Affordances for Physically Active Play in an Outdoor, Nature-Rich Preschool

Joanna Hyman Wright

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Nancy Hertzog

Jodi Burrus Newman

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Abstract

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Joanna Hyman Wright

Chair of the Supervisory Committee:
Nancy Hertzog, Educational Psychology

Outdoor, nature-rich environments offer unique opportunities for young children's physically active play. The purpose of this study was to explore affordances of nature-rich environments for young children's physically active play by describing frequency of types of physical activity and associated features of the environment in an outdoor preschool. Drawing from existing video data collected at one program over two years, the researcher used an adaptation of the Observational System for Recording Physical Activity in Children - Preschool Version (OSRAC-P) to code physical activity types and contexts. Analysis was conducted in two phases. In the first phase, coded data were analyzed to determine frequencies of each type of activity overall. In the second phase, relative frequencies of types of activity within each activity context were calculated. Results showed that children in the setting engaged frequently in varied forms of physical activity and demonstrated especially high levels of manipulative activity as well as stability and locomotor activity. Some features of the environment such as open space and natural loose parts appeared to be particularly conducive to certain types of activities. Although larger samples are needed to understand generalizability of results, this study offered insight into actualized physical activity affordances in an outdoor, nature-rich environment. These findings are important in light of the significance of physically active play in nature for several areas of young children's development including motor skills, cognition, psychosocial well-being and executive functioning. Results have the potential to inform design and pedagogy in early learning environments to promote physically active play and associated benefits.

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Introduction

Physically active play functions as an important support for young children's development in many ways, including by supporting motor skills, physical health, cognition, socioemotional development and executive function (Timmons et al., 2012; Zeng et al., 2017). Outdoor, nature-rich spaces offer unique supports for physically active play (Herrington & Brussoni, 2015; McCurdy, Winterbottom, Mehta, & Roberts, 2010; Meyer, Müller, & Macoun, 2017), particularly because of availability of space for gross motor play (Tonge, Jones, & Okely, 2016) and the richness and variation of natural landscapes and materials (Fjørtoft, 2001).

However, many young children have limited opportunity to engage in physically active play in outdoor, nature-rich spaces. Young children in the United States spend a greater amount of time indoors and engaged in sedentary activities than their peers of previous generations (Clements, 2004; Frumkin et al., 2017). Factors contributing to the decline of outdoor play among children of all ages include safety concerns, academic pressures leading to more time devoted to homework and extra-curricular activities, an increasing presence of technology in children's lives, and declining availability of open public space (Dowdell, Gray, & Malone, 2011). Access to nature-rich spaces is especially curtailed for children living in urban areas (Strife & Downey, 2009).

Childcare settings are one potential leverage point for improving physically active play opportunities for young children. An increasing percentage of children under the age of five spend large proportions of their day in childcare programs (Tandon et al., 2017). Approximately 5 million children are enrolled in center-based care (Corcoran & Steinley, 2019), with the average child spending 36 hours per week in a care setting outside the home ("About Child

Care," n.d.). Participation in a childcare program has been shown to influence a child's level of physical activity (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008). Physical activity standards for childcare settings vary state by state, ranging from 60-90 minutes of outdoor time daily and 90-120 minutes of physical activity daily (Tandon et al., 2017). Despite these standards, children's activity in childcare is overwhelmingly sedentary, with moderate to vigorous physical activity occurring in relatively small segments of the day (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Tandon, Saelens, & Christakis, 2015; Tucker, 2008). Children in these settings tend to be more active outdoors compared to indoors (Bower et al., 2008; Brown et al., 2009), but outdoor time is often limited; for example, relatively few childcare programs in Washington State meet standards for outdoor play time (Tandon et al., 2017). Together, these trends demonstrate the need for greater attention to outdoor play in early childhood care settings.

The present study investigated the frequency with which children in an outdoor, nature-rich preschool engage in various types of physical activities and explored associations between physical activity types and contextual features of the environment. This inquiry was informed by prior research demonstrating the potential of nature-rich, outdoor environments to support physically active play, as well as the importance of such play for multiple domains of development in early childhood (Kemple, Oh, Kenney, & Smith-Bonahue, 2016). Nature preschools have emerged as one avenue for fostering opportunity for outdoor, physically active play in early childhood; however, empirical study of exactly how such environments support children's engagement in physically active play is limited. As interest in nature preschools grows (North American Association for Environmental Education, 2017), the present study contributes needed evidence-based understanding of how outdoor, nature-rich environments can support children's physically active play. Results can also provide insight for early childhood

education practitioners in planning and utilizing optimal environments for children's learning and development.

Theoretical Framework

The approach in the present study to examining children's physically active play in relation to features of the environment drew primarily on Gibson's theory of affordances (Gibson, 1979). This theory posited that human beings perceive not only structures or forms in their environment, but also functional significance. For example, objects that afford sitting are not limited only to chairs, but include any object that is stable enough, large enough and at the appropriate height for an individual to sit on. Gibson argued that such functional meanings of sensory information are perceived *directly*, rather than being mediated by cognitive processes (Heft, 1988). Affordances are "relationally specific" (Heft, 1988, p. 30), meaning that perception or and realization of affordances arise not solely out of environmental characteristics but out of the relationship between characteristics of the environment and of the individual. Kyttä (2004) expanded on the work of Gibson (1979) and Heft (1988) by differentiating between *potential* affordances – latent functional possibilities at the interface between an individual and the environment – and *realized* affordances which are perceived or acted upon.

Heft (1988) argued that the theory of affordances is particularly appropriate for study of young children's play. One reason for this is that, unlike form categories which are more conceptual (e.g. the concept of "tree" is abstracted to include many organisms which share similar attributes), functions lie closer to immediate experience. This aligns well with the way young children explore their world, often through hands-on experimentation rather than an "intellectualization" (Heft, 1988, p. 31) of the environment. For example, a plate, which adults conceptualize as an object used solely as a vessel for food, may be perceived by a young child as

having numerous possibilities for action including lifting, dropping, throwing and so on. Another reason for the goodness of fit between this theory and research on children's play is that affordance theory offers an inherently developmental lens to understanding an individual's perception of and engagement with their environment. Affordances are not only specific to an individual; they are specific to an individual *at a moment in time*. The possibilities for action perceived by a child are not fixed; they continue to change as that child's "behavioral repertoire" (Heft, 1988, p. 37) grows and changes.

Gibson's theory of affordances has been applied to inquiry into the influence of natural environments on a range of dimensions of young children's play behaviors, including physical activity (Bjørgen, 2016; Little & Sweller, 2015; Storli & Hagen, 2010), risky play (Brussoni, Ishikawa, Brunelle, & Herrington, 2017; Little & Sweller, 2015; Sandseter, 2009), sociodramatic play (Drown & Christensen, 2014) and problem-solving (Carr, Brown, Schlembach, & Kochanowski, 2017). For example, Sandseter (2009) conducted observations and interviews with children to compare affordances for risky play in a traditional and a nature preschool in Norway. Her theory-driven content analysis of this qualitative data utilized categories of risky play to code potential and actualized affordances of risky play in each setting. Similarly, the present study utilized a set of categories (in this case, physical activity types and contexts) to, effectively, document *actualized* affordances for (children's observable engagement in) physically active play.

The theory of affordances, by situating behavior as arising from an individual's perception of functional possibilities of the environment, is a useful framework for examining the role of context in children's physically active play. Drawing on this theory, the present study

aims to consider frequency of types of physical activity in relation to affordances of an outdoor, nature-rich preschool context.

Literature Review

Scope and Definitions

The literature review for the present study is divided into two parts. In Part 1, "Environmental Influences on Physical Activity," extant research regarding the influence of environmental characteristics on children's physically active play behaviors is presented. This work, in concert with the theory of affordances, guided the approach to the present study. Part 2, "Why it Matters: Developmental Benefits of Children's Physical Activity in Nature," explores the broader significance of this topic for young children's development. Together, these two bodies of literature paint a picture of how relationships between environment and young children's physical activity behaviors have been studied and what they have found, as well as the salience of these relationships for early childhood development across domains.

Research for this literature review was gathered from the University of Washington database. An initial search of "outdoor," "physical activity," and "early childhood" or "preschool" yielded 42 results. Of these, only studies that specifically examined the impact of outdoor environments on physical activity, as well as studies that specifically examined the impact of physical activity and/or outdoor, nature-rich play on developmental outcomes, were included. Other inclusion criteria were: a focus on children ages 3-5; research done in childcare centers (not external contexts, e.g. families); and completed studies rather than study protocols. Due to relatively limited research in U.S. settings, all studies which met inclusion criteria, regardless of country of origin, were included. The scope of this literature review was limited to neurotypical populations.

12 of the 42 studies met these criteria. Using an ancestral literature review approach, the references cited by each of these studies were then drawn from using the same inclusion criteria. Particular attention was paid to studies cited frequently by other authors. Subsequent searches with slightly varied key terms (e.g. replacing "early childhood" with "preschool", replacing "outdoor" with "nature") yielded few new results, which were included, but primarily led back to the same set of articles, suggesting a saturation point. Although the majority of included articles were selected via this process, a small set of articles familiar to the researcher prior to the study were also included due to their relevance to a particular topic. Using these parameters and procedures, this literature review, while not claiming to be comprehensive, illustrates prominent threads of inquiry regarding environmental supports for, and developmental benefits of, physically active play in outdoor, nature-rich settings. In order to clearly delineate the scope of this work, definitions for relevant terms are provided, next.

Play has been defined as "the spontaneous activity in which children engage to amuse and occupy themselves" (Burdette & Whitaker, 2005, p. 46) and as activity that is "concerned with means over ends […] or to occur for its own sake" (Pellegrini & Smith, 1998, p. 577). Physical activity is defined as bodily movement using the muscular-skeletal system and resulting in expenditure of energy (Caspersen, Powell, & Christenson, 1985), and, drawing from extant measurement tools, is operationalized in the present study as types of motor activities. Physically active play refers to physical activity which occurs in a playful manner or context.

Among preschool-age children, physically active play typically takes the form of exercise play or locomotor play (Becker, McClelland, Loprinzi, & Trost, 2014; Pellegrini & Smith, 1998; Tandon et al., 2017). This form of play includes activities such as running, climbing, balancing

and more, and has been defined as "gross locomotor movement in the context of play" (Timmons, Naylor, & Pfeiffer, 2007, p. 124).

Although physically active play can occur in a variety of settings, this study investigated play in an outdoor, nature-rich environment. The meaning of "nature-rich" can be understood in terms of the following definition of nature: "areas containing elements of living systems that include plants and nonhuman animals across a range of scales and degrees of human management, from a small urban park through to relatively 'pristine wilderness'" (Frumkin et al., 2017, p. 1; citing Bratman et al., 2012). Nature preschools, which operate in a range of these settings including urban parks, nature centers and other green spaces, "use nature as the organizing principle for their programs" and spend at least a substantial portion of the day outside (North American Association for Environmental Education, 2017, p. 6).

Research into how outdoor environments, and, in particular, nature-rich environments, support young children's physically active play, are discussed below. The scope of this literature review was limited to neuro-typical populations.

Part 1: Environmental Influences on Physical Activity

How do outdoor, nature-rich outdoor environments influence young children's physically active play? Gibson's theory of affordances, alongside empirical research showing that environmental factors are predictors of physical activity in young children (Pate, McIver, Dowda, Brown, & Addy, 2008), highlights the value of centering contextual factors in inquiry into children's physical activity. The following section discusses evidence of the contributions of nature-rich spaces to children's physically active play. Due to the limited research focused specifically on nature-rich preschool settings, studies of outdoor early learning spaces that are not necessarily nature-rich were also included. Trends identified include higher levels of

physical activity outdoors compared to indoors, an influence of open space and other features of outdoor settings on levels of physical activity, and the potential for diverse forms of physical activity in highly nature-rich settings.

Outdoor play and level of physical activity.

Extensive research using direct observation and/or accelerometry has demonstrated that children in early childhood programs tend to be much more physically active outdoors compared to indoors. For example, in a study of 476 children at 24 different preschools in the United States, Brown et al. (2009) found that 94% of children's activity indoors was sedentary, and only 1% of indoor intervals were found to include moderate-to-vigorous physical activity (MVPA). In contrast, the researchers found that 17% of outdoor activity was characterized as MVPA. Similarly, Tandon et al. (2015) found that children's physical activity in childcare was primarily sedentary overall (73%), with much smaller proportions of light physical activity (15%) and MVPA (14%), and that children were significantly more active and less sedentary when playing outdoors compared to indoors. Another study with similar results concluded that one of the most promising ways to increase children's physical activity levels in childcare settings "may be as simple as providing more active play time," (p. 29) including outdoor play time specifically (Bower et al., 2008). Indeed, both boys and girls in preschool settings are more than twice as active outdoors compared to indoors (Tandon, Saelens, Zhou, & Christakis, 2018). Systematic reviews of literature have affirmed the findings of these individual studies, concluding that children in preschool program settings tend to be consistently more active outdoors than they are indoors (Tremblay et al., 2015; Truelove et al., 2018). Although numerous studies have identified these associations, it should be noted that a lack of randomized controlled trials is a barrier to certainty as to whether this is a causal relationship (Gray et al., 2015).

Why might young children so consistently engage in more physically active play outdoors compared to indoors? One possible factor contributing to this pattern is the greater availability of open space in many outdoor settings. Open space is strongly associated with higher levels of MVPA in preschool children (Berg, 2015; Brown et al., 2009; Dowda et al., 2009; Nicaise, Kahan, & Sallis, 2011). Decreasing play area density has been shown to be a strong predictor of greater MVPA (Broekhuizen, Scholten, & de Vries, 2014; Nicaise et al., 2011). Other features of outdoor environments found to contribute to higher levels of MVPA include use of balls or other objects that enable gross motor activity (Brown et al., 2009; Nicaise et al., 2011; Tonge et al., 2016), riding toys and looping cycle paths (Cosco, Moore, & Smith, 2014; Nicaise et al., 2011), and portable play equipment (Berg, 2015; Dowda et al., 2009; Gubbels, Van Kann, & Jansen, 2012).

Some features of outdoor environments appear to have more mixed impacts on physical activity levels. For example, one study found that MVPA was less frequent when children were engaged with fixed equipment (Brown et al., 2009), but this contrasted with other studies (Bower et al., 2008; Dowda et al., 2009; Sugiyama, Okely, Masters, & Moore, 2012) which found the opposite association with fixed play equipment. These mixed outcomes associated with fixed play equipment may be due to the various ways that such equipment can be used. For example, fixed equipment is also used in more sedentary forms of sociodramatic play and interaction (Maxwell, Mitchell, & Evans, 2008). Furthermore, fixed features may elicit movement but also require children to stand relatively still while waiting for a turn, for example, on a slide or a swing (Gubbels et al., 2012). Systematic reviews (Broekhuizen et al., 2014, Gray et al., 2015) affirm the likelihood of a relationship between such features and young children's play behaviors

and call for more RCT studies to confirm these findings in order to better understand effective intervention strategies.

Finally, although not the focus of the present study, it should be noted that social factors in the environment – in particular, teacher training, attitudes, and practices associated with outdoor play – also play a pivotal role in young children's physical activity behaviors (Tonge et al., 2016). For example, child-led active play has been found to be associated with higher levels of physical activity in preschool children in comparison with activities structured and led by teachers (Brown et al., 2009; Cosco et al., 2014; Tandon et al., 2015). On the other hand, some studies have found higher levels of physical activity and greater gains in motor skills (Roach & Keats, 2018) in adult-guided, structured play in comparison with child-led free-play (Palmer, Matsuyama & Robinson, 2017; Ward, 2010). Despite these mixed findings regarding social influences on physically active play, the present study focused on physical activity and associated features of the environment in the context of child-directed play only. This choice was made because outdoor play in traditional early childcare settings is largely child-led, and because the majority of nature-based early learning programs place a strong emphasis on child-directed activity (North American Association for Environmental Education, 2017).

Nature-rich settings and diverse types of physically active play.

Adequately-sized outdoor spaces evidently have the potential to promote physically active play among young children. However, nature-rich spaces in particular not only impact *level* of physical activity, but may also promote diverse *types* of physical activity. One possible explanation for this is that the varied, dynamic, open-ended qualities of many natural landscapes offer a wide range of movement opportunities for children. In the language of Gibson's theory:

natural environments may be particularly affordance-rich in relation to young children's physically active play.

In a seminal study on this subject, Fjørtoft (2001) examined affordances of outdoor play environments for versatile play and the impact of outdoor play on children's motor skills in three Norwegian kindergartens. Fjørtoft's study was based on the idea that "natural environments represent dynamic and rough playscapes that challenge motor activity in children" (p. 111). She hypothesized that this challenge and physical variation in the environment offered children versatile play opportunities which promote mastery of motor skills. An experimental group from one kindergarten (N = 46) played in a nearby forested area for 1-2 hours per day throughout a school year, and reference groups from two other kindergartens (N = 29) used traditional outdoor playgrounds for 1-2 hours per day, with occasional visits to forested areas. Qualitative observation was used to describe various "play habitats" of the areas, and pre- and post-tests measured balance, speed, flexibility, strength and coordination. The experimental group outperformed the reference group on fitness post-tests, particularly in balance and coordination. Fjørtoft also found that gains in motor skills over the course of the year were greater for the experimental group, who at pre-test had lower average scores than the reference group. Descriptions of the "play habitats" illustrated ways children used different types of spaces and features in the forested area, as well as how use of spaces and features changed throughout the year. For example, she described, "Very special was the flexible juniper bush, which motivated for functional play (how to get in and out) and social play (play house)" (p. 113) and other "trees suitable for climbing, depending on the branching pattern, the stem diameter, and the flexibility of the tree" (p. 113). A limitation of Fjørtoft's study is the absence of specification given for her method of making these qualitative observations of play habitats. However, this study offered a

window into the potential of nature-rich environments to support children's motor development, particularly through the way rich variation in physical characteristics of the environment invited diverse types of play. A later study further explored these results by adding landscape ecology and topography metrics to the data collection process and found that the structure and complexity of the landscape promoted diverse play activities which support motor development (Fjørtoft, 2004).

In a similar vein, Meyer et al. (2017) compared physical activity behaviors in traditional and nature-based kindergartens in Western Canada and found greater diversity in physical activity types in the nature kindergarten sample compared with the sample from the traditional kindergarten. All classroom observations were done during teacher-led morning activity time, which for the traditional kindergartens involved routine home classroom activities and for the nature kindergartens involved excursions to nearby outdoor areas such as public parks and beaches. Types of activity in the traditional kindergartens were largely limited to sitting, squatting, walking and fine motor activity, in contrast to activity types occurring in the nature kindergartens which were more distributed among a variety of actions included those common in traditional kindergartens but also including activities such as running, climbing and balancing.

One source of variability in many natural landscapes is the presence of loose parts. Simon Nicholson summarized his theory of loose parts thus: "In any environment, both the degree of inventiveness and creativity, and the possibility of discovery, are directly proportional to the number and kind of variables in it." (Nicholson, 1972, p. 6). In early childhood settings, the concept of loose parts has been operationalized as referring to open-ended materials which children can choose to engage with in a variety of ways to modify their environment (Maxwell et al., 2008). In a nature-rich environment, examples of loose parts may include sticks, stones,

leaves, as well as water, mud and so on. Drawing on the concept of loose parts, Maxwell et al. (2008) designed an intervention in which loose parts were added to the outdoor play area at a lab preschool at a university-based childcare center. The researchers found that after adding loose parts to the outdoor play area, children's constructive play behavior ("children building or creating objects with a specific goal in mind", p. 37) increased. According to Maxwell et al. (2008), the malleability of natural loose parts contrasted with the static qualities of many play structures.

Although nature-rich environments may afford greater diversity in some types of movements, some studies have challenges this idea, suggesting that such settings may also limit particular types of physical activity. For example, in an assessment of natural elements on school grounds in British Columbia, Lim et al. (2017) examined the degree to which natural elements offered opportunity for practice of fundamental motor skills (FMS) which were categorized as locomotor, manipulative or stability skills. Their results echoed prior research showing that natural elements afford a variety of locomotor and stability skills. However, Lim et al. (2017) did not identify any opportunities for children's manipulative activities. One potential explanation for this result is that the types of nature-scape elements measured by Lim et al. (2017) included forested area, natural playground, boulders/logs, elevated area, garden area, and trails, but did not include any form of natural loose parts. Given the evidence from Maxwell et al. (2008) that loose parts promote constructive play – which would involve high levels of manipulative activity – the absence of manipulative activity opportunities found by Lim et al. (2017) may be due to the researchers not perceiving and/or not considering loose parts in the school grounds they studied. Furthermore, unlike the studies by Fjørtoft (2001, 2004) and Meyer

(2017) which conducted direct observation of children, FMS opportunities in the study by Lim et al. (2017) were inferred only from an adult perspective.

The versatility and complexity of natural landscapes for children's physically active play may not only support extended engagement in physically active play (Tremblay et al., 2015) for an individual child; a greater diversity of play may also support physical activity among groups of children by "appealing to a greater breadth of students" (McCurdy et al., 2010; citing Dyment & Bell, 2007). Indeed, as affordance theory highlights, types and frequencies of children's physically active play depend not only on the external environment but also on individual characteristics. Indeed, Nicaise et al. (2011) found evidence that some individual child characteristics (gender, weight status) may interact with qualities of the physical environment to impact MVPA. The variation and change present in many nature-rich landscapes may enable children to find opportunities to engage in physically active play that match their skills, abilities and interests.

As a whole, this body of research highlights avenues by which outdoor, nature-rich settings impact young children's physical activity. Particular qualities of outdoor spaces, such as the availability of open space and versatility of natural elements, may be especially important. The developmental significance of play in outdoor, nature-rich settings is explored, next.

Part 2. Why it Matters: Developmental Benefits of Children's Physical Activity in Nature

Clearly, outdoor, nature-rich spaces have the potential to promote physically active play among preschool children. Why does this matter? What role does physically active play, particularly in outdoor, nature-rich spaces, have in young children's motor, cognitive, psychosocial and executive function development? These relationships are discussed next and

situate the present study in current understandings of these domains of early childhood development.

Motor development.

Motor skills are an important aspect of early childhood development in several ways. Young children's motor skills enable them to navigate and explore their physical environments (Logan, Robinson, Wilson, & Lucas, 2012). Although the bulk of school readiness literature has focused on cognitive measures such as early math and literacy skills and behavioral skills such as attention, motor skills are also key elements of school readiness (Pagani & Messier, 2012) and are linked to a range of cognitive, emotional and academic outcomes (for a summary, see Piek et al., 2012).

Motor skills are defined as "learned sequences of movements that are combined to produce a smooth, efficient action in order to master a particular task" (Zeng et al., 2017, citing Davis et al., 2011). Many studies of motor skill development in preschool-age children focus on fundamental movement skills (FMS), which include locomotor, stability and object control skills (Lim et al., 2017; Logan et al., 2012). Types of motor skills include gross and fine motors skills, manual coordination, static and dynamic balance, bilateral coordination, speed, strength, agility, aiming and catching, postural control, and one- and two-handed dexterity (Piek et al., 2012) as well as perceptual-motor skills (Pagani & Messier, 2012). Early childhood is a pivotal time for motor skill development, as large movement skills lay a foundation for more complex, refined movement (Logan et al., 2012) including fine-motor control (Hanscom, 2016).

Evidence strongly suggests that physical activity supports development of motor skills among preschool children (Timmons et al., 2007; Zeng et al., 2017). Nature-rich environments may especially benefit motor skills by offering diverse affordances for types of motor

engagement (Fjørtoft, 2001), as discussed in Part 1. By increasing physical activity as well as offering children a versatile setting in which to engage in a range of motor activities, outdoor, nature-rich settings can play an important role in motor development and associated outcomes.

Cognition.

Research on the cognitive benefits of young children's physical activity in nature-rich settings is relatively limited, but has shown effects on problem-solving, resilience and creativity (Tremblay et al., 2015). One reason for this may be that nature-rich play spaces support opportunities for extended, complex sociodramatic play (Drown & Christensen, 2014), supported by the same versatility of materials which, as discussed earlier, also support varied forms of motor activity. Furthermore, physical activity generally, particularly high-intensity physical activity (which, as described in Part 1, is more prevalent in outdoor, open spaces) and activity involving relevant tasks integrated into an activity, has been associated with cognitive improvement in young children's language, academic achievement, working memory and executive function (Zeng et al., 2017).

Nature play may also benefit young children's attention. This idea has been explored among older youth and adults and has yet to be systematically investigated at the preschool level. In older youth, naturalness of the environment has been associated with improved attention span in the general population (Kuo and Taylor, 2004) as well as among children living in poor urban environments (Wells, 2000). According to Bratman et al. (2015), attention restoration theory offers a lens for understanding such relationships. Natural environments, he wrote, "invoke a different sort of attention […] that may result in the replenishment of directed attention" which is often overly taxed in the sensory stimuli of urban environments. Whether and how natural environments exert this effect among younger children warrants further investigation.

Psychosocial well-being.

As with impacts on cognition, most research on the influence of outdoor, nature-rich experience on psychosocial outcomes has been conducted with older children, adolescents or adults. This research has highlighted the power of nature for promoting mental health, decreasing stress, and protecting against risks associated with adverse life circumstances. For example, Wells and Evans (2003) found that nearby vegetation moderated the negative psychological effects of life stress among rural 3rd-5th grade children. In a population study of green space and mental health among adults, Beyer et al. (2014) found that, after controlling for confounding factors, more neighborhood green space was associated with lower levels of depression, stress and anxiety. In their review of nature contact and human health outcomes, Frumkin et al. (2017) cautioned that, although there is strong evidence for a relationship between nature contact and psychological well-being, the degree to which this is a direct relationship or is mediated by other factors (e.g. social interaction, physical activity) warrants further investigation. It should also be noted that these studies examined exposure to nature generally, not physically active play in natural settings specifically.

Another branch of literature has examined socioemotional benefits associated with physically active play but not necessarily focused on outdoor, nature-rich play contexts. This research has shown that physically active play may improve psychosocial outcomes such as self-esteem among preschool-age children (for reviews, see Timmons et al., 2007) as well as improving mood and emotional well-being in older children (Burdette & Whitaker, 2005).

Piecing these different areas of research together points toward the potential for physically active play in nature-rich settings for promoting psychosocial well-being throughout the life span. Study of these relationships among preschool children is limited (Frumkin et al.,

2017) but suggests that many of these psychosocial benefits extend to young children as well (Kemple et al., 2016). Clearly more research is needed to understand the influence of outdoor, nature-rich play on children's psychosocial well-being.

Self-regulation and executive function.

Early childhood is a pivotal time for the development of executive function and self-regulatory skills (Diamond, 2002). Executive function refers to a suite of cognitive processes including working memory, cognitive or attentional flexibility, and inhibitory control, all of which are involved in self-regulation (Blair & Raver, 2015; McClelland & Cameron, 2012). Self-regulation is multidimensional and refers to adaptively managing attention, thought, feeling and action (McClelland & Cameron, 2012). These skills have been identified by a growing body of research as critical components of school-readiness (Blair & Raver, 2015) and have been linked to academic achievement in kindergarten (Blair & Razza, 2007). A seminal longitudinal study of self-regulation (operationalized as delay-of-gratification) showed that self-regulation skills in early childhood may be powerful indicators of a range of adaptive physical and mental outcomes throughout the life course (Mischel et al., 2011).

Prior research specifically examining the impact of outdoor, nature-rich, physically active play on young children's executive functioning is extremely limited. However, neurobiological research on the relationships between motor development and executive function can shed light on this subject. Areas of the brain involved in motor development and cognitive development are intricately linked from an early age and are jointly involved in executive function processes. For example, the cerebellum, which manages movement skills, and the prefrontal cortex, which houses many executive functioning processes, function in an integrated way to support self-regulatory behaviors (Cairney, Bedard, & Dudley, 2016; MacDonald et al., 2016). In fact, the

cerebellum "is implicated in sensorimotor, cognitive, and emotional processes to monitor, adjust and regulate behavior" (MacDonald et al., 2016, p. 397). Motor skills and executive functioning "codevelop in young children in bidirectional and synergistic ways" (McClelland & Cameron, 2018, p. 1).

These relationships have borne out in some experimental studies of preschool children's physical activity, for example showing that more active preschool children performed better than their less-active peers on tasks requiring contra-habitual inhibitory control (Campbell, Eaton, & McKeen, 2002); that preschool children with higher visuo-motor integration in the fall had higher executive function scores in the spring (MacDonald et al., 2016); and that preschool children's aerobic fitness and motor skills were related to measures of attention and working memory (Niederer et al., 2011). In an exploratory study of outdoor, nature-rich playscapes specifically, Carr et al., (2017) found that natural loose parts invited preschool children to engage in goal-directed problem-solving and in doing so, exercise components of executive function such as planning and organization, flexibility and working memory. Drawing on a framework of embodied cognition, which posits that "mental processes are facilitated through the body's interactions with the physical world" (p. 58), Becker et al. (2014) found evidence that the positive effect of active play on academic achievement in preschoolers may be at least partially explained by the indirect effect of physically active play on self-regulatory behavior.

Most research on relationships between motor development and executive function focus primarily on fine motor skills. However, Oberer, Gashaj, and Roebers (2017) found correlations between both gross and fine motor skills and executive function. The researchers argued that the "correlation between gross motor skills and some aspects of self-regulation have been

underestimated in previous studies" (p. 176). They suggested that both fine- and gross-motor activity play important roles in young children's executive function.

Furthermore, moderate to vigorous physical activity may offer unique support to executive functioning. Acute physical activity increases blood flow to the brain, impacting the brain's glucose supply and promoting other aspects of brain health, all of which impact cognition in the short- and long-term (Cairney et al., 2016; Zach, Inglis, Fox, Berger, & Stahl, 2015). Increased intensity or duration of physical activity has been associated with improvements in attention span (Palmer, Miller, & Robinson, 2013) and other measures of executive functioning among preschool children (Carson et al., 2016; Niederer et al., 2011). Given the demonstrated potential for outdoor environments to promote motor activity and physical activity generally, this research suggests that the benefits of such play may extend directly and/or indirectly to executive function and self-regulation.

Purpose

The present study sought to quantitatively examine frequency of types of children's physical activity in an outdoor preschool as well as associations between activity types and physical features of the environment. Prior empirical work demonstrated that physical environments exert substantial influence on children's physically active play behaviors. Literature on children's physical activity in outdoor, nature rich settings is relatively limited, and has suggested that such contexts offer unique affordances for young children's physically active play, including promoting greater amounts of vigorous movement in open spaces, as well as greater diversity of types of movement via the degree of variability, change and complexity of natural landscapes and elements. The significance of such opportunities for children's development has been underscored by research showing connections between physically active

play outdoors/in nature and a number of positive outcomes in motor skill development, cognition, psychosocial well-being and executive functioning. In light of the research outlined in this literature review, a setting such as the nature preschool in the present study has the potential to promote high levels of diverse physical activities and in doing so impact a number of developmental outcomes. The present study aimed to take a small step toward understanding this potential impact by examining how children engage their bodies in relation to physical affordances of the environment.

The present study contributed to addressing several significant gaps in the literature on environmental influences on children's physically active play. Empirical studies of physically active play in nature-rich settings are extremely limited in number and methodology. Most studies of preschoolers' physical activity have been conducted in traditional childcare centers with playgrounds that are typically dominated by manufactured materials and have minor nature-based elements at most. In contrast, the present study was conducted in two entirely-outdoor preschool "classrooms" in a highly nature-rich environment, a forested public park. The motor affordances of such an environment may have some similarities with traditional preschool playground contexts, but also distinct differences (for example, relatively limited playground equipment, high prevalence of natural loose parts, and uneven rather than uniform terrain).

Furthermore, of the few studies of physical activity that have been conducted in fully-outdoor preschool settings, the vast majority utilized direct observation or accelerometry to collect data on children's engagement. No studies that the researcher is presently aware of have examined children's physical activity using naturalistic video data, which offered the methodological benefit of reviewing video as necessary when uncertainties arose in the coding process. Also, many studies collected data over the course of weeks or months; in contrast, data

for the present study were collected over the course of two full school years. These methodological strengths offered a window into children's actual engagement with a nature-rich environment not provided by previous studies.

Finally, the bulk of research on preschool children's physically active play outdoors has focused primarily on assessing the intensity levels of children's physical activity (e.g. Bower et al., 2008; Brown et al., 2009; Tandon et al., 2015). In a review of research from the 1970s to the present on the impact of nature on children's health and well-being, Chawla (2015) pointed out that most studies of physical activity utilize accelerometry or self-reported levels of physical activity. This focus on physical activity level is understandable, given concern about the pervasiveness of sedentary activity in children's daily experiences in childcare centers, and the importance of young children's moderate to vigorous physical activity (MVPA) for prevention of risk factors associated with major health issues such as heart disease (Saakslahti et al., 2004) and obesity (Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003). However, in addition to level of intensity, *type* of physical activity also has major implications for children's development. The choice in the present study to focus on type, rather than intensity of physical activity was based on the recognition that a relatively extensive body of research has already established the value of outdoor settings for promoting higher levels of physical activity such as MVPA, but exploration of other aspects of physical activity (such as types of motor activity) is more limited.

To describe children's physical activity behaviors in the context of a nature-rich outdoor preschool program, this study was guided by the following research questions:

RQ1. With what frequency do children in this nature preschool program engage in various types of physical activity?

RQ2. Are frequencies of physical activity types associated with contextual features of the environment? If so, how?

The present study followed the model of other comparable investigations which take a descriptive rather than hypothesis-driven approach (Brown et al., 2009). Because very few studies of this kind have been conducted in nature preschools specifically, this study aimed to describe and explore children's actual, observable engagement in physically active play in this setting and suggest directions for further inquiry into observed behaviors and relationships.

Methods

Study Context

Data for the present study were collected at a year-round outdoor preschool program affiliated with a large research university in the Pacific Northwest. This program consists of two outdoor "classroom" sites located in proximity to one another in a forested public park in an urban area. Children and teachers spend all four hours of the school day outdoors in all weather, with the exception of hazardous conditions such as high wind.

Both classroom sites, although unique, share many of the same elements and characteristics. The sites are approximately 10,000 square feet each (S. Heller, personal communication, March 7, 2019), with log borders constructed to indicate the parameters of the classroom. The ground, which is relatively flat with some sloping areas, is maintained with a layer of mulch. Patches of understory plants such as Oregon grape and sword ferns punctuate the landscape; some plant collections are marked by borders so as to protect them from the impact of the regular presence of children, and some are left open for children to walk through and explore. The landscape is home to many large trees (primarily cedar, Douglas fir, Western Hemlock and big leaf maple) as well as some smaller trees and shrubs (e.g. Indian plum). The

evergreen trees maintain a green canopy year-round, which covers much of the sites, and the deciduous trees and shrubs drop their leaves each fall which children can rake and play with. Loose parts such as sticks, bark and moss are prevalent, and program staff bring in additional found and/or altered natural loose parts such as rounds of wood, collections of stones and flowers, etc., as the season allows. Program staff also bring manufactured supplies to the classroom sites each day, including tools (e.g. child-size rakes, shovels, wheelbarrows), art supplies, books, magnifying glasses and more. These materials, which are provided to enrich children's play and learning opportunities, take up a minimal amount of space on site compared with natural elements. Due to park rules, children are not permitted to climb trees, so climbing is limited primarily to large features such as stumps, logs, and upturned root balls, which have been cut and transported to the site by grounds-keeping staff. Both sites contain one large tarp which creates shelter, primarily used as the art station. Because the present study focused on physical activity in child-led play, children's activities at stations with designated uses (e.g. the art station, the science station) were not included. Of course, children sometimes utilized these areas in the context of play, but for clarity purposes the present study only examined children's behavior in more open-ended areas (which make up the majority of the space).

Participants in this study were 3-5 year-old children enrolled in the program. Over two years of data collection, 61 families were invited to participate in the study. Participation involved children being filmed in their regular daily activities in the program. A total of 48 parents gave informed consent for their child's participation. Of these, 29 children stayed in the program throughout both years of the study, 10 were in the program for only Year 1 of the study, and 9 were in the program for only Year 2 of the study. Reasons for children participating in only Year 1 or Year 2 of the study included the child graduating from the preschool (leaving the

program at the end of Year 1 to attend kindergarten) or entering the preschool (enrolling for the first time at the beginning of Year 2). No families withdrew consent mid-year. Altogether, 79% of families enrolled in the preschool program at the time of the study gave consent for their child to be filmed for the study. Although demographics of specific participants were not available to the researcher, the school profile as a whole includes 50% boys, 50% girls, 52% three-year-olds, 48% four-year-olds, with 10-12% of students receiving financial aid (S. Heller, personal communication, March 8, 2019). In the most recent demographic survey of program participants, 56% were white, 28% were multiracial, 8% were Asian, 3% were Hispanic/Latino, 3% were White-identifying with Persian and Native American grandparents and 2% were Nigerian American (K. Harrington and S. Heller, personal communication, March 8, 2019).

Data Collection

Video data used in the present study was originally collected for a different study (Kahn, Weiss, & Harrington, 2018). Video data were collected in a naturalistic manner over the course of two school years by undergraduate and graduate students. Filming was conducted using a randomized time sampling protocol with ten-minute intervals per classroom zone. Each classroom was divided into five film zones in order to ensure full classroom coverage under the time-sampling procedure. Zones were designated to capture a variety of classroom features such as mud pits, obstacle courses made of stumps and wood, as well as landscape features such as trees and natural enclosures. Researchers acted as non-participant observers, filming from a reasonable distance so as to document children's activities while interacting directly with children as minimally as possible.

Coding: Video Selection

Due to the extensive footage collected and limited time and resources, a subset of video data was taken for the present study using the following procedures. Footage from the second half of the first school year (Jan. - May 2017) and the first half of the second school year (Sept. - Dec. 2017) was viewed and coded. This allowed for variation in seasonality as well as variation in children and teaching staff, both of which underwent changes between the end of the 2016-2017 school year and the beginning of the 2017-2018 school year. Footage from two days of each week's footage was viewed and coded. When there were multiple video clips within the same classroom zone on the same day, only the longest clip was viewed and coded. Coding was conducted at the 0:00, 1:00 and 2:00 mark for 20-second intervals. For a video clip to be included in the coding process, it had to be at least 3 seconds long. Videos were excluded if they contained only teacher-led activities, only non-play activities (e.g. eating snack, managing gear), or if no children were fully visible in the video at any point.

Coding: Measures

The present study used an adaptation of the Observational System for Recording Physical Activity in Children – Preschool Version (OSRAC-P) to code physical activity types and contexts. Originally developed by Brown et al. (2006), the OSRAC-P was designed for direct observation of preschool children's physical activity behaviors indoors and outdoors as well as social and environmental contexts within which these behaviors occur. The OSRAC-P has been used extensively in studies of children's play, including many of the studies described above.

Brown et al. (2006) drew from two existing systems for direct observation of young children to develop the OSRAC-P instrument: the Child Activity Rating Scale (CARS) and the Code for Active Student Engagement Revised (CASPER). In the initial study by Brown et al., (2006), three exercise scientists and one early childhood investigator collaboratively revised the

categories and codes presented by CARS and CASPER, with the goal of creating a comprehensive system for directly observing children's physical activity behaviors in context. Brown et al. (2006) tested the preliminary coding scheme through direct observation by multiple observers at two preschool sites. They used momentary time sampling protocols, with a 5-second observational interval followed by a 25-second coding interval for each focal child. Following initial analysis, their coding system was further field tested and refined, resulting in a final set of categories, codes, and definitions of behaviors and contexts. Multiple observers were trained in the use of the OSRAC-P instrument until 80% inter-observer agreement was reached. During subsequent observation periods in three preschools, inter-observer agreement assessments were conducted regularly, totaling approximately 13% of all observations. Kappa values and inter-observer agreement means were collected for each category of observation, with most being above .80. Categories with lower scores were investigated to identify which codes were problematic and adjustments were made as appropriate.

The present study adapted the Brown et al. (2006) OSRAC-P instrument to reflect a nature-preschool environment. Changes to the original codes were made in collaboration with an occupational therapist and two qualitative researchers (one faculty advisor, one PhD student), who viewed sample video footage and gave feedback on coding amendments and definitions. Once the coding system was finalized, two researchers independently coded a random selection of the same video clips and compared coding decisions. This was conducted once at the beginning of the study and once in the middle of the coding process to assess consistency of coding over time. In all, 19 video clips were coded by both researchers, representing 35% of total video clips coded. This resulted in a total of 120 distinct coding decisions (type or context),

of which 92 coding decisions were consistent between the two coders and 28 differed, demonstrating 77% inter-observer agreement.

Coding Parameters: Physical Activity Types

The original OSRAC-P instrument is provided (see Appendix A). Adaptations were made to reflect common motor activities in the observed setting. Modified activity type codes and definitions are presented (Table 1). All physical activity types needed to clearly occur for 3 seconds or more (be sustained rather than fleeting) unless otherwise noted. If a physical activity type occurred multiple times in the same video clip, it was recorded only once, unless it was a discreet action (e.g. jumping, throwing) or occurrences were separated by 15 seconds or more.

Table 1.

Physical Activity Types

Code	Definition
Balance	Balancing on a raised, uneven surface, either standing or walking
Climb	Using hands, feet, or both to move from one level to another
Crawl	Using hands and feet to translocate along ground/other flat surface
Dance	Dancing, expressive movement
Dig/Rake	Digging, raking
Jump/Skip	Jumping, skipping, hopping, galloping. Includes small jumps off logs. (Discrete)
Lean	Giving weight passively from a standing position
Lie Down	Lying down horizontally
Manipulation	Manipulating materials with hands/fingers or gripping to maneuver.
Push/Pull	Pushing or pulling an object (includes wheelbarrow) across a distance
Resistive	Hitting a stick or object on something, kicking an object, stomping (Discrete)
Rough & Tumble Play	Rough and tumble play (e.g. wrestling, play fighting)
Rock	Rocking
Roll	Rolling
Run	Running (min. 2 seconds)
Sit	Sitting, weight resting passively (min. 10 seconds)
Stand	Standing in one place, without re-placement of feet (min. 10 seconds)
Squat	Squatting or kneeling with weight held dynamically (Squatting in the transition from standing to sitting or sitting to standing is not included)
Swing/Hang	Using hands/arms to hang or swing
Throw	Throwing an object (Discrete)
Walk	Walking (min. 10 seconds)

Coding Parameters: Physical Activity Context

The primary guideline for coding activity context was that the context was visibly, directly involved in the activity. Contexts included major elements of the landscape such as Fixed Landscape Features (e.g. trees) and Open Space, as well as common items within the space such as Natural Loose Parts, Logs and Stumps, and Manufactured Supplies. Group composition codes in the original OSRAC-P (Brown et al., 2006) were beyond the scope of the present study, but Solo Space was included as a code in order to differentiate obvious solitary engagement in a space with engagement in physical proximity to others. Definitions that guided coding of physical activity context are presented in Table 2.

Table 2.

Physical activity contexts

Code	Definition
Fixed Landscape Features	Trees, shrubs, shelter, plant matter still attached to living plant
Logs/Stumps	Logs or stumps of any size
Natural Loose Parts	Branches, sticks, stones, leaves, plant matter no longer attached, etc.
Open Space	Open ground of at least 5x5’
Mud/Mulch/Water	Substrates such as mud, mulch, water, gravel and soil
Solo Space	No one else interaction with the child, AND at least 3 feet of space between child and any other individuals AND/OR no one else in the filming frame
Manufactured Supplies	Human-made items (tools, art supplies, books, etc.)

For a physical activity type to be coded in association with context(s), the context(s) had to be *directly* involved in activity (e.g. what the child is manipulating, what they are balancing on), not just peripherally involved (e.g. the child happens to be holding a stick while balancing). Due to difficulty identifying the degree to which some objects/features were directly involved in certain activity types, further parameters were developed: the only contexts that could be coded

for walking, running, standing and squatting were Solo Space or Open Space. For example, a child may be holding a stick while running, but it is unclear whether the stick is directly involved in the run, so Open Space but not Natural Loose Parts (the stick) would not be coded as context for the run.

Results

Coding of video data yielded 469 instances of physical activity types. Each instance of a physical activity type was associated with 0 – 4 physical activity contexts as per the coding protocols.

RQ1: Frequencies of Activity Types

To address the first research question, "With what frequency do children in this nature preschool program engage in various types of physical activity?", absolute frequency and relative frequency (percentage) of each type of physical activity are reported in Table 3 and Figure 1, respectively.

Table 3.
Frequency of physical activity types (absolute values)

Physical Activity Type	Overall Frequency
Balance	34
Climb	22
Dig/Rake	19
Jump/Skip	29
Lie Down	9
Manipulation	107
Push/Pull	21
Resistive	28
Run	34
Sit	33
Stand	38
Squat	44
Throw	16
Walk	16
Total	469

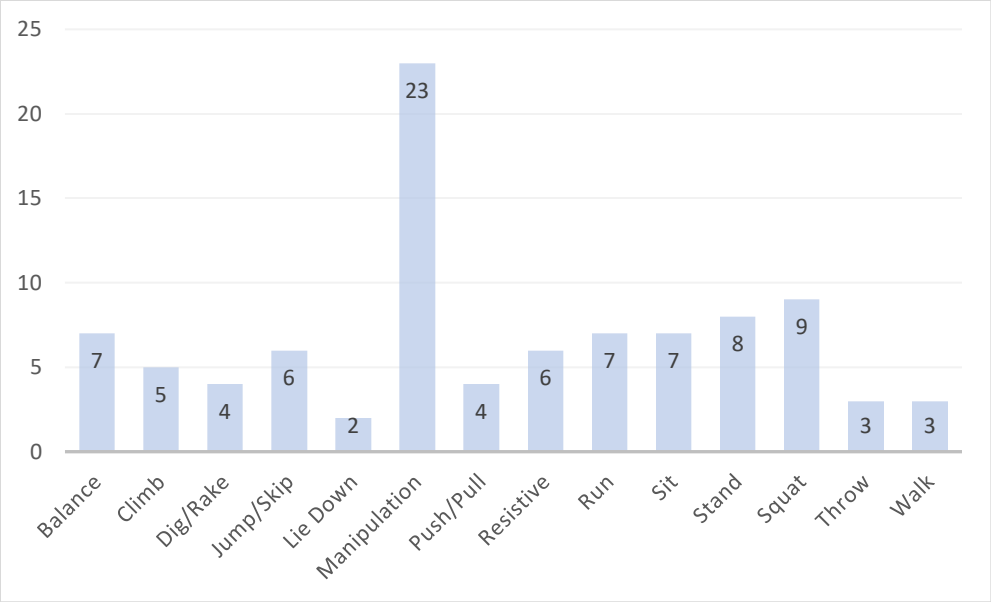

Figure 1. Relative frequency of physical activity types. This figure shows what percentage each type of activity was out of total instances of all physical activity types.

Instances of manipulation were dramatically higher than all other physical activity types and represented 23% of the total. Squatting (9%) and standing (8%) ranked second- and third in frequency, respectively, followed by balancing, running and sitting (7% each). All other physical activity types occurred at a rate of 6% or less of the total, with throwing, walking and lying down being the least frequent (3%, 3% and 2%, respectively). Activity types occurring less than five times (crawling, dancing, leaning, rough and tumble play, swinging/hanging, rolling) were excluded from analysis.

To further explore the data, physical activity types were grouped according to fundamental movement skills (FMS) categories (Figure 2). Grouping of physical activity types into FMS categories was guided by prior literature (Lim et al., 2017). Organizing the data this way helped identify broader patterns of physical activity. Of the total instances of physical activity, 36% were manipulative, 21% were locomotor, 20% were stability and 17% were stationary. Thus, stationary activities comprised 17% of the total, and all other activities together comprised 77%.

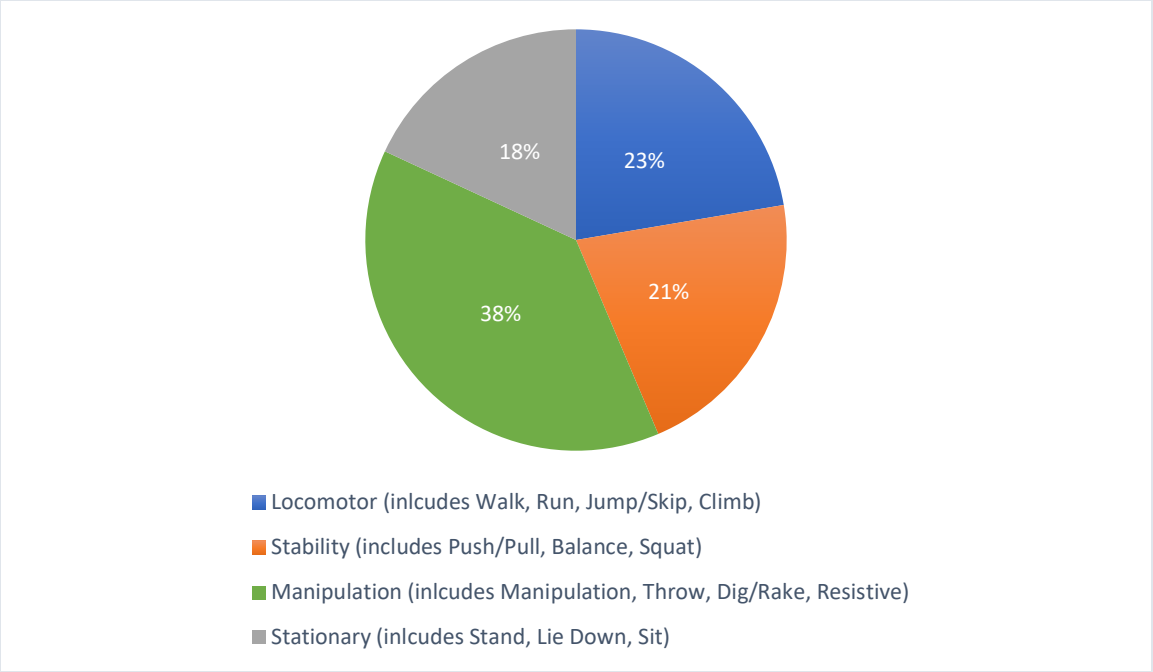

Figure 2. Percentage of physical activity types grouped by FMS categorization.

RQ2: Frequency of Activity Types in relation to Activity Contexts

In response to the second research question, "Are frequencies of physical activity types associated with contextual features of the environment? If so, how?" several models were created to explore relationships between physical activity types and physical activity contexts. First, frequencies of physical activity types in relation to each context were calculated to see what types of physical activities were occurring most frequently in each context. The results are presented in Table 4. Manipulation was the most frequent type of activity in several contexts, including Manufactured Supplies, Natural Loose Parts, Fixed Landscape Features, Mud/Mulch/Water and Solo Space. This is not surprising given the high frequency of manipulation overall. The most frequent activity in Solo Space was running, which is unsurprising given prior literature on open space and locomotion, as well as the coding parameters associated with running. Activity types involving Logs/Stumps were more evenly distributed, with balancing and climbing as the predominant activities. Of the total instances of

physical activity types (469), 105 involved Natural Loose Parts, 100 occurred in Solo Space, 94 involved Manufactured Supplies, 87 involved Logs or Stumps, 72 occurred in Open Space, 65 involved Fixed Landscape Features and 59 utilized Mud/Mulch/Water.

Table 4.

Frequency of activity type by activity context (absolute values)

Physical Activity Context	Physical Activity Type														
	Balance	Climb	Dig/Rake	Jump/Skip	Lie Down	Manipulation	Push/Pull	Resistive	Run	Sit	Stand	Squat	Throw	Walk	Total
Manufactured Supplies	0	0	21	0	0	47	11	10	X	2	X	1	2	0	94
Natural Loose Parts	8	0	0	3	0	65	3	15	X	0	X	1	10	0	105
Fixed Landscape Features	11	7	0	2	1	25	5	5	X	5	X	1	0	3	65
Mud/Mulch/Water	0	1	20	0	0	28	1	4	X	1	X	0	4	0	59
Logs/Stumps	26	17	1	10	2	13	5	7	X	5	X	1	0	0	87
Open Space	0	0	7	4	3	10	8	0	25	3	4	2	3	7	72
Solo Space	4	7	6	5	4	30	3	6	5	8	10	10	6	8	100
Totals	49	32	55	24	10	218	36	47	30	24	14	16	25	18	

Note. X indicates that due to coding parameters, context was not applicable to the given activity.

To further explore the data, absolute frequencies were converted into percentages which allow for more meaningful comparisons. For each activity type, the percentage of that type of activity occurring in each activity context was calculated and is presented visually in Figure 3. Note that this represents not the percentage of various activities relative to each other within each context, but rather the contribution each context made to percentages within each activity type. For illustrative purposes, only the most frequent physical activity types that were directly associated with any context are presented.

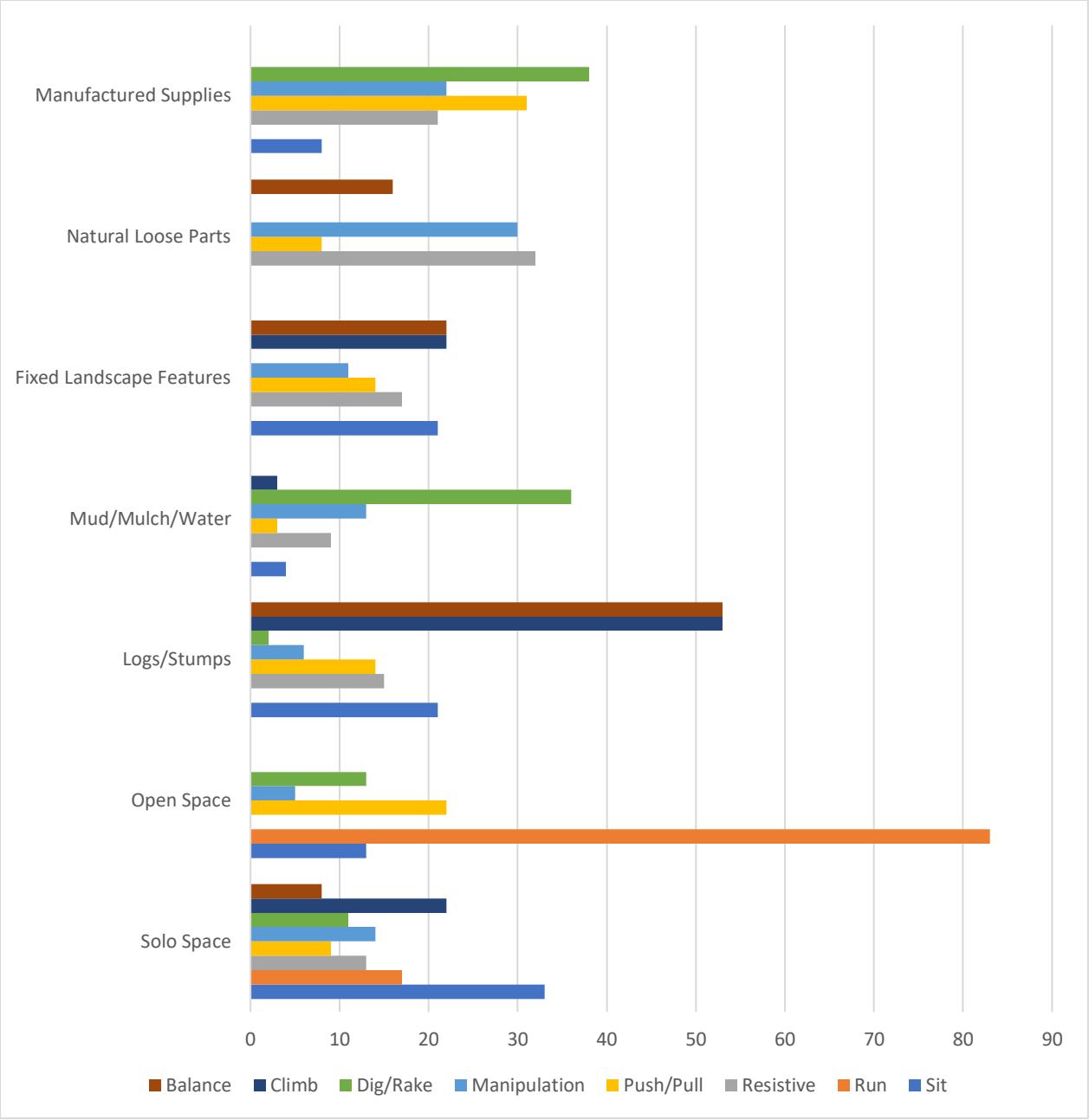

Figure 3. Physical activity contexts associated with physical activity types. This figure depicts the percentage of each activity context's contribution to physical activity types.

Results show the degree to which each activity context was involved in instances of activity types. Logs/Stumps were the primary activity context for three activity types (balance and climb, as well as jump/skip), and the margins that differentiated Logs/Stumps from other contexts in these categories were relatively large. Despite narrower margins, Natural Loose

Parts was the primary context for three activity types (manipulation and resistive, as well as throw). Solo Space was frequently associated with several activity types, especially sitting. Open Space was a secondary contributor to many physical activity types (push/pull and sit, as well as squat and walk) and by far the primary contributor to running (83% of running instances occurred in Open Space). Fixed Landscape Features were often involved in balancing, climbing and sitting, although were not the primary context associated with any one of these activities. The involvement of Mud/Mulch/Water was mostly limited to what was coded as Dig/Rake.

These results also showed that while some contextual features such as Mud/Mulch/Water and Fixed Landscape Features were more limited in their contributions to diversity of physical activity types, other contextual features were involved in a range of physical activity behaviors.

Grouping physical activity types by FMS categories offered a broader view of the relative contributions of activity contexts. Percentages of physical activity types, grouped by FMS, occurring within each activity context are depicted in Figure 4.

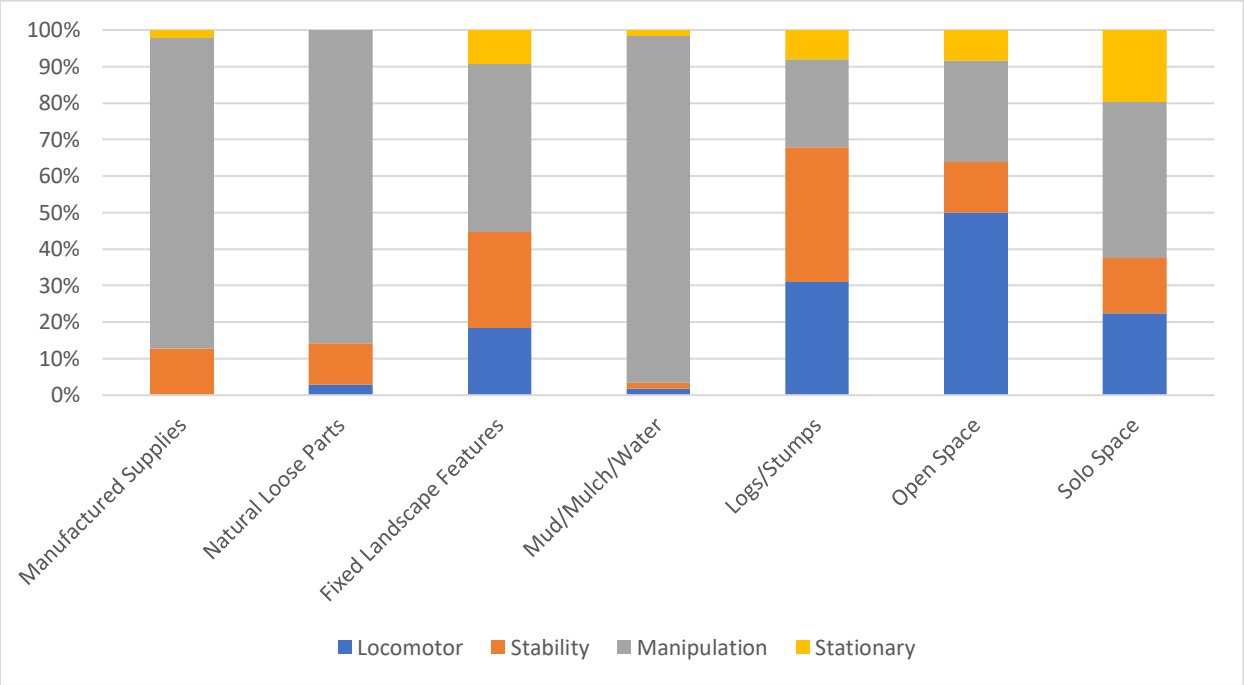

Figure 4. Frequency of FMS by Activity Context (percentages).

This showed that some activity contexts were dominated by particular FMS activities. Manufactured Supplies, Natural Loose Parts and Mud/Mulch/Water were overwhelmingly associated with manipulative activity, which included manipulation, resistive, dig/rake and throw. In contrast, activity occurring on Logs/Stumps was much more evenly divided among locomotor, stability and manipulation, as was, to a lesser degree, Fixed Landscape Features. Open Space was the only context in which the most prevalent FMS was locomotor activity.

Discussion

The purpose of the current study was to describe frequency of types of physical activity in a nature-rich outdoor preschool, as well as to explore associations between children's physical activity types and affordances of the environment. Findings revealed that children engaged in a variety of types of physical activities, with especially high levels of manipulative activity. Results also suggest a number of relationships between physical activity types and contexts. Prominent trends in the results are discussed thematically, next.

Frequent Physical Activity

Extensive prior research has found evidence that preschool-age children tend to be highly active outdoors compared to indoors (Brown et al., 2009; Tandon et al., 2015; Tandon et al., 2018; Truelove et al., 2018). The present study, although not comparative, affirmed this understanding that outdoor environments afford relatively high levels of engagement in physical activity. Children in this study engaged regularly in many types of physically active play including climbing, running, balancing, jumping and skipping, pushing and pulling objects across distances, and more. Furthermore, grouping types of physical activities by Fundamental Movement Skill categories revealed that 17% of total instances of physical activity were stationary and 77% were locomotor, stability or manipulative. This low frequency of stationary

activity contrasts with indoor levels of sedentary activity in preschools, which have been documented to be anywhere from 73% (Tandon et al., 2015) to 94% (Brown et al., 2009). Because in this study physical activity levels themselves were not assessed, only physical activity types, conclusions about the intensity level of children's physical activity in the present study are limited. However, results showed that stationary activities such as sitting, standing and lying down occur relatively infrequently compared to other types of activity in this environment.

These findings are important in light of the high movement needs of preschool-age children. Exercise play peaks around the ages of four to five (Pellegrini & Smith, 1998; Timmons et al., 2007). Many preschool teachers are well aware of this need of their students; for example, one study interviewing 37 teachers in Head Start early childhood centers in Pennsylvania found that teachers perceived children as "constantly moving" and having a natural "need to move" (Gehris, Gooze, & Whitaker, 2015, p. 125). Campbell, Eaton, and McKeen (2002) argued that the "prevalence and persistence of physical movement suggest that activity level is a biological imperative for children" of this age (p. 295). The preschool years represent a sensitive period during which physically active play, in the form of locomotor or exercise play, functions as an important support for healthy development. Therefore, the relatively high frequency of physical activity compared to more stationary types of activity found in the present study both confirmed this desire children have to engage in various types of physically active play, as well as underscored the role of the environment in affording such play opportunities.

Open Space and Locomotor Activity

Results of the present study indicated that a majority of children's locomotor activity, particularly running, occured in open space. This result is consistent with prior literature indicating a relationship between availability of open space and young children's moderate to

vigorous physical activity (Berg, 2015; Broekhuizen et al., 2014; Brown et al., 2009; Gubbels et al., 2012; Meyer et al., 2017; Nicaise et al., 2011; Tonge et al., 2016).

There are several potential explanations for this result. Open space may promote highly active locomotion because children feel able to move about freely in such spaces. Greater distances between activity centers may also require children to move more in order to transition from one play episode to another, further contributing to this relationship. Also, the terrain of the open spaces in the study sites is variable and uneven. Hilly terrain on preschool grounds has been associated with higher levels of physical activity, perhaps because, similarly to open space, it invites children to run, jump and move about (Määttä et al., 2019) as well as move at varying speeds (e.g. running downhill). The present study showed that the open, variable terrain in this nature-rich setting may have played a role in promoting children's locomotor activity.

High Levels of Manipulative Activity and the Role of Loose Parts

Manipulative activity occurred at a dramatically higher frequency than all other types of physical activities coded. Common examples of children's manipulative activity included functional play such as constructing things out of loose parts, building structures, and arranging objects such as sticks, stones, and fallen leaves.

The results of the present study contrasted with findings from Lim et al. (2017) who suggested that natural playgrounds offered ample affordances for stability and locomotive activities but no opportunities for manipulative play. Unlike Lim et al. (2017) who observed the environment only, without the presence of children, the present study drew from naturalistic video data of children's play. Clearly, children perceived and engaged with affordances of their nature-rich preschool space for manipulative activity. The discrepancy between these results and Lim et al. (2017) may come from the fact that loose parts were not included on their list of

features examined for physical activity affordances; either the settings they observed lacked loose parts or the researchers did not perceive loose parts or their possibilities for manipulative activity. In contrast, the present study showed that manipulative activity occurs frequently in this outdoor preschool setting, and that much of this activity was associated with natural loose parts.

Natural loose parts are highly malleable (Maxwell et al., 2008) and therefore children are able to interact with them and see the impact of their actions on their environment. For example, unlike an indoor setting, where breaking something is often not permitted and may result in the loss of a toy, an abundant supply of things like fallen twigs in a forest setting allows children to freely experiment with bending, breaking, and otherwise exploring the physical properties of materials. Furthermore, in contrast to most manufactured toys which remain relatively static over time, many natural loose parts change dynamically with fluctuating conditions and the passage of time. A piece of moss could function like a sponge in the winter, absorbing water which can be squeezed out, but then become dry and fluffy in warmer conditions. Even the availability of certain types of loose parts changes with the seasons. For example, as trees shed their leaves in the fall the ground becomes blanketed in a whole new collection of affordances for action. As a whole, the complexity and variation of natural loose parts enable children to engage with these versatile features of the environment in a diversity of ways (Fjørtoft, 2001), including, as the present study demonstrated, through manipulative activity.

Although not distinguished by the coding system, sometimes this manipulative activity was more fine-motor in nature, as children used their fingers to feel, hold, transfer, break, and otherwise maneuver small items in the environment such as sticks, leaves and small stones. Other times, this manipulative activity involved fingers and hands in conjunction with the arms or whole body, particularly when children maneuver large items such as branches. Both types of

manipulation offer something valuable for development, as larger movements help develop skills such as grip strength, crossing the midline and coordination, which lay a foundation for more fine motor control (Hanscom, 2016; Logan et al., 2012). Although fine-motor skills have been emphasized as indicators of school readiness and strong predictors of academic achievement in kindergarten (Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010), the role of gross-motor skills in such outcomes may be underestimated by extant literature (Oberer, Gashaj, & Roebers, 2017). Additionally, anecdotal observation from teachers suggested that children's fine motor movements increase in warmer weather when temperatures permit comfortable use of fingers without gloves for more extended periods of time, but analysis of manipulative activity by season was not part of the present study.

Logs and Stumps: Diversity of Affordances

Many physical activity contexts appear to predominantly promote certain kinds of physical activity types (e.g. loose parts were primarily linked to manipulation; the majority of instances running occurred in open space). In contrast, children's use of logs and stumps for stability, locomotor activity and manipulation were much more evenly distributed. The frequency of locomotor and stability activity on logs and stumps is unsurprising, given that logs and stumps were among the few features of the sites in the present study which afforded balancing, climbing and jumping. More surprising was that, in addition to these locomotor and stability affordances, logs and stumps were also substantially involved in children's manipulative activity. This suggests that logs and stumps may be particularly versatile and used by children in a variety of ways.

One possible explanation for this result is the variation in size, shape, weight and other characteristics of logs and stumps. Some were large enough to afford climbing, others were

small enough to afford being held, carried, rolled and maneuvered. Some stumps were sturdy enough to sit on; others were wobbly and required more dynamic effort to maintain balance. As the theory of affordances highlights, this environmental variation comes into dialogue with different individuals' perception of possibilities for action (Gibson, 1979). A single log may be perceived as climb-on-able for some children and not others, lift-able for some children and not others, and so on. During periods of rapid development such as early childhood, this variation occurs not only among individuals, but within an individual child over time. A small stump may present a compelling balancing challenge for a child when they are younger, and once they have mastered this, they may shift from using it for balance to a new challenge such as rolling it across the ground and building with it. It may also be that logs and stumps function as a nature-rich equivalent to the "activity-genic portable equipment" (p. 314) identified by Nicaise et al. (2011) as associated with increased physical activity; these items are large enough to invite gross-motor play but are small enough, and not fixed in place, and therefore can also be moved and manipulated by children.

This finding builds on prior understanding of the contribution of loose parts to varied physical activity behaviors. Smaller loose parts were associated with high levels of manipulation only; logs and stumps are also loose parts, albeit of larger size. These results suggested that larger loose parts may be particularly important for promoting diverse types of motor engagement, in contrast to small loose parts which contributed primarily to manipulative activity.

Solo Space and Stationary Activity

Children in the present study utilized solo space primarily for stationary activities such as sitting, standing and lying down. Taken together, these stationary activities occurred less frequently than locomotor, stability or manipulative activities. This indicates that, despite the

fact that children in the setting tend to engage more frequently in activity that is physically active, more stationary behaviors also occurred throughout the day and were often, although not always, a solitary moment for children.

Why might this be the case? Are children more likely to be physically active and less likely to be stationary while playing with peers? Do children who spend more time alone also tend to engage in more sedentary play? Does something about the experience of solitary space elicit more stationary behavior, or do children seek out more solitary places when they want to engage in more stationary play? Some research has suggested young children are more physically active in the presence of a friend (Barkley et al., 2014) and that physically active preschool children tend to "find each other" (Lehto, Reunamo, & Ruismäki, 2012, p. 281) while more socially withdrawn children tend to play in less physically active ways.

However, these studies (Barkley et al., 2014; Lehto et al., 2012) were limited to indoor play environments. Do the same explanations apply to outdoor environments? Possibly. Another possible interpretation of this finding is that the space to be "alone" afforded by this outdoor environment may have offered children a pause from the highly social, interactive school environment. Sometimes, children in the video data appeared to play alone for extended periods of time in more sedentary ways (e.g. sitting and constructing something with small twigs). However, after these solo episodes, children were often observed re-entering play interaction with peers. Did these more stationary moments in solo space function as in some way restorative for children and thereby support children's engagement with peers overall? This study focused on observable behaviors rather than interpretation of such behaviors, so the alignment of stationary activity and solo space is an intriguing finding which warrants further investigation.

It should be noted also that many active types of physical activity also occurred in solo space, such as climbing, jumping and skipping, running and throwing, although solo space was a relatively more minor contributor to these activities overall.

Implications

These results, although exploratory in nature and requiring further study with a larger sample, offered insight into how frequently children engaged in types of physical activity in an outdoor, nature-rich preschool setting. Additionally, possible relationships between frequency of activity type and activity context were examined and suggested trends in affordances of this nature-rich environment for children's physically active play.

The results of this study underscored the role of the physical environment in children's physically active play. Given the high levels of sedentary activity among children in many early childhood education programs, attention to environmental affordances for active play in early learning settings is needed to better meet children's physical activity needs. For example, results of this study suggest that creating and utilizing areas with open space may be critical to enabling children to engage in locomotive play such as running, jumping and skipping. Also, small natural loose parts may promote extensive manipulate activity, but larger loose parts such as logs and stumps may offer a greater variety of motor affordances ranging from fine-motor manipulation to gross motor challenges such as pushing/pulling, balancing, climbing and more. These environmental affordances are not only important for physical activity, which is valuable in and of itself; such activity is often embedded in social play in which children exercise emerging social, emotional, cognitive and self-regulatory skills. By attending to physical characteristics of the preschool environment, whether in a traditional preschool or an outdoor

model, early childhood professionals have an opportunity to enrich children's opportunities for play.

This study also has implications for the growing interest in outdoor and nature-based preschools specifically. Anecdotal evidence and a small handful of studies have begun to explore the impact of these programs on children's development, but empirical evidence regarding children's actual behaviors in these programs is limited. This study found that children do engage in frequent and diverse forms of physical activity in the outdoor preschool setting, affirming the possibility for these programs to play a role in promoting physical activity among attending children. This study complements accelerometry studies, which have described high levels of physical activity among preschool children outdoors, by adding that outdoor settings may benefit children not only via *level of intensity* of physical activity, but also via *type* of motor activity the setting affords. In particular, outdoor settings that offer a variety of open-ended, natural loose parts may enable children to hone manipulative and object-control skills which are understood to be important aspects of kindergarten readiness. These loose parts are often used in tandem with other features or elements of the environment – for example, propping sticks up against a tree to build a fort, or using a shovel to scoop up fallen leaves. Therefore, attention to not only each individual element, but also to how different elements interact to create affordances for action, will offer the greatest benefit to children's engagement. Although not investigated by the present study, these affordances are also socially situated, so attention to educator modeling, classroom norms and other forms of interaction can further enrich children's physically active play.

It is tempting to make proscriptive statements based on these results (e.g. advocate for particular environmental features to promote particular forms of play). However, the present

study sought to identify broad patterns, not specific interventions. For example, this study pointed toward the value of natural loose parts for children's manipulative activity; however, the type of loose parts that are available and appropriate for a given setting will vary depending on a variety of individual program factors. Similarly, open space in a forested public park will offer different kinds of opportunities, as well require different considerations for appropriate use, then open space located in a grassland, near water, or in a more urban environment. Rather than lay out specific guidelines for environmental design, this study sheds light on how children use their bodies in relation to types of functional possibilities in the environment. This information can guide pattern-based thinking about affordances for motor activity in outdoor early learning programs. How do children move through a space? How do they interact with features within it? What opportunities are there for children to challenge themselves physically, to balance, clamber, maneuver, run, tumble, roll? In what ways is their learning embodied, and how does the environment support that? Such reflection among designers and educators in early childhood care settings can help promote the physically active play opportunities that many young children need.

Limitations and Directions for Future Research

One of the primary limitations of the present study is the fact that data were collected at a single preschool program. Within this program, filming was conducted on at least a weekly basis for two years in each class, offering the benefit of diversity of children and weather conditions. However, due to this limited sample, the extent to which results are generalizable to other nature preschools or early childhood settings was limited. Natural preschool programs utilize a variety of types of settings and pedagogies which can differentially impact children's play possibilities and behaviors (Meyer et al., 2017). Given that individual background

characteristics (e.g. gender) can also influence children's physical activity patterns (Broekhuizen et al., 2014; Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016), the lack of consideration for individual factors in the present study further curtailed generalizability to wider populations.

Data collection procedures posed additional limitations to how representative the data are of the overall physical activity behaviors of children in the program studied. First, filming was limited to children whose parents had given informed consent, which may impact the degree to which the data are representative of all program participants' physical activity behaviors. If a child whose parents had not given consent entered the frame, filming was stopped immediately until the child left the frame. This may have resulted in documentation weighted heavily to reflect the activity preferences of certain children and not others. Additionally, filming occurred only in the classroom settings and therefore did not capture children's physical activity on excursions to other parts of the park. Classes regularly traveled to other areas of the park for exploration or particular activities, and some of these other areas offer very different affordances for physical activity. For example, a regular destination was a large fallen tree which children were able to climb on, a swale lined with boulders which allowed for yet a different type of clambering movement, and a large grassy hill which allowed for rolling down. These activities and many others were regular parts of children's engagement in physical activity in the program and were not captured by the video data used in the present study.

Another limitation of the present study stemmed from process of adapting the OSRAC-P. Many detailed parameters were needed in order to achieve coding consistency and this may have predisposed some of the data toward particular results. However, despite these limitations, the coding scheme still offered valuable information. For example, the only physical activity contexts that could be coded in association with instances of running were Open Space and Solo

Space. The consequence of this was that insight into how other contexts (e.g. logs/stumps, fixed landscape features) may have been involved in children's running is limited. Nonetheless, this finding did still illuminate the degree to which running occurred in open spaces in comparison to spaces that were not open.

Additionally, due to time limitations, testing inter-rater reliability of the present study's adaptation of the OSRAC-P via kappa calculation within each coding category was not feasible. Although reliability of the original OSRAC-P measurement was tested by Brown et al. (2006), the present study's adaptation of this instrument requires further assessment. That being said, this study's adaptation of the OSRAC-P was developed and refined in collaboration with two other researchers and an occupational therapist who all gave input as to clarity of code definitions and applications. Inter-rater agreement in the form of a percentage was calculated to provide a general check on coding consistency for the primary researcher; future studies should further test use of this adaptation of the OSRAC-P in order to refine the instrument and ensure reliability.

This study was designed to focus on how features of the physical environment were related to physical activity behaviors and, in doing so, omitted a number of characteristics, particularly regarding the social environment, that may be relevant to the results. This is especially salient at the preschool level, when children are taking cues from teachers' modeling and mobility license (Bjørgen, 2016). Furthermore, social experience plays an important role in how potential affordances become realized affordances (Kyttä, 2004). This study did not capture how social interaction with peers and teachers supported and constrained children's physically active play. Also, because of the goal of understanding physical activity in the context of child-led play, teacher-directed games/activities were not coded; however, some research suggests that

teacher-led, structured games may be important for promoting PA in preschoolers (Bjørgen, 2016; Kallestad & Odegaard, n.d.; Roach & Keats, 2018; Tonge et al., 2016). Future studies of nature preschools can build on these results by including investigation of social influences (such as the involvement of teachers and peers) alongside the influence of physical features in children's physically active play.

Finally, the present study analyzed only the observed motor behavior and not the larger activity context. For example, many instances of physical activity types appeared to occur within the context of sociodramatic play, but this was not systematically coded. Some instances of physical activity also represented examples of "risky play" which Sandseter and Kennair (2011) argued may have important developmental function. Future research can shed light on children's physical activity in these settings by asking not only what children are doing but also inquiring into the meanings of observed actions. Nonetheless, a strength of the present study is that it focused solely on directly observable motor behaviors, therefore minimizing the need for inference regarding the reasons behind children's observed behaviors.

Conclusion

Physically active play functions as an important support for multiple domains of development in early childhood including physical health, motor skills, cognition, psychosocial well-being and executive function (Timmons et al., 2007; Zeng et al., 2017), and these benefits may be especially apparent in nature-rich settings (Kemple et al., 2016). However, many young children's exposure to and active play in nature-rich settings are extremely limited (Clements, 2004; Dowdell et al., 2011; Frumkin et al., 2017; Strife & Downey, 2009). The impact of lack of physically active play during the preschool years on children's developmental and health outcomes, particularly obesity rates, is of growing concern (Trost et al., 2003).

In response to these issues and others, nature preschools represent a small but rapidly growing early childhood education model in the United States (North American Association for Environmental Education, 2017). These programs, which are diverse in many aspects of their settings and approaches, share a commitment to centering child-led exploration of nature and spending a substantial portion of each day outside (North American Association for Environmental Education, 2017). This approach regards the environment itself not merely as a backdrop for children's engagement, but as a key factor in shaping play and learning opportunities.

This view of the physical environment as a central influence on children's engagement is supported by theory and empirical research. Gibson's theory of affordances framed functional possibilities for action as arising jointly from qualities in the environment and the perception of individuals (Gibson, 1979; Heft, 1988). Potential affordances exist in the properties of the physical world, and realized affordances are those that are perceived and able to be acted upon (Kyttä, 2004). Research into affordances for or environmental correlates of young children's physical activity has highlighted several trends, including the increase in MVPA outdoors compared to indoors (Tandon et al., 2018), greater locomotion in open spaces (Nicaise et al., 2011), as well as natural playscapes offering opportunities for diverse motor behaviors (Fjørtoft, 2001) and extensive embodied problem-solving (Carr et al., 2017).

Despite this prior work on environmental affordances for physically active play and the growing interest in nature preschools, few studies have examined *actualized* physical activity affordances of entirely-outdoor nature preschool programs. The present study sought to describe frequencies of types of children's physical activity and associated features of the environment in an outdoor, nature-rich preschool. Results showed that children engaged in a variety of types of

physical activities including high levels of manipulative activity as well as locomotor and stability activities. Results also pointed toward associations between affordances of the setting and physical activity behaviors. For example, findings affirmed prior literature showing the value of open spaces for young children's locomotor activities, as well as children's extensive use of loose parts for manipulative play. Additionally, this study found that larger forms of loose parts such as logs and stumps may be especially diverse in their affordances for physically active play, offering children locomotor, stability and manipulative possibilities.

This study offered insight into how children in a nature preschool program engage in physical activity affordances of their play environment. While limited in generalizability, these results point toward the potential of nature-rich spaces to promote frequent, varied physical activities and associated developmental benefits in young children. Future studies can build on this work by examining actualized physical activity affordances in other nature preschool programs. This line of inquiry can shed light on how children in these increasingly popular programs engage with their learning environment. As parents, teachers, program directors, designers and policy-makers seek to provide high-quality care and education for young children, this line of inquiry can also inform efforts to increase physical activity in all early childhood education centers, nature-based or otherwise, by identifying evidence-based strategies for enriching children's physically active play opportunities.

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Appendix A. Original OSRAC-P Activity Type and Activity Context Codes

Table 1. Observational categories, accompanying codes, and brief descriptions for the OSRAC-P

Activity level codes	Brief descriptions
1—stationary or motionless	Stationary or motionless with no major limb movement or major joint movements (e.g., sleeping, standing, riding passively in a wagon)
2—stationary w/ limb or trunk movements	Stationary with easy movement of limb(s) or trunk without translocation (e.g., standing up, holding a moderately heavy object, hanging off of bars)
3—slow-easy movements	Translocation at a slow and easy pace(e.g., walking with translocation of both feet, slow and easy cycling, swinging without assistance and without leg kicks)
4—moderate movements	Translocation at a moderate pace (e.g., walking uphill, two repetitions of skipping or jumping, climbing on monkey bars, hanging from bar with legs swinging)
5—fast movements	Translocation at a fast or very fast pace (e.g., running, walking upstairs, three repetitions of skipping or jumping, translocation across monkey bars with hands while hanging)
Activity type codes	
Climb	Climbing, hanging
Crawl	Crawling
Dance	Dancing, expressive movement
Jump/skip	Jumping, skipping, hopping, galloping
Lie down	Lying down
Pull/push	Pulling or pushing an object or child
Rough and tumble	Rough and tumble play such as wrestling play fighting
Ride	Cycling, skateboarding, roller skating, scooter
Rock	Rocking on a teeter totter or on a horse
Roll	Rolling
Run	Running
Sit/Squat	Sitting, squatting, kneeling
Stand	Standing
Swim	Swimming or playing in a pool
Swing	Swinging on a swing
Throw	Throwing, kicking, catching
Walk	Walking, marching
Other	Physical activity type other than the options listed above
Location codes	
Inside	Being inside the preschool building
Outside	Being outside the preschool building or in an indoor gymnasium
Transition	Lining up and waiting to move inside or outside or moving between two rooms within the building
Outdoor activity context codes	
Ball and object play	Engaging in activity with objects used for gross motor activities (e.g., balls, throwing toys)
Fixed equipment	Engaging in activity on fixed playground equipment or being on fixed playground equipment
Games	Participating in a well-known preschool game such as Duck-Duck-Goose, Red Rover, or Freeze Tag
Open space	Being in an open outdoor area that is not one of the other outdoor activity contexts
Pool activities	Being in a pool or playing with water play toys in a water area
Portable equipment	Engaging in activity with equipment brought to the playground or gym other than balls or wheel toys
Sandbox	Engaging in activities using sandbox materials or being in a sandbox
Snacks	Preparing, eating, or cleaning up food during mealtime or being in an outside eating area
Sociodramatic props	Engaging in activity with sociodramatic play props or similar materials outdoors or in a gym
Teacher arranged	Engaging in teacher planned, arranged, and led gross motor activities with or without equipment
Time out	Child is placed in solitary time-out for disciplinary reasons
Wheel	Touching, riding, or pushing wheel toys that are not fixed equipment (e.g., tricycles, scooters, wagons)
Other	Outdoor or gym activity context other than the options listed above

Note. OSRAC-P = Observational System for Recording Physical Activity in Children-Preschool Version; PA = physical activity.
[Table 1 con. on p. 170.]