Object Control Skills Mediate the Relationship Between Neighborhood Vulnerability and Participation in Physical Activities

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This study examined the influence of physical health and well-being vulnerability on participation in physical activities, and whether motor skill proficiency mediated this relationship. Kindergarten children ($n = 260$) completed the Test of Gross Motor Development-2 and the Children's Assessment of Participation and Enjoyment survey. A multivariate analysis of covariance was used to compare the motor skills and participation in physical activities of children in schools classified as more or less vulnerable. We also examined whether motor skill proficiency mediated the relationship between vulnerability status and participation. Children in neighborhoods with higher vulnerability demonstrated lower motor skill proficiency and participation. Object control skill proficiency mediated the relationship between vulnerability and participation. Children from more vulnerable schools started their school career with less developed motor skills and a narrower array of recreation participation. Children in vulnerable neighborhoods need more opportunities to master object controls skills and access recreational activities. Fortunately, motor skill proficiency among children considered 'at risk' is amenable to improvement and intervention early in the children's school career may have a beneficial impact on children's physical activity at school and beyond the school environment.

Keywords: early childhood, motor development, pediatrics, physical activity

Early child development is an important determinant of lifelong health (World Health Organization, 2011) and disadvantage during early childhood can have widespread effects during childhood and throughout the lifespan (Elhakeem, Cooper, Bann, & Hardy, 2015; Kershaw, Irwin, Trafford, & Hertzman, 2005; Lloyd, Li, & Hertzman, 2010; Pinto Pereira, Li, & Power, 2014; World Health

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Organization, 2007). Disadvantage, as gauged by poverty and low socio-economic status, is a predictor of school literacy achievement (Buckingham, Wheldall, & Beaman-Wheldall, 2013), physical health and well-being of children (Cushon, Vu, Janzen, & Muhajarine, 2011), children's physical activity levels (Simen-Kapeu & Veugelers, 2010; Singh, Kogan, Siahpush, & van Dyck, 2008), and school readiness (Santos, Brownell, & Ekuma, 2012). Disadvantage in childhood is also associated with the manifestation of developmental delay (Najman, Bor, Morrison, Andersen, & Williams, 1992), higher levels of childhood sedentary behavior (Drenowatz et al., 2010; Goodway & Smith, 2005; Singh et al., 2008; Stone, Faulkner, Mitra, & Buliung, 2012; van Rossem et al., 2012), and predicts mid-adulthood physical inactivity (Elhakeem et al., 2015; Pinto Pereira et al., 2014). From their systematic review of 45 manuscripts from 36 studies, Elhakeem et al. identified that sports and exercise early in life tend to be patterned by disadvantage and track into adulthood. In their discussion, these authors hypothesized that disadvantage-related differences in children's motor development would contribute to differences in subsequent leisure-time physical activity, and they expressed that a better understanding of the mechanisms linking disadvantage and physical activity is needed.

Building a better understanding of the relationships between motor development and physical activity engagement was central to the development of Stodden and colleagues' (2008) conceptual model. The model illustrates a developmentally dynamic and reciprocal relationship between motor skill competence and physical activity; where fundamental motor skill development is both an antecedent for physical activity, as well as an outcome of participating in physical activity (Stodden et al., 2008). During early childhood, participation in physical activities stimulates the perceptual, nervous, and muscular systems to interact more efficiently, thus promoting the development of motor skills; and motor skill proficiency provides children with the tools to participate in physical activities (Berger & Adolph, 2007; Payne & Issacs, 2008; Stodden et al., 2008). Stodden and colleagues' conceptual model does not explicitly include macro level factors such as disadvantage; although motor delay associated with disadvantaged environments was part of the rationale for the model. Our study has explicitly blended the thought that disadvantage in children's motor development could contribute to differences in leisure-time physical activity (Elhakeem et al., 2015) with the central portion of Stodden and colleagues' conceptual model. Specifically, this study examined whether physical health and well-being vulnerability (a measure representing disadvantage) predicted participation in recreational activities among children in kindergarten (average age was 5 years), and whether this relationship was mediated by the children's motor skill proficiency.

The terms 'vulnerability' and 'readiness to learn' are often applied when considering disadvantage in early child development. Essentially, if a child is vulnerable, he or she is at risk of being less successful than their peers in many areas, involving cognitive, social, physical, and emotional components (Janus et al., 2007). In British Columbia, Canada significant work has been done in identifying vulnerability in kindergarten children. Since 2000, the Human Early Learning Partnership at the University of British Columbia has been gathering data and mapping vulnerability and early child development data for all of the school districts in the province (Kershaw et al., 2005). Using the Early Development

Instrument (EDI) developed by Janus and colleagues at McMaster University in Ontario, Canada, the Human Early Learning Partnership has measured children's development during their kindergarten year in five areas: physical health and well-being, social competence, emotional maturity, language and cognitive development, and communication skills and general knowledge (Kershaw et al., 2005). The EDI questionnaires are completed by kindergarten teachers in late winter each year. Based on the teacher's responses, children are identified as being vulnerable, or having decreased school readiness, if they score in the bottom tenth percentile for a component. This study examined whether physical health and well-being vulnerability predicted participation in physical activities among children in kindergarten, and whether this relationship was mediated by the children's motor skill proficiency. The following research questions were addressed: (1) What types of activities do children in kindergarten participate in? (2) Does activity type differ between children in more and less vulnerable schools? (3) What are the motor skill levels of the children and do they differ by vulnerability status? (4) Does motor skill proficiency mediate the relationship between vulnerability status and physical activity level?

Methods

Participants

The sampling frame for this cross-sectional study was elementary schools in one urban school district in British Columbia, Canada. The principal investigator described the study at a district meeting of school administrators and invited participation. The administrators of eight elementary schools enrolled their school in the study after consultation with their teaching staff. Approval for this study was granted by the University of Victoria Human Research Ethics Board and the school district. Consent forms were distributed to all of the kindergarten children's families ($n = 341$) in the eight schools. Parental consent and children's assent was received for 267 children, representing 78% of the potential participants. Data were incomplete for seven children (six due to repeated absence and one child chose not to complete the motor skills testing); therefore the final sample was 260 children. Participant age ranged from 5 to 6 years old and girls were 48% of the sample. The proportion of children in the final sample ranged from 6.8% at one of the smaller elementary schools to 26.4% at the largest elementary school.

Measures

Gross Motor Skills. The Test of Gross Motor Development (TGMD-2; Ulrich, 2000) was used to assess the locomotor (run, hop, slide, leap, gallop, and horizontal jump) and object control (strike, catch, dribble, throw, kick, and underhand roll) skills of the children and to provide an estimate of each child's current level of gross motor development (the gross motor quotient). The range of possible raw scores for object control and locomotor skills was 0–48 and gross motor quotients can range from 46–160. A gross motor quotient of less than 70 (less than two standard deviations below the mean) indicates that a child is at risk of gross motor delay; denoted qualitatively as “very poor” motor skill proficiency (Ulrich, 2000).

Participation in Recreation and Leisure Activities. Children's participation in everyday activities outside of mandated school activities in the past four months was assessed individually with each child using the Children's Assessment of Participation and Enjoyment survey (CAPE; King et al., 2004). The CAPE items were selected following a review of the literature and with input from expert reviewers. Using factor analysis, the authors of the CAPE identified five types of formal and informal activities, specifically: Recreational activities, Physical activities, Social activities, Skill-Based activities, and Self-Improvement activities. Internal consistency reliabilities of the activity types ranged from 0.30 (Skill-based activities) to 0.65 (Recreational activities), and test-retest reliabilities for the activity type intensity scores ranged from 0.72 (Social activities) to 0.81 (Physical activities). Table 1 details the 55 CAPE activity items organized by activity type.

Early Development Instrument (EDI). The EDI is a teacher-administered assessment of individual kindergarten aged children on each of five scales: physical health and well-being, social competence, emotional maturity, language and cognitive development, and general knowledge (Janus et al., 2007; Kershaw et al., 2005). It is designed for interpretation at an aggregated level (e.g., neighborhood) rather than for individual diagnostic purposes. The physical health and well-being subscale of the EDI refers to children's physical preparedness for the school day, fine and gross motor skills, energy level throughout the day, and physical independence. It contains 13 items and includes questions about pencil holding, hand preference, washroom independence, energy levels, coordination, and the ability to manipulate objects. Psychometric properties of the Physical Health and Well-Being subscale of the EDI include: strong internal consistency (Cronbach's $\alpha = 0.849$) and moderately strong interrater reliability between two independent observers (school kindergarten teachers and early childhood educators) ($r = .69$) (Janus & Offord, 2007).

A score for each scale is defined as a percent of vulnerability. It is calculated by analyzing each child's EDI assessment in such a way that the child receives a score between 0 and 10 for each scale. "A score of 10 means the child is doing all the things s/he should be doing, all of the time, in relation to the given scale; whereas a score of 0 means s/he is not doing any of them at any time" (Kershaw et al., 2005, p. 26). A 'vulnerability threshold' is calculated for each EDI scale. It is the cut-off point that distinguishes 10% of the children in British Columbia at the lower end of the scale from the other 90%. For the physical health and well-being scale, the vulnerability threshold was 7.12. Children whose scores fell below 7.12 were said to be vulnerable in physical health and well-being, that is, on average, these children were more likely to be limited in their development than children that received scores above the threshold. The percent of vulnerability represents the number of children whose scores are below the vulnerability threshold out of the total number of children tested in the school (Kershaw et al., 2005).

To provide an indication of the relationship between the physical health and well-being subscale of the EDI and broader measures of disadvantage, the physical health and well-being subscale was compared to the Human Early Learning Partnership (HELP) SES index. Developed by HELP for neighborhoods in the Province of British Columbia, the SES index was derived from the following Census variables: unemployment, poverty, lone parenthood, shelter costs,

Table 1 Prevalence of Participation in Specific Recreational Activities by Kindergarten Children Enrolled in Schools From Less and More Vulnerable Neighborhoods

Item	All	Less Vulnerable	More Vulnerable	BH <i>p-Value</i> *
Recreational activities				
Puzzles	55.0	57.4	49.4	.385
Board/card games	60.8	63.4	54.5	.354
Crafts/drawing	80.8	82.5	76.6	.411
Collecting things	55.4	56.3	53.2	.504
Computer/video games	78.8	78.7	79.2	.586
Playing with pets	56.2	54.6	59.7	.444
Pretend play	60.8	61.7	58.4	.492
Playing with toys	94.2	94.5	93.5	.577
Walk/hike	58.8	65.0	44.2	.009
Playing on equipment	75.4	83.1	57.1	.003
TV/rented movie	93.5	96.7	85.7	.014
Caring for a pet	55.0	54.6	55.8	.579
Social activities				
Talk on phone	43.5	43.7	42.9	.579
Go to party	75.8	77.0	72.7	.444
Hanging out	55.8	57.4	51.9	.444
Visiting	73.8	75.4	70.1	.444
Friends over to play	59.1	59.6	57.9	.569
Go to movies	64.2	67.8	55.8	.169
Go to live event	26.5	28.4	22.1	.411
Full-day outing	18.8	18.6	19.5	.479
Listen to music	55.8	59.6	46.8	.153
Making food	59.2	64.5	46.8	.037
Skill-based activities				
Swimming	63.8	65.0	61.0	.460
Gymnastics	34.2	35.5	31.2	.444
Horse riding	6.5	6.6	6.5	.612
Learning to sing	11.5	10.9	13.0	.509
Learning to dance	24.2	25.7	20.8	.444
Play musical instrument	38.8	46.4	20.8	.003
Music lessons	13.8	13.7	14.3	.580
Community organization	11.5	12.6	9.1	.444
Dancing	49.2	55.7	33.8	.009
Art lessons	12.7	11.5	15.6	.444

(continued)

Table 1 (continued)

Item	All	Less Vulnerable	More Vulnerable	BH p-Value*
Self-improvement activities				
Writing letters	45.8	43.7	50.6	.411
Write story	31.5	33.3	27.3	.442
Help from tutor	10.4	9.3	13.0	.444
Religious activity	24.2	23.0	27.3	.444
Public library	50.8	54.6	41.6	.153
Reading	57.7	62.8	45.5	.039
Volunteering	3.1	3.3	2.6	.592
Chores	61.5	62.8	58.4	.444
Homework	28.8	31.7	22.1	.249
Shopping	75.4	81.4	61.0	.009
Physical activities				
Martial arts	16.9	16.4	18.2	.545
Track & Field	7.7	7.7	7.8	.592
Team sports	31.2	35.0	22.1	.124
School clubs	5.0	4.4	6.5	.467
Bike riding/skateboard	62.3	68.3	48.1	.014
Water sports	4.2	4.4	3.9	.592
Snow sports	37.3	43.7	22.1	.009
Games (e.g., soccer at the park)	61.5	63.9	55.8	.382
Gardening	29.2	31.1	24.7	.411
Fishing	8.8	10.9	3.9	.172
Individual physical activities	16.2	18.0	11.7	.382
Non-team sports	16.5	20.2	7.8	.045
Paid job	4.2	4.4	3.9	.592

*To correct for multiple testing we have used Benjamini-Hochberg *p*-value (Banjamini & Hochberg, 1995).

education, young population age, language and immigration, number of second generation Canadians, and the number of women in manufacturing occupations (Dr. Barry Forer, HELP Research Methodologist, personal communication 24 Mar, 2015). We ranked the school neighborhoods from the least to the most disadvantaged for both the SES index and the physical health and well-being subscale. The Kendall tau rank correlation coefficient demonstrated a marked relationship between the two indices of disadvantage, $\tau = .704$, $p = .017$.

Procedures

Motor skills were assessed by a trained research team during scheduled physical education lessons and in accordance with the testing procedure outlined in the

TGMD-2 Examiner's Manual (Ulrich, 2000). Each class was divided into four small groups (3–5 children) to reduce the time children had to wait and the degree to which they were performing in front of their peers. These groups rotated around four stations (3 skills per station). As lessons at each school varied in duration, 1–3 lessons were required to gather these data. The performance of consented children was digitally video-recorded for later analysis. Non-consented children also participated in the skills as per the teachers' and administrators' wishes; and all children participated in games toward the end of each lesson.

The CAPE questionnaire was interviewer-administered individually with each child following one of the physical education lessons. Administration took place in a private, quiet space as available in each school and was performed according to the tool's guidelines using the 55 CAPE Activity Cards and the summary score sheets (King et al., 2004).

Data Treatment and Analysis

The percentage of vulnerable children in each EDI neighborhood is classified into quintiles, specifically: 1) <4.8%, 2) 4.9%–8.1%, 3) 8.2% to 10.9%, 4) 11.0%–15.8%, and 5) >15.9% (Human Early Learning Partnership, 2010). Preliminary analyses revealed there were no schools in neighborhoods with <4.8% of children classified as vulnerable on the physical health and well-being subscale (quintile 1). Further, initial results revealed no motor skill differences between quintiles 2 and 3 or between quintiles 4 and 5. Consequently for the descriptive statistics and the multivariate analysis of covariance (MANCOVA), quintiles 2 and 3 were combined and coded as 'less vulnerable schools' ($n = 5$) and quintiles 4 and 5 were combined as coded as 'more vulnerable schools' ($n = 3$) in terms of physical health and well-being.

The behavioral components of each motor skill in the TGMD-2 were scored dichotomously; 0 or 1 depending on whether the component was completed correctly. Fifteen percent of the video was scored by a second observer to establish inter-observer reliability. Percent Agreement [$\text{Number of Agreements} / (\text{Number of Agreements} + \text{Disagreements}) \times 100$] for 20 separate classes ranged from 80.2% to 94.8%, with a mean of 87.8%. Mean and standard deviations were computed based on raw scores for locomotor skills, object control skills, and the five categories of activity. In addition, the prevalence of participation in each CAPE activity and the proportion of children with gross motor quotients below 70 ('very poor') were computed. Chi-squared analyses and Fisher exact test (when frequencies were below 5) were used to examine vulnerability status differences in specific activities and the proportion of children with gross motor quotients below 70. To correct for multiple testing of the specific activities, we used q -values to represent the false discovery rate (FDR) (Benjamini & Hochberg, 1995). The activities with a FDR q -value < 0.05 level were considered significant.

A MANCOVA was used to compare motor skills (object control and locomotor skills) and participation in types of activities (Recreational, Physical, Social, Skill-Based, Self-Improvement) of children in more and less vulnerable schools, with age in months as a covariate. An analysis of variance (ANOVA) was used to compare the gross motor quotients of children attending the more and less vulnerable schools. A parallel multiple mediator model (Hayes & Preacher, 2014)

Figure 1 — A statistical diagram of the parallel multiple mediator model for the influence of physical health and well-being vulnerability on participation.

was used to estimate the direct effect of vulnerability (antecedent variable) on participation in physical activities (outcome variable) as well as whether this relationship was mediated (indirect effect) by the children’s locomotor and object control skills (see Figure 1). All analyses were performed using IBM SPSS 24 for Windows, together with the SPSS version of PROCESS (www.afhayes.com).

Results

Table 1 shows the proportion of children participating in each of the 55 CAPE activities. Chi-squared analyses (see Table 1) revealed there were 11 significant differences between the groups for specific activities, in each case the children in less vulnerable schools participated in more of the particular activity. Table 2 provides descriptive statistics for the activity categories and motor skill proficiency. The MANCOVA showed a significant overall effect for vulnerability as suggested by a Wilk’s lambda (Neal & King, 1969) of .876 with $F(7, 248) = 5.03, p < .001$. Results of univariate F tests for vulnerability presented in Table 2 reveal that on average children in less vulnerable schools had more proficient object control and locomotor skills and they participated in a more diverse array of recreational and physical activities. The gross motor quotient of children in more vulnerable schools was significantly lower than children attending less vulnerable schools, $F(1,256) = 15.89, p < .001$, partial $\eta^2 = .058$. Chi-squared analysis also

Table 2 Means (*M*) and Standard Deviation (*SD*) of Motor Skill Proficiency and Activity Participation by Level of Vulnerability

Variable (max. score)	All (<i>n</i> = 260)		Less Vulnerable (<i>n</i> = 183)		More Vulnerable (<i>n</i> = 77)		<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Motor skills							
Locomotor skills raw score (48)	26.0	7.3	27.6	6.7	22.3	7.3	<.001
Object control skills raw score (48)	21.0	7.3	22.1	7.3	18.3	6.7	.001
Gross motor quotient (160)*	79.6	13.7	81.7	13.6	74.4	12.6	<.001
CAPE types/categories of activities							
Recreational activities (12)	8.3	2.0	8.5	2.0	7.8	1.9	.008
Social activities (10)	5.4	2.0	5.5	1.9	4.9	2.3	.076
Self-improvement activities (10)	3.9	1.8	4.1	1.7	3.5	1.8	.054
Skill-based activities (10)	2.7	1.7	2.8	1.7	2.3	1.7	.055
Physical activities (13)	2.4	1.7	2.6	1.8	1.9	1.5	.007

*A separate ANOVA was conducted for the gross motor quotient as it is highly correlated with the motor skills.

revealed that a significantly greater proportion ($\chi^2 = 13.48$, $df = 1$, $p = .001$) of children in more vulnerable schools had gross motor quotients below 70 compared with children in less vulnerable schools, 32% and 12.6%, respectively.

The mediation analysis revealed that vulnerability did not have a significant direct effect on physical activities, but vulnerability did influence participation in physical activities through its effect on object control skills. In addition, vulnerability influenced locomotor skill proficiency. As can be seen in Figure 1, the children from schools with higher levels of vulnerability had lower levels of object control skill proficiency ($b = -2.092$) and children with higher levels of object control skills were more active ($b = 0.043$). A bias-corrected bootstrap confidence interval (CI) for the indirect path (vulnerability $\times$ object control skills) based on 10,000 bootstrap sample did not cross zero and was therefore negative to a statistically significant degree. There was no evidence of an indirect effect of locomotor skills on participation (bootstrap 95% CI, -0.102 , 0.027).

Discussion

We found that children attending more vulnerable schools demonstrated significantly lower proficiency in object control and locomotor skills and a higher proportion of them had gross motor quotients below 70; indicative of very poor gross motor proficiency (Ulrich, 2000). One-third of kindergarten children attending more vulnerable schools had very poor motor skills, especially their object control skills. This result is consistent with findings from Northern Ireland demonstrating that social disadvantage at the family and neighborhood level were associated with lower fine motor skills, balance, and balls skills (McPhillips & Jordan-Black, 2007).

We also found that kindergarten children in more vulnerable schools participated in significantly fewer physical and recreational activities; including significantly lower participation in walking/hiking, bike riding/skateboarding, and non-team sports. These results are generally consistent with the existing literature on older children, which show lower participation in physical activities (Simen-Kapeu & Veugelers, 2010; Singh et al., 2008; Stone et al., 2012) and organized sport (Clark, 2008) among disadvantaged children. In terms of sport participation, Clark concluded that expenses for equipment, travel, facility rental, club memberships, and competition entry fees were at the heart of these lower levels of participation in organized sport in Canada. The individual activity data from our study appears to support this notion. Participation in several potentially expensive activities such as non-team sports, snow sports, and bike riding were significantly lower among kindergarten children attending more vulnerable schools, whereas there was no difference for many less formal activities such as pretend play or kicking a soccer ball at the park. However, the relationship between vulnerability and participation in physical activities in this study was not direct.

The mediation model shows that the relationship was influenced by the children's object control skills. This finding is consistent with previous research demonstrating that children's object control skills, rather than their locomotor skills, predict physical activity levels (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009). This finding may be particularly important as object control skills such as catching, throwing, and kicking a ball are positively associated with overall physical activity levels among older children in low-income communities (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014) as well as moderate to vigorous physical activity levels of kindergarten children (Crane, Naylor, Cook, & Temple, 2015). Cohen and colleagues found that in low-income communities object control skills predicted children's school-based moderate to vigorous physical activity at lunchtime, recess, and after-school (3–6 PM). Although there is no definitive evidence why object control skills, but not locomotor skills, are more likely to predict physical activity levels, it has been suggested that object control skills are used in activities that are more active (e.g., soccer) (Barnett et al., 2009). It is also possible in relation to this study, that children who were more vulnerable had less access to equipment needed for object control-related activities such as tennis, tee-ball, or Frisbee. Examination of affordances for these types of activities within the children's environment is a logical step for future research efforts. Our results also signal that to more fully appreciate the forces acting on the central relationship between motor skills and physical activity within Stodden and colleagues' (2008) model, broader, macro level factors, need to be considered. The developing child is influenced by the properties of their environment and how they interact with that environment (Bronfenbrenner & Morris, 2006). Although research incorporating broader ecological perspectives is likely to be more complex and expensive (Bronfenbrenner & Morris, 2006), incorporating measures examining children's immediate environment or settings (such as schools, sports clubs, and family) may highlight how and where intervention is more likely to be effective.

Our findings also suggest that children in more vulnerable schools begin their school career with lower levels of participation in physically active recreational pursuits and motor skills and a different repertoire of experiences that ought to be considered when designing and implementing physical education curriculum. But,

as Lawson (1998, p. 10) explained in an early paper discussing vulnerable children and physical education, "'At risk' applies to their environments and living challenges, not to these people. They are 'at promise,' but nevertheless vulnerable to social-structural impediments." To optimize children's promise there needs to be an increase in the opportunities for young children in more vulnerable schools to develop their motor skills and participate in a wider array of organized physical activities. These opportunities, whether in or out of school, need to be tailored to family and cultural differences (Lawson, 1998). Such tailoring should include being affordable and manageable for families since cost, scheduling, and travel can be major impediments to participation (Clark, 2008; Hardy, Kelly, Chapman, King, & Farrell, 2010; Holt, Kingsley, Tink, & Scherer, 2011). Teachers and coaches need to be cognizant of additional challenges experienced by families in neighborhoods with greater vulnerability in providing opportunities for organized physical activities for their children. As Holt and colleagues' qualitative analysis of the barriers to participation in sport for children in low-income Canadian families pointed out, work schedules may not allow flexibility and often sports have many additional small costs that in sum can be prohibitive, and potentially cause embarrassment if families cannot afford them. Being aware of the financial and scheduling demands being made of families and providing information about potential subsidies and grants may help disadvantaged families include their children in organized forms of physical activity (Holt et al., 2011).

Children spend a great deal of time at school, and schools have been identified as environments that can influence health behaviors such as physical activity both at school and beyond the school environment (Ball, Timperio, & Crawford, 2006). More importantly, they provide equitable access to physical development opportunities for most children. Fortunately, there is sound evidence from intervention studies that young children from disadvantaged communities and children at risk of developmental delay can significantly improve their object control skills if they receive high quality movement instruction (Goodway & Branta, 2003; Goodway, Crowe, & Ward, 2003; Hamilton, Goodway, & Haubenstricker, 1999; Robinson, Goodway, Dunn, Johnson, & Devins, 2007). Specifically, these efficacious interventions have focused on motor skill development and provided 35- to 45-minute sessions twice per week for 8 to 12 weeks. Each of the interventions resulted in significantly greater improvement in object control skills compared with control groups that participated in their usual activities; which suggest that poor motor skills should not be accepted as a *fait accompli*. Teachers who provide deliberate and sustained opportunities for motor development can produce positive and meaningful change for young children, including children at risk of developmental delay.

The overall levels of recreational activities (which are largely more sedentary in nature) were higher among the kindergarten children from less vulnerable schools in this study. This finding is perhaps somewhat surprising given the literature generally shows higher levels of sedentary behavior among more disadvantaged children (Singh et al., 2008; van Rossem et al., 2012). However, our data also demonstrated that the children from less vulnerable schools participated in a more diverse array of activities in general, but there were few differences in the less active types of recreational activities between the groups. Where differences were identified (e.g., TV/rented movie, playing a musical instrument), children from less vulnerable schools were more likely to have participated in that

activity. Overall, the children from the least vulnerable schools participated in virtually more of every type of recreational activity irrespective of whether the activities were sedentary or physically active.

This study has limitations that should be noted. Assessment of participation was limited to use of the CAPE survey, which imposed a particular structure on activities and examined the diversity of participation in recreational activities during the previous four months. As data were collected from November to May during the school year, participation in activities during June and July would not have been represented. Future research may benefit from examining participation patterns throughout the year as well as the frequency and intensity of participation. In addition, EDI data are based on subjective teacher ratings and represents a broad, group level vulnerability status, making it impossible to identify the vulnerability status of individual children. The vulnerability levels reflect averages over the area in which a school is located, and will not accurately represent children in each extreme; a school classified as more vulnerable may include children with very low levels of vulnerability. However, our confidence in these findings is bolstered by the significant and substantive relationship between the physical health and well-being subscale of the EDI and the broader Human Early Learning Partnership SES index ($\tau = .704$). As disadvantage is multidimensional, we did not expect that these indices would be equivalent, but we did expect them to be related. The strong relationship suggests that teachers' ratings of physical health and well-being vulnerability are indeed indicative of a more expansive conception of disadvantage.

The findings of this study suggest that neighborhood-level early childhood physical health and well-being vulnerability manifests in significantly lower object control and locomotor skill proficiency, higher levels of poor motor skill performance, and lower participation in physical activities. Mediation analysis revealed that the relationship between physical health and well-being vulnerability and participation in physical activities was influenced by children's object control skill proficiency. Fortunately, motor skill proficiency among children considered 'at risk' is particularly amenable to improvement, and intervention early in their school career (i.e., kindergarten) may have a beneficial impact on children's physical activity at school and beyond the school environment.

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