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Motor Skill Proficiency Among Homeschooled Children

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Almost 2 million American children are homeschooled but no information is currently available regarding motor skill proficiency within this population. The purpose of this research was to describe motor skill proficiency among homeschooled children and assess differences in homeschooled subgroups. This cross-sectional study screened 73 homeschooled children aged 5–8 years for overall motor skill proficiency using the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition, Short Form (BOT-2 SF). Independent *t* tests examined differences in motor skill proficiency within the homeschooled population. Mann-Whitney *U* tests examined differences in motor skill proficiency classification within significantly different subgroups. Homeschooled children demonstrated average motor proficiency. Significantly different motor proficiency was seen among homeschooled children participating in 3 or more hours of organized sports per week, $t(71) = 2.805$, $p = .006$, 95% CI = 1.77, 10.49, and whose primary caregiver was employed versus unemployed, $t(71) = -3.875$, $p < .001$, 95% CI = –13.29, –4.26. Mann-Whitney *U* tests revealed significantly different motor skill proficiency classification in these same subgroups. Overall, homeschooling showed no detrimental effect on motor skill proficiency. Participation in 3 or more hours of organized sports per week or having an unemployed primary caregiver may improve motor skill proficiency among this population.

Keywords: motor development, pediatrics, sports

Motor skill proficiency is an important component of child development. Gross and fine motor skills serve as building blocks for more complicated movements required for participation in many sports and physical activities (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Clark & Metcalfe, 2002). Improved motor skills in children have been associated with increased physical activity, improved

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cardiorespiratory fitness, and healthier weight classification (Lubans et al., 2010; Robinson et al., 2015). Motor skill proficiency also improves self-efficacy, eases the transition to sports, and increases enjoyment of physical activity throughout the life span (Meredith & Welk, 2013). Moreover, motor skills in children have been shown to predict future risk of lower-extremity injury and fitness levels as adolescents (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008; Larsen, Kristensen, Junge, Rexen, & Wedderkopp, 2015).

Development of motor skill proficiency has been alleged to improve other areas of a child's life, including social and cognitive development (Haapala, 2013; Lubans et al., 2010). Longitudinal studies have shown that fine motor skills in early childhood can predict future improvements in math and reading (Haapala, 2013). Links between cognition and fine motor skills, bilateral body coordination, and object control have also been reported for children under the age of 12 (van der Fels et al., 2015). The literature shows gross motor skills to be a significant predictor of academic achievement as well (Haapala, 2013; Lopes, Santos, Pereira, & Lopes, 2013). In fact, children aged 9–12 who struggle with motor skills are 6–7 times more likely to also struggle academically (Lopes et al., 2013). Therefore, developing motor skill proficiency during early elementary school is important not only for optimal physical development but also for optimal cognitive development.

As motor skills are so important to child development, public schools employ structured curriculum and activities designed to develop age-appropriate motor skills in their students. This exposure to structured physical education has been proposed to contribute to motor skill development in young children (Stodden et al., 2008). However, recent data indicate that 1.8 million American children receive schooling outside of the public school system (U.S. Department of Education, 2014). In most states, homeschooled children are not subject to regulated curriculum or physical education classes (https://education.uslegal.com/homeschooling/homeschooling-laws-by-state/). Instead, parents assume full responsibility for all aspects of their child's education, including academic, social, and physical development.

Homeschooling occurs in a variety of formats, including online public schools, individual families, and religious or secular cooperatives. Outside of the traditional gym and classroom, homeschooled children theoretically have different opportunities for developing motor skills than their public school peers. Without constant peer interaction, homeschooled children may have fewer opportunities for developing motor skills than their public school counterparts. On the other hand, homeschooled children may also have more opportunities for physical activity, crafts and fine motor activities, or sports participation throughout the school day. However, it is unclear whether the structural differences inherent in homeschooling affect motor skill proficiency. To date, the potential effect of homeschooling on motor skill proficiency has not been reported in the literature.

Therefore, the aims of this study were to describe overall motor skill proficiency among early elementary aged homeschooled children as well as to examine any differences between subgroups of homeschooled children. Based on known correlates to motor skill proficiency (Lubans et al., 2010; Robinson et al., 2015), it was hypothesized that homeschooled students would demonstrate motor skill proficiency that improved with lower body mass index (BMI) and sports participation but that was unaffected by socioeconomic status, primary caregiver education or employment, or gender if gender-specific standardized scores were used.

Methods

Participants

Full institutional review board approval was secured for this cross-sectional exploratory study before any enrollment or data collection. Families of homeschooled children were contacted in April and May of 2016 through email, homeschool support groups, cooperatives, and word of mouth. Interested families completed study enrollment, including parental informed consent during a single testing session. No follow-up was required. Data collection was completed in group settings at local parks or the participant's home as per parental preference in May 2016.

Typically developing male and female children of all ethnicities and socioeconomic statuses between the ages of 5 and 8 years who had completed at least one year of homeschooling were included in the study. Children enrolled in online public schools or other organizations that required physical education classes and/or regular fitness testing were excluded. Children aged 5–8 years were selected because the greatest gains in motor skill proficiency using the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition, Short Form (BOT-2 SF) are shown to occur before the age of 8 years, with a ceiling effect happening beyond this age (Bruininks & Bruininks, 2005).

Assessment

Motor skill proficiency was assessed using the BOT-2 SF. The BOT-2 SF is an efficient means of screening overall motor proficiency in children and has been shown to be both reliable and valid in the literature (Bruininks & Bruininks, 2005; Deitz, Kartin, & Kopp, 2007; Fransen et al., 2014; Lucas et al., 2013). It contains 14 items from 8 subtests, including drawing lines through paths-crooked and folding paper (fine motor precision subtest), copying a square and star (fine motor integration subtest), transferring pennies (manual dexterity subtest), jumping in place-same sides synchronized and tapping feet and fingers-same side synchronized (bilateral coordination subtest), walking forward on a line and standing on one leg on a balance beam with eyes open (balance subtest), one-legged stationary hop (running speed and agility subtest), dropping and catching a ball with both hands and dribbling a ball with alternating hands (upper-limb coordination subtest), and knee or full push-ups and sit-ups (strength subtest). Knee push-ups were used with all participants unless they expressed a preference for full push-ups. Individual item scores were summed to create an overall raw score ranging between 0 and 88.

Participant height and weight were assessed using a portable stadiometer (Neewer Stature Meter) and digital pediatric scale (Tanita Corporation BF-689). Parents also completed a demographic survey that included information on household characteristics and organized sports participation. To minimize bias, all three raters (physical therapist, occupational therapist, and student physical therapist assistant) were blinded to population mean and participant subgroup, with the exception of gender. Raters were trained on test administration before data collection and used standard test kits and administration guidelines as outlined in the BOT-2 manual (Bruininks & Bruininks, 2005).

Variables

Dependent variables included BOT-2 SF standardized score and standardized score classification. Raw scores were converted to standardized scores that ranged from 20 to 80 (median = 50) using BOT-2 SF age- and gender-specific charts to allow for comparisons between participants. Participants were then classified into one of five ordinal descriptive categories (well below average, below average, average, above average, well above average) using a standardized score classification chart. Average classification corresponded to ± 1 *SD* from the mean (*SD*), below/above average to ± > 1 but < 2 *SD*, and well below/well above to ± ≥ 2 *SD*.

Categorical independent variables were used to explore potential differences between subgroups of homeschooled children. Binary independent variables were used to allow for maximum number of participants in each BOT-2 SF motor skill category. Motor coordination is known to be affected by gender and BMI, while socioeconomic status has inconsistent associations, and ethnicity has no known effect (Barnett et al., 2016). Organized sports participation has also been linked to motor skill proficiency (Fransen et al., 2012; Vandorpe et al., 2012). Thus, gender (male vs. female), BMI (underweight or normal vs. overweight or obese), socioeconomic status (≥ $75K vs. < $75K gross annual household income), organized sports participation (yes vs. no), and hours of organized sports per week (≥ 3 hr vs. < 3 hr) were examined as independent variables. A cutoff of 3 hr/week of organized sports was used to dichotomize homeschooled children into above or below the group mean of 2.77 hr/week. This same cutoff score of 3 hr/week of organized sports has been used in other studies on children in this age range to dichotomize participants (Fransen et al., 2012). Additional variables hypothesized to affect motor skills included primary caregiver education level (bachelor's degree or higher vs. associate degree or some college) and primary caregiver employment status (employed part-time or full-time vs. unemployed).

Data Analysis

Outliers were assessed using box plots, and they indicated that all data should be used in the final analysis. As parametric assumptions were met, independent samples *t* tests with a Bonferroni correction of .007 ($p = .05/7$) were used to examine differences in the BOT-2 SF standardized score between homeschooled subgroups. Mann-Whitney *U* tests were performed on subgroups with significant differences to determine if the difference in score also equated to a significant difference in ordinal motor skill proficiency classification. Effect sizes for each test were calculated using Pearson's *r* with .10 indicating a small effect, .30 a medium effect, and .50 a large effect (Field, 2013). All data analyses were completed using SPSS software (IBM) version 23.

Results

Participants

In all, 73 children completed the BOT-2 SF. These 73 participants completed all study components and were included in all data analyses, with one exception. Gross

annual household income was missing for one participant as one parent declined to report this information. This participant was excluded only from the socioeconomic subgroup comparison, which had an *n* of 72. Remaining comparisons included all 73 participants.

The final participant population had a mean age of 7.00 years, (*SD* = 1.04, range = 5.0–8.9), was predominantly white (86.3%), had a normal BMI classification for their age/gender (82.2%), and participated in organized sports (mean hours/week = 2.77, *SD* = 2.84, range = 0–13). Household demographics indicated a high socioeconomic status (mode gross annual income = $75K–$150K, range = $30K–$150K+), with all households having at least 2 adults (mean = 2.26, *SD* = 1.00, range = 2–7) and an average of 4 children (mean = 4.08, *SD* = 1.50, Range = 1–8). Primary caregivers were educated (mode = bachelor's degree, range = some college–master's or doctoral degree), and were primarily unemployed (mode = unemployed, range = unemployed–employed full-time). More specific participant demographics are found in Table 1.

Table 1 Participant Characteristics

Characteristic	Number of participants (*N* = 73)	Sample percentage (%)
Age (years)		
5	15	20.5
6	21	28.8
7	22	30.1
8	15	20.5
Gender		
Male	35	47.9
Female	38	52.1
Ethnicity		
White	63	86.3
Hispanic	1	1.4
African American	3	4.1
Asian	3	4.1
Biracial	3	4.1
BMI classification (kg/m^2)		
Underweight	5	6.8
Normal	60	82.2
Overweight	6	8.2
Obese	2	2.7

Group and Subgroup Scores

As a whole, the sample population scored slightly above the BOT-2 SF standardized score scale mean of 50, with an average standardized score of 53.49 (*SD* = 9.70, range = 31–76). Six participants (8.2%) were classified as below average, 43 (58.9%) as average, 19 (26.0%) as above average, and five (6.8%) as well above average for their age/gender. Differences in BOT-2 SF standardized score between subgroups are summarized in Table 2. Significant differences were seen between homeschooled children who participated in 3 or more hours per week of organized sports as compared with those who did less than 3 hr per week, $t(71) = 2.805$, $p = .006$, 95% CI = 1.77, 10.49, with a medium effect size ($r = .316$), as well as between participants whose primary caregiver was employed versus unemployed, $t(71) = –3.875$, $p < .001$, 95% CI = –13.29, –4.26, with a medium effect size ($r = .418$). No other significant differences in standardized score were found between homeschooled subgroups.

Mann-Whitney *U* tests revealed that the distribution of the BOT-2 SF standardized score classification was significantly higher for children who participated in ≥ 3 hr of organized sports per week (mean rank = 44.67), compared with those who participated in < 3 hr per week with a medium effect size (mean rank = 31.01, $U = 901.5$, $z = 2.733$, $p = .006$, $r = .32$). There was also a significant difference in the BOT-2 SF standardized score between participants whose primary caregiver was employed (mean rank = 26.66) versus unemployed, with a medium effect size (mean rank = 41.46, $U = 333.5$, $z = –3.10$, $p = .002$, $r = –.36$).

Discussion

The aims of this study were to describe overall motor skill proficiency among early elementary aged homeschooled children as well as to examine any differences between subgroups of homeschooled children. Since homeschooled children demonstrated average age- and gender-specific motor skill proficiency, it can be inferred that homeschooling has no detrimental effect on motor skill proficiency. As homeschooled children scored slightly above the scale median as a whole, families of homeschooled children and pediatric health care providers can be reassured that there is no indication that homeschooled children have inferior motor skill proficiency. This result held true across both genders, BMI classifications, socioeconomic categories, primary caregiver education levels, and regardless of whether children participated in organized sports or not.

This study produced several unexpected results. Notably, motor skill proficiency scores in our sample were unaffected by BMI or participation in organized sports but were improved with 3 or more hr/week of organized sports as well as an unemployed primary caregiver. It was originally hypothesized that homeschooled students would demonstrate motor skill proficiency that improved with lower body mass index (BMI). Unlike other published research that showed motor skills to be negatively affected by increased BMI, this study found no difference in motor skill proficiency between underweight/normal children and overweight/obese participants (D'Hondt et al., 2013; Khalaj & Amri, 2014; Lubans et al., 2010).

Table 2 Homeschooled Children Subgroup Differences in BOT-2 SF Standardized Score

Group 1 (*n*) vs. group 2 (*n*)	Group 1 BOT-2 SF score (mean [*SD*])	Group 2 BOT-2 SF score (mean [*SD*])	Independent *t* test (*t*)	Significance (*p* value)	95% confidence intervals	Effect size (*r*)
Gender	54.63 (8.90)	52.45 (10.39)	.959	.341	–2.35, 6.72	.113
Males (35) vs. females (38)						
BMI	53.57 (9.92)	52.88 (8.29)	–.190	.850	–7.99, 6.60	.023
Normal/underweight (65) vs. overweight/obese (8)						
Organized sports participation	53.62 (10.09)	53.22 (9.02)	.164	.871	–4.50, 5.31	.019
Yes (50) vs. no (23)						
Hours/week organized sports	56.94 (10.27)	50.80 (8.41)	2.805	.006*	1.77, 10.49	.316
≥ 3 (32) vs. < 3 (41)						
Gross annual household income	53.78 (8.70)	53.14 (11.98)	.257	.798	–4.56, 5.65	.031
≥ $75K (50) vs. < $75K (22)						
Primary caregiver education	53.50 (10.01)	53.46 (8.54)	.013	.990	–5.92, 6.00	.002
Bachelor's degree or higher (60) vs. associate degree or some college (13)						
Primary caregiver employment	47.36 (9.25)	56.14 (8.71)	–3.875	< .001*	–13.29, –4.26	.418
Employed (22) vs. unemployed (51)						

Note. * = significant at the $p = .05$ level with Bonferroni correction.

However, our sample population was largely composed of participants classified as normal by BMI. With only 8 participants in the overweight/obese categories, this may have affected our results. Further research investigating these same constructs with a larger sample of overweight/obese homeschooled children is needed to support these findings.

Furthermore, it was assumed that homeschooled students who participated in organized sports would also demonstrate improved motor skill proficiency. As motor skills are often facilitated during organized sports participation, it was unexpected that there were no differences in standardized scores between homeschooled children who participated in organized sports versus those who did not. However, significant differences were seen when children were divided not simply by participation but rather by time spent in organized sports per week. Those who were engaged in less than the group mean of 3 hr per week scored significantly lower on the BOT-2 SF both in standardized score and in classification. This 3 hr/week cutoff score was also shown to significantly improve gross motor coordination in boys aged 6–8 years by Fransen et al. (2012) in a separate study linking motor skills to organized sports. These findings suggest that simply participating in organized sports may not enhance motor skill proficiency; rather, a threshold of at least 3 hr per week may be needed for a significant improvement in motor skill proficiency to happen.

Notably, homeschooled children whose primary caregiver was not employed outside the home scored significantly higher on overall motor proficiency, compared with those whose primary caregiver worked part-time or full-time. This held true not only for a higher standardized BOT-2 SF score but also for a higher motor skill classification as well. In fact, the only children classified as "well above average" had unemployed primary caregivers. The reason for this remains largely unclear. However, rather than implying that caregiver employment might be detrimental to child motor skill proficiency, this might hint at differences in homeschooling environments. Caregivers who are employed may be more likely to place their children in homeschooled groups or other cooperative learning environments during their work hours than those who are unemployed. Unemployed caregivers may also have additional time during the school day to engage in free play with their child, thus helping develop, refine, and reinforce motor skills. Homeschooling environments were not explored in this study, and further research would be required to determine potential causes for this difference between homeschooled children with employed versus unemployed primary caregivers.

Finally, the hypothesis that motor skill proficiency among homeschooled children would be unaffected by socioeconomic status was shown to be correct. However, these results could have been affected by the high socioeconomic status of the group as a whole, with most families reporting an average annual gross household income of $75K–$150K. Future research should investigate these constructs in homeschooled children from lower socioeconomic classes to support these results. Likewise, primary caregiver education was not shown to have any effect, but it could again have been a result of the sample of largely college-educated primary caregivers. After accounting for the effects of gender on motor skill proficiency using standardized score charts, there was also no difference in motor skill proficiency shown between homeschooled boys and homeschooled girls.

Limitations

This was a cross-sectional study and, as such, causality cannot be implied from these results. Generalizability of results is also limited to typically developing homeschooled children aged 5–8 years who do not participate in required physical education. Study limitations include a relatively homogenous sample, with similar ethnicity and socioeconomic status. However, ethnicity has not been shown to affect motor skill proficiency in the literature, and the sample is assumed to be representative of the homeschooled population at large. Furthermore, no specific level of interrater reliability was established, although all raters demonstrated competence in test administration before data collection. As the first study to examine motor skill proficiency in the homeschooled population, future research is needed to confirm and further clarify these initial findings.

Conclusions

In short, homeschooling showed no detrimental effect on overall motor proficiency among children aged 5–8 years. Participating in 3 or more hours of organized sports per week or having an unemployed primary caregiver may improve overall motor skill proficiency within this population.

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