Complex Physical Activity, Outdoor Play, and School Readiness Among Preschoolers

Derek R. Becker
Western Carolina University

Cathy L. Grist
Western Carolina University

Lori A. Caudle
Western Carolina University

Myra K. Watson
Western Carolina University

Abstract

High quality educational settings play a crucial role in preparing a child to enter kindergarten, but little work has explored how outdoor play and complex physical activity outside school and childcare settings promote school readiness among preschoolers. To address this gap, the present study explored connections among school readiness with outdoor play and participation in complex physical activity. Parents (N = 107) reported the extent and frequency of time their child spent in outdoor play during a typical week, and what complex activities (e.g., soccer, biking, basketball) the child played over the last year. School readiness was assessed with parent reports on the Preschool Behavior and Emotional Rating Scale. Results showed participating in complex activities significantly moderated the relationship between time in outdoor play with school readiness, with time in outdoor play positively related to school readiness for children who participated in two or less complex activities. For children who participated in three complex activities, time in outdoor play was not related to school readiness. Findings offer support that encouraging both outdoor play and participation in complex physical activities could promote school readiness, particularly when opportunities for outdoor playtime are limited.

Keywords

Complex physical activities, outdoor play, school readiness, preschoolers

Introduction

While the National Association for the Education of Young Children (NAEYC) endorses a multi-dimensional view of school readiness (NAEYC, 2004), little research has focused on whether preschoolers' participation in complex physical activities and outdoor

Corresponding Author:
Derek R. Becker, Western Carolina University, 1 University Drive, Cullowhee, NC 28723.
E-mail: drbecker@wcu.edu

 Citation: Becker, Derek. R., Grist, Cathy L., Caudle, Lori A., & Watson, Myra K. (2018). Complex physical activity, outdoor play, and school readiness among preschoolers. *Global Education Review, 5* (2), 110-122.

play promote the development of early academic skills. Early childhood is a crucial time for motor and cognitive skill development (Myer et al., 2015), and evidence suggests preschool children who engage in active forms of play have better memory and attention (Becker, McClelland, Loprinzi, & Trost, 2014; Diamond & Lee, 2011). However, in a typical school day, preschoolers engage in many forms of play and other learning experiences, yet it is not clear how specific types of activities and play outside of educational settings promote school readiness. Therefore, the present study examines the direct and moderated relationship between parent reports of child outdoor play and participation in complex physical activities (e.g., soccer, basketball, dance, gymnastics) on school readiness. Complex physical activities can occur both during spontaneous indoor/outdoor play and within organized team sports, with the former being more likely among preschoolers.

Following evidence with older samples that participating in complex physical activity (i.e., sports) is associated with academic achievement (Becker, 2016), and that children who engage in active play have better memory and attention (Becker et al., 2014), it was predicted that participating in a greater number of complex physical activities and spending more time in outdoor play would be related to school readiness. We also examined if participating in complex physical activities moderated the relationship between time in outdoor play with school readiness, such that for children who participate in less complex physical activities, the extent and frequency of time spent in outdoor play will positively relate to school readiness.

School Readiness and Academic Achievement

School readiness is a multidimensional construct that includes domain general skills related to intellectual and social development (Duncan et al., 2007; Romano, Babchishin, Pagani, & Kohen, 2010). Cognitive skills that promote school readiness often involve executive function, which are cognitive processes involved in the control of goal-directed cognition and behavior (Koziol, Budding, & Chidekel, 2012; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Executive function is involved in the development of abstract thought and the formation of rules involved in the learning process (Kharitonova & Munakata, 2011; Snyder & Munakata, 2010), and can predict short and long-term academic development. For example, executive function measured in the fall of both prekindergarten and kindergarten predict change in math in spring of the respective academic year (McClelland et al., 2014).

Along with executive function, prosocial behaviors that include the ability to understand self and others, cooperate with peers, and regulate emotions are also related to short and long-term academic outcomes. For boys, high levels of aggressive behavior and low levels of prosocial behaviors in prekindergarten are linked to low concurrent emergent literacy scores, with solitary play related to low emergent literacy for boys and girls (Doctoroff, Greer, & Arnold, 2006). Children who display more prosocial behavior in kindergarten are also found to have higher math and reading scores in the third grade (Romano et al., 2010). Given the above connections between school readiness with academic achievement, it is important to examine factors such as outdoor play and complex physical activities that could promote school readiness.

Outdoor Play, Complex Physical Activities, and School Readiness

The connection between the cognitive and social components of school readiness with outdoor play and sport participation can be found in the

aerobic activity that could be achieved during play, the complexity of participating in a complex task that taps executive function, and in the social skills that could be developed when interacting with peers. For the former, evidence suggests that children who spend more time in outdoor play are more physically active and physically fit (Cleland et al., 2008), with physical activity and physical fitness linked to higher executive function. For example, in a non-experimental study with children between 9 and 10, higher fit youth showed better executive function and greater activity in brain regions associated with attention and memory (Chaddock, Erickson, Prakesh, Chaddock, Erickson, Parkash, Van Patter, et al., 2010). Higher physically fit children are better able to control their behavior (Chaddock-Heyman et al., 2013), and show greater prefrontal and parietal activation (Chaddock et al., 2012). In preschool samples, active outdoor play is linked to better executive function (Becker et al., 2014), with physical fitness also predicting working memory and attention (Niederer et al., 2011).

Evidence also suggests the combination of exercise and cognitive engagement enhance the relationship with executive function (Curlik Ii & Shors, 2013; Koutsandréou, Wegner, Niemann, & Budde, 2016), with sports such as soccer, baseball, and wrestling associated with higher executive function (Memmert, 2009; Nakamoto & Mori, 2012; Williams & Ford, 2008). Although the majority of work examining the cognitive benefits of sport participation are with older samples, exposure to the perceptual and cognitive demands of a sport such as soccer, gymnastics, or dance, or sport type activity such as riding a bike, is associated with change in executive function, the retention of motor skills, and increased activation in brain areas involved in executive function (Lin et al., 2013; Saemi, Porter et al., 2012). In work with kindergarten age children, following eight weeks of soccer skills training, improvements in executive function were found for children in both a high and low training group (Chang, Tsai, Chen, & Hung, 2013). Similar to Chang, after participating in a 6-month soccer intervention, children between age 7 and 9 showed improvement in executive function relative to a non-exercise control group (Alesi, Bianco, Luppina, Palma, & Pepi, 2016).

At the same time, both complex physical activities and natural outdoor play often involve peer interactions that could be linked to the development of social skills (Bailey, 2006; Gould & Carson, 2008). For example, in a study with shy children, participation in complex physical activity was linked to a reduction in anxiety and better socials skills (Findlay & Coplan, 2008). Children who participate in sport-type activities also show higher levels of social competence and lower levels of social anxiety (Dimech & Seiler, 2010; Haugen, Säfvenbom, & Ommundsen, 2013). Finally, when comparing both outdoor and indoor play, outdoor play was linked to more peer- based interactive dramatic play (Shim, Herwig, & Shelley, 2001).

Together, the above evidence suggests that an outdoor environment that encourages the child to be physically active, promotes activities that include a combination of aerobic movement and complex motor skills such as kicking, throwing, or riding a bike, and allows for social interactions could be associated with school readiness. In the present study, we examine if children who spend more time in outdoor play, participate in more sport activities, or some combination of the two have higher school readiness in the fall of the prekindergarten year.

The Moderating Role of Complex Physical Activity with Outdoor Play and School Readiness

Although evidence points to a direct relationship between outdoor play and participation in complex physical activity with school readiness,

it's also possible that the relationship between outdoor play with school readiness could vary based on the number of complex physical activities a child plays. For example, in work with older children, evidence suggests that if a child plays a high number of complex sports, such that require attention and are played in a shifting environment (e.g., soccer, volleyball), the physical activity required to play the sport (assessed as metabolic intensity), is less related to executive function (Becker, 2016). However, when a child plays repetitive sports that require less attention (e.g., running, swimming), the level of physical activity required to play the sport (metabolic intensity) is positively related to executive function.

For children in the present study that participate in fewer complex physical activities, it is possible they could achieve a similar level of school readiness if they spend more time in outdoor play. Given that motor skills are developing in preschoolers, participating in complex physical activity at a young age could promote school readiness (Chang et al., 2013). However, for children who participate in fewer of these activities, it is possible that spending more time in outdoor play could improve school readiness through spending more time being physically active (Becker et al., 2014; Cleland et al., 2008). Thus, it is possible for preschoolers who participate in multiple complex activities, the extent and frequency of time spent in outdoor play could be less related to school readiness.

Summary and Hypothesis

High quality early childhood educational settings play a crucial role in promoting academic skills (Vandell, Belsky, Burchinal, Steinberg, & Vandergrift, 2010), yet little work has focused on how outdoor play and complex physical activities, both at home and preschool, could promote academic skill development. Therefore, the purpose of this study was to assess the relationship between time spent in outdoor play and participating in complex physical activities with school readiness. Research question one investigated if children who spend more time in outdoor play and/or participate in more complex physical activities have higher school readiness? Drawing on research suggesting participating in outdoor play and complex physical activities are linked to the cognitive and social components of school readiness (Becker et al., 2014; Chang et al., 2013; Shim et al., 2001), it was predicted that the extent and frequency of time spent in outdoor play and participating in more types of complex physical activities would be positively associated with school readiness. Research question two assessed if participation in complex physical activities moderated the relationship between time spent in outdoor play with school readiness? Following evidence from Becker, (2016), which suggests if a child plays multiple complex sports, the physical activity required to play each sport is less related to executive function, it was predicted the relationship between outdoor play with school readiness would be moderated by the number of complex physical activities a child played; such that for children who participated in less complex physical activities, time spent in outdoor play would be positively related to higher school readiness.

Method

Participants

Participants included 107 children attending preschool in a child development center in Western North Carolina. Children were sampled from a single center with multiple classrooms (n = 6). Data was collected in the fall of the prekindergarten year through packets sent home with parents. The average age at the beginning of the study was 50.94 months (range = 36.03 –

60.11 months). A total of 54 of the children were female, and 55 were male. The average yearly income of the sample was 45,060 (range = 0 - 161,710).

Measures

Outdoor Play

The extent and frequency of time spent in outdoor play was measured by asking parents, "On a typical week, how many hours is your child outside playing?" The average number of hours of outside play reported by parents was 8.00 (range = 0 - 25).

Complex Physical Activity

Participation in complex physical activities was measured by asking parents on a typical week, if the child participated in any of 8 complex physical activities (see Table 1). The average number of complex physical activities which children participated in was 2 (range 0 - 8), with 83 of the children participating in at least one complex physical activity. The complex physical activity variable was a count of the number of activities in which the child participated in, outside of the formal early childhood educational setting. Given that over a third (78.49%) of the sample participated in 3 or fewer sports, children who participated in 4 or more sports were aggregated into one group (see Table 1).

School Readiness

The Preschool Behavioral and Emotional Rating Scales (PreBERS) is a standard, norm-referenced assessment, which measures the behavioral and emotional strengths of preschool children, particularly 3-5 years of age. The scale includes 42 items, which rate on a 4-point Likert scale (0=not all like the child; 1=not much like the child; 2=like the child; 3=very much like the child). The PreBERS includes 4 subscales: Emotional Regulation (13 items), School Readiness (13 items), Social Confidence (9 items), and Family Involvement (7 items). The school readiness subscale was used in the present analysis. The internal consistency reliability for the School Readiness subscale, coefficients averaged .94 for males, and .95 for females (Epstein & Synhorst, 2009).

Table 1
Complex Physical Activities *N* = 93

Activity	*Played Sport*	*Did not Play Sport*	*Sports*	*Sport Groups*
	n	*n*		*n*
Soccer	23	70	No Sport	11
Basketball	21	72	One Sport	27
T-Ball	17	76	Two Sports	18
Football	13	80	Three Sports	19
Dance	33	60	Four or More	18
Gymnastics	22	71		
Bike	59	34		
Scooter	33	60		

Note: Played Sport = The number of children who played each individual sport. Did not Play Sport = The number of children who did not play each individual sport

Analytic Plan

Direct and moderated connections were examined between complex physical activity, outdoor play, and school readiness. Pearson bivariate correlations were conducted on complex physical activity, extent and frequency of time spent in outdoor play (hours), and school readiness, as measured by the PreBERS. A multiple regression was computed to examine the connection among complex physical activities and hours of outdoor play on school readiness. The main effect of complex physical activity and outdoor play was examined in model one, with the interaction between physical activity and outdoor play added in model two.

All analyses were completed using Stata 13.1 (StataCorp, 2013). The percent of missing data ranged from < .02% to .18%, with Full Information Maximum Likelihood estimation (FIML) used to address the issue of missing data (Schafer & Graham, 2002). FIML utilizes all available information and has been shown to produce less biased estimates than listwise deletion (Acock, 2012; Enders, 2001). Outliers were classified as values which were greater or lesser than 3.3 standard deviations from the mean. There was 1 outlier for outdoor play and 2 for family income. Both outliers were recoded to the next closest valid value for that measure within +/- 3.3 standard deviations. One outlier was also found for child age.

Child gender, child age, and family income were used as control variables for each model. To assess if school readiness was stronger for children who spent more time in outdoor play, participated in more complex physical activities, or if the connection with school readiness varied by complex physical activities, model one regressed outdoor play and sport participation on school readiness. The interaction between outdoor play with sport participation on school readiness was added in model two.

Results

Descriptive information for complex physical activity participation can be found in Table 1, and descriptive statistics (including correlations) for all variables included in the current analyses can be found in Table 2.

Results for model one showed that the extent and frequency of time spent in outdoor play was not significantly associated with school readiness (B = .09. p = .374) after controlling for child gender, child age, and family income. However, participating in complex physical activities was positively and significantly associated with school readiness (B = 1.07, p = .015), with children who participated in more complex physical activities showing higher scores on the measure of school readiness (see Table 3).

Table 2

Descriptive Statistics and Bivariate Pairwise Correlations Between Variables.

Variables	*1*	*2*	*3*	*4*	*5*	*6*
1. Outdoor Play	-	-	-	-	-	-
2. Sport Activity	.32**	-	-	-	-	-
3. School Readiness	.17†	.26*	-	-	-	-
4. Gender	-.11	-.05	-.18†	-	-	-
5. Child Age	-.02	-.02	.26*	.06	-	-
6. Family Income	.01	.02	.13	.09	-.02	-
N	93	93	91	107	107	95
Mean	8.01	2.41	32.07		51.19	45,060
SD	5.88	1.98	5.89		6.84	35,271
Min	0	0	1	0	36.3	0
Max	25	8	39	1	60.11	161,710

†$p < .10$. *$p < .05$. **$p < .01$

Table 3

Regression Model Results: Main Effects Outdoor Play, Complex Physical Activity, and the Interaction Between Outdoor Play and Complex Physical Activity with School Readiness.

	School Readiness[a]					
	Model 1			Model 2		
Variables	*B*	*SE*	*β*	*B*	*SE*	*β*
Outdoor Play[b]	.09	.09	.09	.47**	.18	.46
Complex PA[C]	1.07*	.44	.24	2.47**	.71	.55
Gender	-2.01†	1.11	-.17	-2.03†	1.08	-.17
Child Age	.26**	.08	.30	.27**	.08	.32
Family Income	.00	.00	.08	.00	.00	.03
Outdoor Play* Sports	–	–	–	-.17*	.07	-.59

Note. *B* = Unstandardized Estimate. *β* = Standardized Estimate. *SE* = Standard Error.

†$p < .10$. *$p < .05$ **$p < .01$

[a]The Preschool Behavioral and Emotional Rating Scales

[b]The extent and frequency of time in outdoor play is measured in hours.

[C] PA = Complex Physical Activity

Results for model two revealed a significant interaction between the number of complex physical activities a child played with the extent and frequency of time spent in outdoor play on children's school readiness (B = -.17, p = .015) (see Table 3). A test of the regions of significance (Preacher, Curran, & Bauer, 2006) to identify the number of complex physical activities within which time in outdoor play was linked with children's school readiness showed the region of significance fell between 2.57 and 3.06. This suggests that for children who played two sports, more time spent in outdoor play predicted higher school readiness. The extent and frequency of time spent in outdoor play was also positively related to school readiness for children who played no sports. However, for children who played 3 sports, time in outdoor play did not predict higher school readiness (see Figure 1).

Based on a reviewer suggestion, post hoc analysis were conducted that included an average of the number of hours' parents reported their child spent playing each complex physical activity (Mean = .45, range 0 - 2.25). This was done to control for overlap for parents who might have reported the extent and frequency of time in outdoor play as being time the child spent participating in complex physical activity. Results did not differ when including this variable in either model.

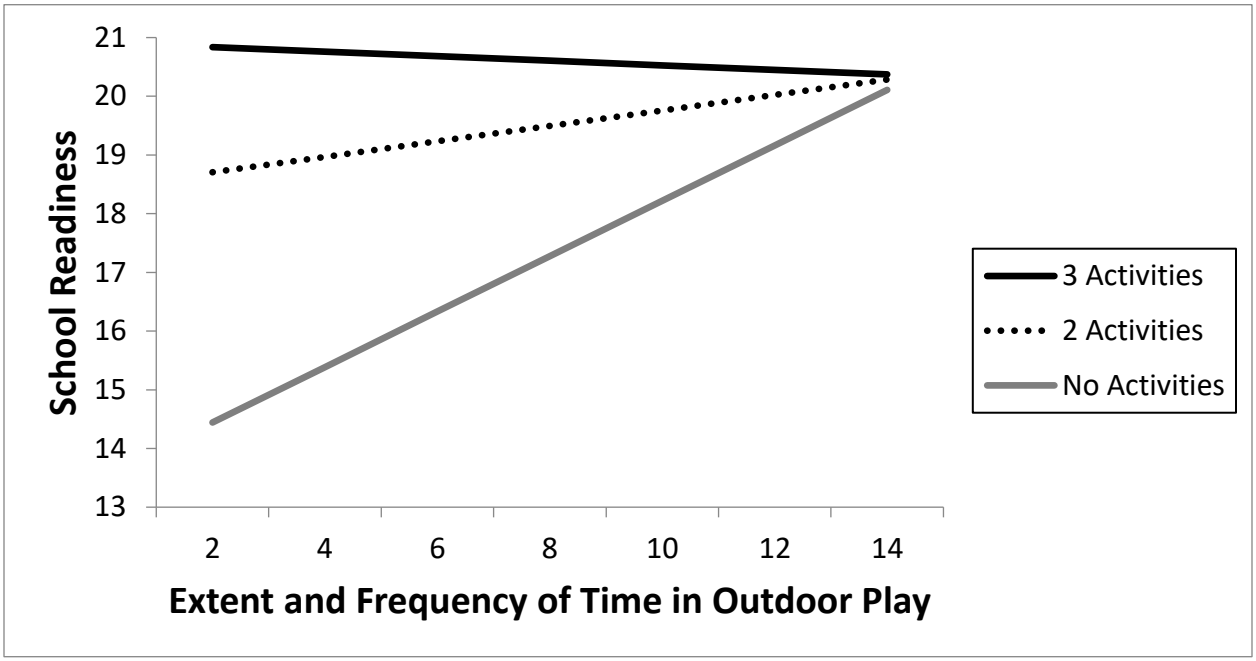

Figure 1. Interaction Between Extent and Frequency of Time in Outdoor Play and Complex Physical Activity Participation with School Readiness.

Note: Slopes represent the relationship between hours in outdoor play with school readiness for children who participated in 0, 2, and 3 complex physical activities. The extent and frequency of time in outdoor play is measured in hours.

Discussion

There is a need to understand the role of outdoor learning environments and activities that occur within such environments in the development of academic skills. Prior studies have found that cognitive components of school readiness are linked to physical activity (Becker et al., 2014; Davis et al., 2011) and participating in sports (Chang et al., 2013), but the cognitive and academic benefits of outdoor play and complex physical activity are not fully understood in prekindergarten children. Therefore, the purpose of this study was to assess if the extent and frequency of time spent in outdoor play, the number of complex physical activities a child plays, or some combination of the two is linked to school readiness. Results supported the hypothesis that participating in complex physical activities would moderate the association between outdoor play with school readiness, with a positive association found between school readiness with time spent in outdoor play for children who played two or fewer complex activities. For children who participated in 3 complex activities, time in outdoor play was not related to school readiness, although children in this group showed the highest level of school readiness. Results offer support that early care settings that offer children the opportunity to participate in complex physical activities could promote school readiness, but also suggests that a similar connection could be found if children are given time to play outdoors.

Outdoor Environments and the Interaction Between Sports and Outdoor Play

Results in the present study showed that complex physical activity significantly moderated the connection between the extent and frequency of time a child spends in outdoor play with school readiness. The nature of the interaction points to a positive connection between outdoor play with school readiness for children who participate in fewer complex activities. This result is somewhat consistent with past work that examined coordinative exercise, team games requiring physical activity, and interventions involving training in a sport skill, such as soccer (Chang et al., 2013; Koutsandréou et al., 2016; Schmidt, Jäger, Egger, Roebers, & Conzelmann, 2015). Evidence from these studies show the perceptual and cognitive demands of a sport and the shifting game context require attention that could be leading to improved cognitive performance following prolonged exposure. However, the interaction also suggests, as participation in complex physical activities increase (e.g., moving from two to three activities), the association between outdoor play with school readiness becomes flat. This suggests, for children who participate in one, two, or no complex activities, their school readiness scores increase when they spend more time in outdoor play.

At a practical level, time spent playing outside likely means that the child is not engaged in screen time. High levels of screen time are linked to lower vocabulary scores, poor interpersonal skills, and lower levels of physical activity (Carson, Rahman, & Wiebe, 2017; Hinkley, Salmon, Okely, Crawford, & Hesketh, 2012; Hinkley, Timperio, Salmon, & Hesketh, 2017). It is possible that children in the present study who spend more time in outdoor play are engaging in less screen time and spending more time being physically active. Non-organized physical activity is also linked to higher vocabulary scores (Carson et al., 2017), and this is consistent with the connection between outdoor play and school readiness found in the present study.

At the same time, children who participated in three or more complex physical activities showed the highest school readiness scores, with school readiness unrelated to the amount of time in outdoor play for these

children. This is consistent with results from Becker (2016), who found, for children who played more complex sports (e.g., soccer, volleyball), the physical intensity needed to play the sport was negatively related to executive function. Further, the highest executive function was found for children who played multiple complex sports at a low physical intensity. It is likely if a child is participating in three or more sports, they are spending time being physically active and interacting with peers, both of which are connected with school readiness.

The present study is unique in that it examined multiple complex activities (i.e., sport type activities) in a population where motor and cognitive skills are starting to develop. Although the complex physical activities assessed in the present study varied in the level of focus and attention needed to perform the activity (e.g., riding a bike or scooter vs kicking a soccer ball to a friend), they all required motor learning to some degree. As motor skills are developing within this age group (Myer et al., 2015), it is possible that learning to ride a bike or scooter, or throw, kick, or catch a ball could be taxing attention and inhibitory control, and improve the cognitive component of school readiness. Neuroanatomical connections support this proposal, with the cerebellum, a brain region central for coordination and motor control (Marr, 1969), connected to cortical systems involved in executive function (Diamond, 2000; Stoodley & Schmahmann, 2009).

Participation in sport-type activities is also linked to higher levels of social competence and lower levels of social anxiety (Dimech & Seiler, 2010; Haugen et al., 2013). As prosocial behaviors are linked to higher math and reading scores (Romano et al., 2010), it is possible that skills involved in positive social interactions could be developing as children interact with peers both during outdoor play and participation in complex physical activity. Together, the intersection among sensory-motor experience, social engagement, and the physical and embodied representation of information could suggest that participating in complex physical activities (i.e., sport type activities) is helping to prepare children for school.

Limitations and Future Directions

This study revealed connections among outdoor play and participating in complex physical activity with school readiness, but there were also a number of limitations. First, given that this was a concurrent study it was not possible to assess the directionality between outdoor play and participating in complex physical activity with school readiness. It is entirely possible that children with better school readiness select to spend more time playing outdoors or participating in complex physical activity. Future work should assess longitudinal connections among school readiness, outdoor play, and participating in complex physical activity (i.e., sports). Second, outdoor play, participating in complex physical activity, and school readiness were all derived from parent reports. We therefore could not objectively determine the amount of time a child spent participating in outdoor play or complex physical activity, and future work should objectively assess both.

It was also not possible to determine if parents' responses ignored the time spent by children playing outside when attending childcare. However, given that little research has examined how participating in outdoor play and complex physical activity could relate to school readiness, this study is a starting point for future work in this area. Results can also only be generalized to the eight complex activities analyzed in the present analysis. Further, school readiness is a complex construct that not only includes children's readiness for school, but also the schools' readiness for the child along with the families and communities' readiness for school (Britto, 2012; Dockett & Perry, 2009; 2014). Future work should examine if similar connections are found with other less traditional sport activities and use a multidimensional assessment of school readiness. Future work should also assess parents' and teachers'

attitudes, perceptions, and beliefs related to the role of physical activity in cognitive development. Finally, assessing connections among engagement in dialogic book reading, motor skills, and physical activity are also important avenues for future research given there connection to early school readiness (Becker, Miao, Duncan, & McClelland, 2014; MacDonald et al., 2016; Mol, Bus, de Jong, & Smeets, 2008).

Conclusion and Implications

Several important applications can be taken from the present results and applied to work within early care settings. First, educating parents and teachers about the cognitive and health benefits of physical activity could promote school readiness by demonstrating the need to create more opportunities for children to play outdoors. Programs aimed at encouraging parents and teachers to get active could also alter attitudes and beliefs about the benefits of outdoor play and increase the overall level of physical activity for both adults and children. Children who are given the opportunity to play outside are also likely to engage in less screen time and be more physically active (Hinkley et al., 2012). Thus, programs with limited sport resources might realize academic benefits by allowing children time to play outdoors.

Second, offering children the opportunity to participate in complex physical activities (i.e., sport type activities) might also promote school readiness. This could be accomplished by providing informal opportunities for a child to ride a bike, or kick, throw, and catch a ball, or through formal sport instruction. Third, the combination of outdoor play and participating in complex physical activity could act in an additive manner to improve school readiness, with programs that integrate both possibly seeing the strongest benefits in preparing children for school.

Acknowledgment

The authors acknowledge the support of a School University Teacher Education Partnership Grant from the College of Education and Allied Professions at Western Carolina University, without which this work would not have been possible.

References

Acock, A. C. (2012). What to do about missing values. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf & K. J. Sher (Eds.), *APA handbook of research methods in psychology, vol 3: Data analysis and research publication* (pp. 27-50). Washington, DC, US: American Psychological Association.

Alesi, M., Bianco, A., Luppina, G., Palma, A., & Pepi, A. (2016). Improving children's coordinative skills and executive functions the effects of a football exercise program. *Perceptual and Motor Skills, 122*(1), 27-46.

Bailey, R. (2006). Physical education and sport in schools: A review of benefits and outcomes. *Journal of School Health, 76*(8), 397-401.

Becker, D. R. (2016). *Moving towards academic success and life long learning*. (Dissertation). Retrieved from http://hdl.handle.net/1957/59362 ScholarsArchive@OSU database.

Becker, D. R., McClelland, M. M., Loprinzi, P., & Trost, S. G. (2014). Physical activity, self-regulation, and early academic achievement in preschool children. *Early Education & Development, 25*(1), 56-70.

Becker, D. R., Miao, A., Duncan, R., & McClelland, M. M. (2014). Behavioral self-regulation and executive function both predict visuomotor skills and early academic achievement. *Early Childhood Research Quarterly, 29*(4), 411-424.

Britto, P. R. (2012). *School readiness: A conceptual framework*. New York: Education Section, Programme Division, United Nations Children's Fund.

Carson, V., Rahman, A. A., & Wiebe, S. A. (2017). Associations of subjectively and objectively measured sedentary behavior and physical activity with cognitive development in the early years. *Mental Health and Physical Activity*.

Chaddock, L., Erickson, K. I., Prakash, R. S., Kim, J. S., Voss, M. W., VanPatter, M., . . . Kramer, A. F. (2010). *A neuroimaging investigation of the association between aerobic fitness, hippocampal volume, and memory performance in preadolescent children*. [doi: DOI: 10.1016/j.brainres.2010.08.049]. Brain Research, 1358, 172-183.

Chaddock, L., Erickson, K. I., Prakash, R. S., VanPatter, M., Voss, M. W., Pontifex, M. B., . . Kramer, A. F. (2010).

Basal ganglia volume is associated with aerobic fitness in preadolescent children. *Developmental Neuroscience, 32*(3), 249-256.

Chaddock, L., Erickson, K. I., Prakash, R. S., Voss, M. W., VanPatter, M., Pontifex, M. B., . . .Kramer, A. F. (2012). A functional MRI investigation of the association between childhood aerobic fitness and neurocognitive control. *Biological Psychology, 89*(1), 260-268.

Chaddock-Heyman, L., Erickson, K. I., Voss, M. W., Knecht, A. M., Pontifex, M. B., Castelli,D.M., . . . Kramer, A. F. (2013). The effects of physical activity on functional MRI activation associated with cognitive control in children: a randomized controlled intervention. *Frontiers in Human Neuroscience, 7*.

Curlik Ii, D. M., & Shors, T. J. (2013). Training your brain: Do mental and physical (map) training enhance cognition through the process of neurogenesis in the hippocampus? *Neuropharmacology, 64*, 506-514. doi: 10.1016/j.neuropharm.2012.07.027

Chang, Y.-K., Tsai, Y.-J., Chen, T.-T., & Hung, T.-M. (2013). The impacts of coordinative exercise on executive function in kindergarten children: an ERP study. *Experimental Brain Research, 225*(2), 187-196.

Cleland, V., Crawford, D., Baur, L. A., Hume, C., Timperio, A., & Salmon, J. (2008). A prospective examination of children's time spent outdoors, objectively measured physical activity and overweight. *International Journal of Obesity, 32*(11), 1685-1693.

Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., . . . Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial. *Health Psychology, 30*(1), 91.

Diamond, A. (2000). Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development, 71*(1), 44-56.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333*(6045), 959-964.

Dimech, A. S., & Seiler, R. (2010). The association between extra-curricular sport participation and social anxiety symptoms in children. *Journal of Clinical Sport Psychology, 4*(3), 191-203.

Doctoroff, G. L., Greer, J. A., & Arnold, D. H. (2006). The relationship between social behavior and emergent literacy among preschool boys and girls. *Journal of Applied Developmental Psychology, 27(*1), 1-13. doi:https://doi.org/10.1016/j.appdev.2005.12.003

Dockett, S., & Perry, B. (2009). Readiness for school: a relational construct. *Australasian Journal of Early Childhood, 34*(1), 20.

Dockett, S. & Perry, B. (2014). *Continuity of learning: A resource to support effective transition to school and school age care*. Canberra, ACT: Australian Government Department of Education.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., . . . Brooks-Gunn, J. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428.

Epstein, M.H., & Synhorst, L. (2009). *Preschool behavioral and emotional rating scale (PreBERS): A strengths-based approach to assessment*. Austin:Pro-Ed.

Enders, C. K. (2001). The performance of the full information maximum likelihood estimator in multiple regression models with missing data. *Educational and Psychological Measurement, 61*, 713-740.

Findlay, L. C., & Coplan, R. J. (2008). Come out and play: Shyness in childhood and the benefits of organized sports participation. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement, 40*(3), 153.

Gould, D., & Carson, S. (2008). Life skills development through sport: Current status and future directions. International *Review of Sport and Exercise Psychology, 1*(1), 58-78.

Haapala, E. A., Väistö, J., Lintu, N., Westgate, K., Ekelund, U., Poikkeus, A.-M., . . . Lakka, T. A. (2016). Physical activity and sedentary time in relation to academic achievement in children. *Journal of Science and Medicine in Sport*.

Haugen, T., Säfvenbom, R., & Ommundsen, Y. (2013). Sport participation and loneliness in adolescents: the mediating role of perceived social competence. *Current Psychology, 32*(2), 203-216.

Hinkley, T., Salmon, J., Okely, A. D., Crawford, D., & Hesketh, K. (2012). Preschoolers' physical activity, screen time, and compliance with recommendations. *Medicine and Science in Sports and Exercise, 44*(3), 458-465.

Hinkley, T., Timperio, A., Salmon, J., & Hesketh, K. (2017). Does preschool physical activity and electronic media use predict later social and emotional skills at 6 to 8 years? A cohort study. *J Phys Act Health (4),* 308-316.

Kharitonova, M., & Munakata, Y. (2011). The role of representations in executive function: Investigating a developmental link between flexibility and abstraction. *Frontiers in Psychology, 2*.

Koutsandréou, F., Wegner, M., Niemann, C., & Budde, H. (2016). Effects of motor versus cardiovascular exercise training on children's working memory. *Medicine and Science in Sports and Exercise, 48*(6), 1144-1152.

Koziol, L. F., Budding, D. E., & Chidekel, D. (2012). From movement to thought: Executive function, embodied

cognition, and the cerebellum. *The Cerebellum, 11*(2), 505-525. doi: 10.1007/s12311-011-0321-y

MacDonald, M., Lipscomb, S., McClelland, M. M., Duncan, R., Becker, D., Anderson, K., & Kile, M. (2016). Relations of preschoolers' visual-motor and object manipulation skills with executive function and social behavior. *Research Quarterly for Exercise and Sport,* 1-12.

Marr, D. (1969). A theory of cerebellar cortex. The Journal of Physiology, 202(2), 437-470.

McClelland, M. M., Cameron, C. E., Duncan, R., Bowles, R. P., Acock, A. C., Miao, A., & Pratt, M. E. (2014). Predictors of early growth in academic achievement: the head-toes-knees shoulders task. *Frontiers in Psychology, 5*, 599.

Memmert, D. (2009). Pay attention! A review of visual attentional expertise in sport. International Review of Sport and Exercise Psychology, 2(2), 119-138.

Miyake, A. U., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex 'frontal lobe' tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49-100.

Myer, G. D., Faigenbaum, A. D., Edwards, N. M., Clark, J. F., Best, T. M., & Sallis, R. E. (2015). Sixty minutes of what? A developing brain perspective for activating children with an integrative exercise approach. *British Journal of Sports Medicine, 49*(23), 1510-1516.

Nakamoto, H., & Mori, S. (2012). Experts in fast-ball sports reduce anticipation timing cost by developing inhibitory control. *Brain and Cognition, 80*(1), 23-32.

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*(4), 437-448.

Romano, E., Babchishin, L., Pagani, L. S., & Kohen, D. (2010). School readiness and later achievement: replication and extension using a nationwide Canadian survey. *Developmental Psychology, 46*(5), 995.

Schmidt, M., Jäger, K., Egger, F., Roebers, C. M., & Conzelmann, A. (2015). Cognitively engaging chronic physical activity, but not aerobic exercise, affects executive functions in primary school children: a group-randomized controlled trial. *Journal of Sport & Exercise Psychology, 37*(6).

Shim, S.-Y., Herwig, J. E., & Shelley, M. (2001). Preschoolers' play behaviors with peers in classroom and playground settings. *Journal of Research in Childhood Education, 15*(2), 149-163.

Snyder, H. R., & Munakata, Y. (2010). Becoming self-directed: Abstract representations support endogenous flexibility in children. *Cognition, 116*(2), 155-167.

StataCorp. (2013). Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.

Stoodley, C. J., & Schmahmann, J. D. (2009). Functional topography in the human cerebellum: a meta-analysis of neuroimaging studies. *Neuroimage, 44*(2), 489-501.

Vandell, D. L., Belsky, J., Burchinal, M., Steinberg, L., & Vandergrift, N. (2010). Do effects of early child care extend to age 15 years? Results from the NICHD study of early child care and youth development. *Child Development, 81*(3), 737-756.

Williams, A. M., & Ford, P. R. (2008). Expertise and expert performance in sport. *International Review of Sport and Exercise Psychology, 1*(1), 4-18.

About the Author(s)

Derek R. Becker, Ph.D., is an assistant professor in the Birth-Kindergarten program at Western Carolina University. He teaches a range of early childhood research methods courses, along with math, science and curriculum. His research focuses on connections among play, physical activity, and sport participation with executive function and early learning.

Cathy Grist, Ph.D., is an Associate Professor and Director of the Birth-Kindergarten Program at Western Carolina University. She has taught courses in assessment and intervention for young children with disabilities in a fully online program for the last 10 years. She is a licensed clinical psychologist who provides psychological and behavioral assessments, as well as interventions for preschool age children in private practice.

Research interests include preschool personality, assessment, social-emotional competence in young children, behavioral issues, and online teaching strategies and methods.

Lori Caudle, Ph.D., is an associate professor in the Birth-Kindergarten program at Western Carolina University. She teaches a range of early childhood methods courses, including authentic assessment, literacy, environments, and curriculum. Her research focuses on the professional development of in-service and pre-service early childhood teachers, with a particular focus on the use of digital tools and/or collaboration to enhance learning.

Myra Watson, MAEd, NBCT, is an instructor in the Birth-Kindergarten Program at Western Carolina University. She is a former prekindergarten and kindergarten teacher.