involve
9 locomotor skills; for instance 'leaping' in dance or 'jumping' in kindy-gym. Perhaps swimming may
10 require more whole body involvement (i.e. all four limbs). Our finding that the associations between
11 structured activity participation and motor skill proficiency differ according to the nature of the
12 activity, indicate that it is important to be able to specify the actual activity context to be able to detect
13 associations with motor skill type.

14 Having skill-related equipment present in the home was positively associated with locomotor and
15 object control skill after age adjustment. This suggests that having a supportive environment in terms
16 of toys and equipment may help develop motor skill competence, or that children with better
17 locomotor and object control skills are provided with more equipment. The Cools et al. study supports
18 this finding, as the frequency which parents bought new equipment for their child was associated with
19 motor skill¹¹.

20 Our finding that child participation in unstructured activity was only positively associated with object
21 control skill after adjusting for age, but not in the final model, indicates that *time* spent in MVPA and
22 *context specific* activity were more important to object control skills, than general physical activities.

23 Parental confidence in their skills to support their child to be active was also only associated with
24 object control skill, after adjusting for age. It is unclear why parent confidence would only be
25 associated with object control skills but not locomotor skills. Perhaps object control skills rely more
26 heavily on parent demonstration and instruction than locomotor skills. Both object control and

1 locomotor skills can be viewed as phylogenetic and therefore needing environmental support for their
2 development ²⁷, but it is unclear how much support is needed. It is feasible that object control skills
3 require more direct support from parents at this young age, for example, young children need parents
4 to throw them a ball to practice catching and to collect it once it's been kicked or thrown. Children in
5 our sample had not yet commenced any sort of school physical education and whilst some participated
6 in structured activities, these activities do not generally include object control skill instruction. It is
7 also possible that parents may also have considered other skills (e.g. confidence in their ability to be
8 active with their child) in relation to this question.

9 The main limitation of this study is the small sample size. It is possible that with a larger sample we
10 may have been better able to tease out the contribution of family and environmental factors. As a child
11 ages family and environmental factors may become of more importance. Stodden et al. suggests that
12 as a child ages the relationship between individual, family and environmental constraints will
13 compound and relate more strongly over time to movement skill competence and physical activity
14 behaviour ²⁸.

15 Also, the sample is not likely to be representative given the high level of parents' education; although
16 the sample was ethnically diverse. Nevertheless, the strengths are the objective measurement of
17 physical activity and motor skill, and the use of a survey at the child, family and environment level to
18 investigate this little explored topic.

19 **Conclusion**

20 This study has shown that the association between motor skill and its correlates is complex and differs
21 according to skill type. Whilst there is some evidence that motor skill in pre-school aged children is
22 multidimensional, being associated with factors at the child, family and environmental level, in the
23 final models only factors at the child level were associated with motor skills.

24 **Practical Implications**

- 1 • *What* activity a child does, *not how much* physical activity, is important to locomotor skill
2 development
- 3 • *What* activity a child does *and* how much physical activity is important to object control skill
4 development
- 5 • Interventions aiming to increase a young child’s skill level should focus on child level
6 individual factors first.

7 **Acknowledgements**

8 This study was funded by Deakin University. Thank you to the research assistants, and children and
9 parents who participated.

10

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