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Effects of Active Outdoor Play on Preschool Children's on-Task Classroom Behavior

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Abstract
Physical activity—including outdoor motor play—has been associated with learning and brain-related functions and abilities in elementary school children and adolescence. Few studies have been conducted on the relationships between active play and these cognitive processes in preschool aged children. Several investigations have revealed that adult-directed physical activity can enhance preschoolers' performance on measures of executive functions, such as inhibitory control or attention. In the present investigation we sought to determine if naturalistic playground play would have a similar effect to adult-guided exercise on a classroom indicator of young children's cognitive control—on-task behavior during a whole group learning experience. The on-task behavior of 21 three-, four-, and five-year-olds was compared under two conditions—one in which children played outdoors immediately prior to the experience and one in which they did not. Too, the relationship between the level of physical activity on the playground of children and their on-task behavior directly following it was examined. Findings indicate that outdoor play prior to learning resulted in greater on-task behavior for boys and children of low socio-economic status. Level of activity in play prior to a learning time was positively related to on-task behavior. Implications for scheduling of outdoor play and the role of teachers' in facilitating more active motor play are discussed. Future research on a larger, more diverse sample of children is recommended.

Keywords Motor play · Playground play · Physical activity level · On-task behavior

Introduction

Active motor play contributes to the healthy physical development of young children (Figueroa and An 2017; Truelove et al. 2017). Opportunities to engage in such play at home and in school have been associated with children's cardiovascular health and fitness (Simmonds et al. 2016; Vale et al. 2015) and a reduction in obesity and chronic illness in later adulthood (Simmonds et al. 2016; Funtikova et al. 2015). For this reason the Centers for Disease Control and Prevention (2018) recommend that children engage in at least an hour of moderate-to-vigorous physical activity (MVPA) each day.

A growing body of research has focused on the contributions of physical activity to cognitive development and learning. Associations have been found between frequency and level of children's active play and academic achievement and cognitive abilities, particularly for those with disabilities (Fedewa et al. 2015; Gapin et al. 2011). Although most investigations of physical activity and achievement involve elementary school age children, several studies have linked amount of physical activity, both at home and school, to early math and literacy learning in preschool (Becker et al. 2018, 2014).

There are two prominent explanations for why physical activity is associated with early cognitive development and learning. The first, the *chronic aerobic exercise theory*, holds that children who are active in their play over time display greater cardiorespiratory fitness that has been associated with measures of brain development and functioning (Best 2010). Children's overall fitness has been linked to increased blood flow to important learning areas of the brain, positive changes in brain structure, and improved performance of brain regions that are responsible for executive functions—self-regulatory behaviors such as attention, inhibitory control, or working memory (Chaddock et al. 2010; Esteban-Cornejo et al. 2017; Khan and

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Hillman 2014; Hillman et al. 2009a, b; Ortega et al. 2017). Research on the effects of programs designed to improve children's physical fitness support this theory (Krafft et al. 2014; Davis et al. 2011). Such programs have been found, over time, to enhance brain development and various assessments of cognitive control—abilities to regulate and direct one's own mental processes, which predict academic success. The implication of this research is that young children should be provided with enough daily physical activity in school to maintain fitness.

A second explanation for why physical activity is linked to brain-related development and learning is the *acute exercise theory* (Drollette et al. 2014), which holds that motor action has an immediate impact on brain functioning. Far fewer studies have been conducted to test this theory. In one investigation, researchers found that a 20-min bout of moderate-intensity walking on a treadmill resulted in immediate changes in brain-wave activity in eight- to ten-year-olds (Drollette et al. 2014). Specifically, changes in the P3 brain wave amplitude, which is often considered a neurologically-related indicator of focused attention, was higher for children immediately after exercise. This change in brain activity likely explained the additional finding of this study that, after exercise, children performed better on a measure of cognitive control. Specifically, they showed improvement in their ability to focus attention and inhibit impulses when performing a learning task. An implication of this study is that physical activity can have an immediate impact on young children's cognitive abilities that support learning. Active play might enhance children's thinking and learning directly after it occurs.

One study explored the impact of an acute bout of exercise on the cognitive control of preschool-aged children (Palmer et al. 2013). In this investigation, a single, adult-directed, 30 min exercise period that included throwing, running, hopping, and other motor actions was found to increase children's performance on a measure of sustained attention—an important aspect of cognitive control. Although the authors did not examine children's brain activity as part of their study, they speculate that a short period of intense exercise activated areas of the brain responsible for paying attention.

A question that arises from this previous research is whether informal, naturalistic motor play on the playground can have a similar benefit to that of adult-directed exercise programs studied in previous investigations. This question is important, since playground play in preschools is most often open-ended and informal, with less adult direction. Will such free play provide sufficient physical activity to enhance children's cognitive control? One study addressed this question by coding preschool children's attention during classroom activities before and after outdoor play (Holmes et al. 2006). Children were scored as more attentive following an extended playground period. Authors conclude that outdoor play "rejuvenates" children's brain functions.

Applying the acute exercise theory, our present investigation extends the literature on physical activity in several ways. First, it adds to the scant research that has been done on very young children. We include participants as young as three years of age in our study. Second, we examine the impact of naturalistic outdoor free play, including children's level of activity on the playground, on subsequent classroom learning behaviors. Finally, we choose a broader, classroom-based measure of cognitive control—*on-task behavior*—during regularly-scheduled classroom group learning experiences (Grieco et al. 2016; Miramontez and Schwartz 2017). Many previous studies have measured the effects of physical activity on children's performance through one-on-one assessments of a single cognitive ability, such as attention or inhibitory control, in laboratory settings. A measure of on-task behavior captures many different cognitive abilities, including attention, behavioral regulation, inhibitory control, within a single classroom observation (Halliday et al. 2018). More important, the measure of on-task behavior we employ in our study is of greater practical interest to teachers, since it can be observed directly in the classroom.

Specifically, our study addresses the following research questions:

1. Do preschool children exhibit greater on-task behavior in a whole group classroom learning experience that directly follows a free play period on the playground?
2. Do children who play at a more active level on the playground directly prior to a learning experience subsequently demonstrate greater on-task behavior than those who are more sedentary?

Method

Our study was approved by the ethics committee on the treatment of human subjects of our university. All methods were found to comply with the *Federal Policy for the Protection of Human Subjects* of the U.S. Department of Health and Human Services (2017). Informed consent was obtained from legal guardians of all participants. Children were informed that they would be observed and met several times with the researcher. Any expressed resistance to being observed, although none occurred, would have been considered a withdrawal of a child's assent and that child would have not been included in the study.

Participants

Participants were 21 three (n = 12), four (n = 7), and five (n = 2) year old children ($M = 3.58$ years, $SD = 0.67$) who

were enrolled in two preschool classrooms in a community-based child development center on the campus of a small, public university in the Northeast U.S.

All children enrolled in these two preschool classrooms where the study took place, whose parents or guardians had provided informed consent, were included in the sample. Nine of the participants were boys, 12 were girls, 12 were of low or moderately low socioeconomic status (SES); and 9 of middle or high SES. The center where the study took place was an accredited, high quality program with head teachers who held master's degrees, and teacher associates and assistant teachers with bachelor's or associate degrees. The center followed a play-based curriculum and included one hour of outdoor free play in the morning and another in the afternoon. Each classroom included a whole group time in the morning that was normally scheduled prior to the morning playground period.

Procedures

Children's behaviors in a regularly-planned whole group learning experience were observed under two conditions. First, during two different teacher-led group times in each classroom that included all children in the classroom and held when they are normally scheduled, each child's on-task behavior was coded. These two observations in each classroom were conducted one week apart. Coding of on-task behavior was conducted by a researcher who had spent time in the classroom prior to observations, so she was familiar to children. She stood a distance away from the children and saw no evidence that they were aware of, or became distracted by, her presence. These two coding sessions in each classroom provided a base-line measure of on-task behavior following the typical preschool day. These group experiences included songs, brief lessons, and planning for the day, lasting about 30 min. The researcher was aware of the purposes of the study; teachers had a general understanding of the investigation, but were blind to the exact behaviors that were being observed and coded.

One week after the baseline observations, teachers in each classroom rearranged their daily schedules so that children would play on the playground for an hour prior to group time on two different days. Two observations during group time in each classroom, conducted two weeks apart, were conducted immediately after these playground periods. A researcher coded on-task behavior in these post-playground group times. Once again, she was familiar to the children and observed no evidence that her presence distracted them. These observations provided data on a potential change in on-task behavior following outdoor play.

As children played on the playground during these specially scheduled sessions prior to group time, their activity level was coded. This coding was conducted by the same researcher who was familiar to children. She stood inconspicuously on the periphery of the playground. Once again, the researcher knew of the purposes of the study and what was being observed, but teachers on the playground did not.

Measures

On-Task Behavior

During group times, both those before and after playground play, children's behavior was coded as either on- or off-task, using a time sampling measure developed and used in previous research (Mahar et al. 2006). This measure has been found to be reliable, with a mean interrater agreement of 94% in previous studies. The two authors of the present study independently coded 15% of observed on-task behavior. A high level of agreement was achieved, *kappa* = 0.86. The measure has been used, with minor modification, in previous research on preschool aged children (Luke et al. 2014; Webster et al. 2015).

Using this instrument, we observed children, one at a time, on every two minutes, and coded whether they were on or off task. A total of 15 codes were recorded for each child during each group time. On-task behavior was defined as "any verbal or motor behavior that followed the class rules and was appropriate to the learning situation." (Mahar et al. 2006, p. 2008). On-task behaviors included participating in group activities, looking toward the teacher, and sitting attentively. Off-task behaviors were defined as behaviors that disrupted activities, disturbed other children, violated class rules, or clearly indicated nonparticipation (e.g., gazing off, getting up and walking away). When coding, we judged on- and off-task behavior by taking into account the typical behaviors of very young children. For example, the typical wiggliness of preschool children was not coded as off-task. Looking toward the teacher was considered on-task, even if children were not sitting completely still or establishing direct eye contact.

Playground Activity Level

During the outdoor play periods that were specially scheduled prior to group time observations, each child's activity level on the playground was scored, using a coding system that was developed and used in earlier studies (Brown et al. 2006). A direct observation of activity level was utilized because of concerns expressed by some teachers about the use of accelerometers—devices to measure movement—and potential child non-compliance in wearing these, which has been an issue in previous research on preschool aged children (Driediger et al. 2019). This observation system has been found to be reliable, with a mean interrater agreement of 0.80 for preschool settings. The two researchers in the

present investigation independently coded 15% of outdoor play observations and achieved a high interrater agreement, *kappa* = 0.97.

Using this measure, we assigned a code, s*tationary/ stationary with limb or trunk movement*, *slow to moderate movement*, or *fast movement,* to each child on every two minutes during playground play for a total of 25 observations during each outdoor period. The code *stationary or stationary with limb or trunk movement* was defined as behavior in which children were not moving at all or moved only limbs while standing still. A *slow to moderate movement* was defined as movement at a slow or moderate pace (e.g., walking, slow swinging). A code of *fast movement* included fast or very fast behaviors (e.g., running, skipping, jumping).

Analyses

Data were analyzed in two ways. First, a factorial analysis of variance with repeated measures was conducted with condition (outdoor play before and after group time), age, gender, and socioeconomic level as independent variables and group time on-task behavior as the dependent variable. This allowed an examination of outdoor play effects across age, gender, and SES categories. Next we conducted a series of multiple regression analyses with play activity level during the prior-to-group playground condition, age, gender, and SES as independent variables and on-task behavior as the dependent variable. This allowed us to determine whether the level of physical activity on the playground was related to on-task behavior, controlling for age, SES, and gender. Although the number of participants in the study was small, the large number of observations and a repeated measures design allowed these statistical analyses.

Results

The purpose of this study was to determine the effects of an outdoor motor play period just prior to a classroom learning experience on preschool children's on-task behavior. We also examined the relationship between the level of physical activity of children during this prior-to-learning playground experience and on-task behavior.

Outdoor Play Effects

In an initial analysis, we examined differences between children's on-task behavior under two conditions: (1) baseline—a typical mid-morning whole group learning session with playground time scheduled later in the morning and (2) a treatment condition—a similar learning session that immediately followed a specially-scheduled outdoor play period. In a preliminary one-way analysis of variance (ANOVA) with repeated measures no significant main effect was found for condition. Participants as a whole group did not differ in on-task behavior scores following an outdoor play treatment.

However, a 2 (condition) × 2 (gender) × 3 (3, 4, and 5 year olds) × 3 (low, moderate, and high SES) factorial analysis of variance with repeated measure revealed several significant interaction effects. Means and standard deviations for these variables are presented in Table 1. A significant condition x gender interaction effect was found, F (1, 651) = 4.61, $p < 0.05$. The effects size—the strength of findings, given the size of the sample—for this interaction was found to be large, partial $\eta^2 = 0.28$. As shown in the table, the source of this interaction appears to be the relatively high increase in on-task behavior scores for boys, compared to girls, following the outdoor play treatment. An SES × condition interaction effect was found to approach statistical significance, F (2, 650) = 2.88, $p = 0.057$. The effects size for this interaction was large, $\eta^2 = 0.34$. This interaction may be explained by the higher on-task behavior scores for children of low SES following the outdoor play treatment, relative to other groups. No age x condition or three-way or higher interaction effects were discovered.

Relationship of Activity Level and on-Task Behavior

In order determine whether the level of physical activity of children during the prior-to-learning outdoor play treatment was associated with subsequent on-task behavior, we conducted a hierarchical multiple regression analysis with playground activity level scores and demographic variables as independent variables and on-task behavior after play as the dependent variable. Means, standard deviations, and correlation coefficient among all variables in this analysis are presented in Table 2. As shown in the table, all correlations

Table 1 Means and standard deviations for on-task behavior by condition, gender, age, and SES

Condition	Gender	*M*	*SD*	Age (years)	*M*	*SD*	SES	*M*	*SD*
Baseline	Boys	0.79	0.41	3	.81	.39	Low	.84	.37
	Girls	0.89	0.31	4	.89	.32	Middle	.81	.39
				5	.90	.30	High	.87	.33
Treatment	Boys	0.85	0.35	3	.86	.35	Low	.90	.31
	Girls	0.86	0.34	4	.83	.38	Middle	.79	.44
				5	.95	.22	High	.89	.32

Table 2 Correlation coefficients, means, and standard deviations for all variables analyzed

	Age	Gender	SES	Activity	On –Task
Age	1	.18	−.33*	.06	.26
Gender	.18	1	.10	−.24	.09
SES	−.33*	.10	1	.22	.17
Activity level	.06	-.24	.22	1	.47**
On-task behavior	.26	.09	.17	.47**	1
Mean	44.81	1.57	2.00	1.70	.82
SD	6.54	.50	.93	.37	.25

*p < .05

**p < .01

*Age .38

**Activity Level .45

were well below 0.90, above which collinearity is a cause for concern (Alin 2010). We ran collinearity diagnostics for all pairs of variables; tolerance statistics were found to be above 0.10, and the variance inflation factor (VIF) was below 5, indicating that collinearity was not problematic.

We conducted a regression analysis in two stages. We first fitted a model in which only demographic variables—age, gender, and SES—were entered as independent variables and on-task behavior as the dependent variable. This model did not significantly predict on-task behavior and only explained 15% of variance in this behavior after outdoor play, $R^2 = 0.15$, F (3, 34) = 2.05, $p = 0.13$. We next fitted a model in which we entered the same three demographic variables plus activity level scores during the outdoor play treatment as independent variables and on-task behavior as the dependent variable. This second model significantly predicted on-task behavior and explained 33% of variance in this behavior, $R^2 = 0.33$, F (1, 33) = 8.42, $p < 0.01$). This finding indicates that activity level on the playground contributed an additional 17% of variance to on-task behavior, over and above demographic influences, R^2 Change = 0.17.

The independent contributions of each variable in these models are presented in Table 3. As shown in the table, when only demographic variables are entered in Model 1, age was the only variable that was significantly associated with on-task behavior, ß = 0.38, $t = 2.19$, $p < 0.05$. The relationship between SES and on-task behavior approached statistical significance, ß = 0.32, $t = 1.83$, $p = 0.08$. In Model 2, only activity level on the playground was significantly related to on-task behavior, as presented in the table, ß = 0.45, $t = 2.90$, $p < 0.01$. As shown in the table, no other independent variables in Model 2 were significantly associated with on-task scores.

Discussion

Previous research has found associations between children's activity level—on the playground or in the classroom—and measures of academic achievement and cognitive abilities (Becker et al. 2018, 2014; Fedewa et al. 2015). Findings of our study suggest one explanation for these findings: For some children, active play on the playground can enhance on-task behavior in subsequent learning situations. Further, our results support an acute exercise theory that holds that even brief bouts of activity can improve learning-related abilities (Drollette et al. 2014). In our investigation, the on-task behavior of some children improved following a single, hour-long, outdoor play period.

Effects of Single, Outdoor Play Periods

In our study, when some children were provided with a playground play period just before an indoor learning experience, they showed greater on-task behavior. This effect was found for two specific groups of children—boys and those of low socioeconomic (SES) background. The gender finding is important because prior research has indicated that boys are more frequently off-task, exhibit low self-control in classroom activities, and are slower in acquiring executive functions, such as inhibitory control and attention (Daly and Corcoran 2019; Godwin et al. 2016; Matthews et al. 2014; Mileva-Seitz et al. 2015; Montroy et al. 2016). Concern has

Table 3 Multiple regression models predicting on task behaviors following an outdoor play treatment

Model	Variables	*Beta*	*t*	Significance	R^2	R^2 change
	(constant)				.15	
1	Age	.38	2.19	.04		
	Gender	.02	.10	.92		
	SES	.32	1.83	.08		
	(constant)				.33	.17
2	Age	.28	1.72	.09		
	Gender	.15	.97	.34		
	SES	.17	1.00	.33		
	Activity level	.45	2.90	.01		

been raised about a gender gap in early childhood education in which some boys are at greater risk of poor learning outcomes (DiPrete and Jennings 2012; Figlio et al. 2019; Legewie and DiPrete 2012; Owens 2016). Results of our study suggest that active, outdoor play prior to important learning experiences in preschool might be one method for ameliorating this gender gap at an early age.

Our SES findings also have important implications. Children of low SES have been found to score lower on measures of executive functions, such as inhibitory control and attention, on-task behavior, and academic learning. (John et al. 2019; Last et al. 2018; Moffett and Morrison 2019; Vrantsidis et al. 2019). Deficits in on-task behavior may be one reason that many children of low SES families fall behind their peers in school achievement (Hanushek et al. 2020; Whipple et al. 2016). An inability of some children living in poverty to regulate behavior, pay attention, and participate in whole group teaching is likely to have an impact on success in school. Results of our study suggest that scheduling outdoor play prior to classroom learning experiences might be one strategy for supporting the learning of young children of low SES and for reducing this achievement gap.

Association of Activity Level and on-Task Behavior

Findings of the present investigation suggest that simply being outdoors on the playground may not be sufficient in promoting children's on-task behavior in subsequent learning periods. We found that the level of activity in play during prior-to-learning playground sessions was directly related to later on-task behaviors. Children who engaged in the highest levels of physical activity enjoyed the greatest increases in on-task classroom behavior. This finding is consistent with studies showing that the duration and intensity of adult-directed physical activity programs for older children and adolescents is related to on-task behavior (Bartholomew et al. 2018; Hillman and Pontifex 2009; Howie et al. 2014). Too, it supports the implementation of strategies to increase preschool children's activity level on the playground through adult guidance (Tucker et al. 2017; Wadsworth et al. 2020). Based on our findings, such interventions not only promote health and fitness, but might have an impact on young children's on-task behavior and learning as well.

This connection between activity level in play and on-task behavior may be explained, in part, by the immediate effect of intense exercise on brain functions, reported in previous research. Studies of adults and older children have shown that intense physical activity will have a greater immediate impact on the brain than milder forms of exercise (Ferris et al. 2007; Tottori et al. 2019). Specifically, high intensity exercise of older children and adolescents activates important regions of the brain and increases P3 wave amplitude—both of which are associated with self-regulation and attention (Chaddock et al. 2010; Chen et al. 2016; Drollette et al. 2014). Active play on the playground may have similar effects on brain functions—and resulting on-task behavior—for preschool children.

Implications for Teaching

There are several implications of our findings for professional practice in preschools. First, a schedule of the day that provides outdoor play periods just prior to play and whole-group learning activities is likely to lead to greater on-task behavior. Based on our results, this might be particularly important for boys and children living in poverty. This increase in on-task behavior, as indicated in previous research, can lead to greater learning (Moffett and Morrison 2019). Administrators of preschool programs might rethink the practice of scheduling playground time later in the day when many important learning experiences have already occurred (Mahoney and Fagerstrom 2006). A mid-morning outdoor play period before group time lessons or book sharing would be beneficial; scheduling two outdoor play periods in full day programs—each positioned before a whole group learning time—would be ideal (Erwin 2017; Holmes et al. 2006).

A second implication of our findings is that teachers should facilitate children's activity level when they are playing outdoors. In particular, they might adopt strategies to increase the movement of boys and children of low SES. This may result in even greater on-task behavior after children come back into the classroom. Teachers can create outdoor play spaces and materials that are known to inspire greater movement, such as portable playground equipment—balls, hoops, and cones—and natural elements—water, grass, and mud (Gubbels et al. 2012; Määttä et al. 2019; Sugiyama et al. 2012). They can interact with children in ways that promote greater levels of activity, such as initiating active games and movement activities, offering new pieces of equipment, and inviting sedentary children to join their peers in active play (Coe 2018; Culpepper and Killion 2018; Hesketh et al. 2017; Tortella et al. 2019). Based on our findings, these strategies can enhance on-task behavior in learning situations back in the classroom.

Limitations and Recommendations for Future Research

A limitation of this study is its small sample size, which limits the generalizability of findings to larger and more diverse populations of children. Future research on outdoor play and its effects on on-task behavior in the preschool classroom should be conducted with larger and more diverse, including children with disabilities who are now regularly integrated into preschool classrooms and who

have been found to benefit from active play (Ketcheson et al. 2018). Investigations might include children of a greater ethnic diversity, since on-task behavior, executive functions, and activity level have all been found to be influenced by families and culture (Caldas and Reilly 2018; Fan and Cao 2017; Lan et al. 2011).

Aa number of questions are not answered in our present investigation. Does the increase in on-task behavior, resulting from active outdoor play, predict positive learning outcomes? Future research might examine whether outdoor play experiences and subsequent on-task behavior result in greater understanding and retention of concepts or skills taught during group time. Longer term investigations might determine if an ongoing schedule of playground play prior to learning contributes to positive outcomes during a full school year or longer.

A limitation of this investigation is that it does not examine the varying effects of different types of movement and play activities, beyond just physical activity level, on children's on-task behavior. Previous research on older children has found that the type of physical activity will differentially affect cognitive abilities. For example, in several investigations, more cognitively challenging motor play—for example, games that require paying attention and suddenly starting, stopping, or altering movements—predicted greater performance on executive functions tasks, such as inhibitory control (Egger et al. 2019; Jäger et al. 2014). In other research, adult-directed repetitive movement activities, such as balancing on a rope or kicking a ball, did not produce the same increases in measures of cognitive control in older elementary children as more aerobic activities, such as running (Chen et al. 2014; Stein et al. 2017). Are there types of playground play that are particularly powerful in promoting on-task behaviors of preschool-aged children?

Although our study is based on the brain-related acute exercise theory, it does not include measures of brain activity or structure. The majority of studies of physical activity and the brain have been conducted with school-aged children, adolescents, and adults (Bidzan-Bluma, and Lipowska 2018; Chaddock et al. 2011). There is a need for neuroscientific investigations on the effects of typical free play of preschoolers on the playground and changes in brain region activation, wave activity, and architecture of the brain, as measured by magnetic resonance imaging (MRI) and electroencephalography (EEG) (Chaddock et al. 2010; Chaddock-Heyman et al. 2013; Esteban-Cornejo et al. 2017). Such research would not only provide insight into the processes by which active play of preschoolers affects neurological functioning but could provide practical guidance to teachers on which motor skills or activities have the greatest impact on brain regions or functions that are related important areas of learning (Hutton et al. 2019).

Finally, a limitation of our study is that teacher interactions were not examined—either on the playground or during the group time observations. Findings of our study could be affected by differences in the behaviors of teachers on the playground and at group time. Research is needed on the optimal role of teachers during outdoor play in preschools. Studies of older children have examined a range of approaches to adult involvement, from very teacher-directed interventions to informal child-centered approaches (Culpepper and Killion 2018). Investigations on adult interactions with preschool aged children on the playground and how they impact later on-task behavior and learning would guide professional practice. Research might also explore the influence of teacher group time teaching strategies on on-task behavior following outdoor play. For example, to what degree do quieting and calming methods, incorporation of movement and music, or use of visual cues and physical objects affect on-task behaviors after playground play?

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