

**Title:** Physical activity behaviors of highly active preschoolers

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**Running Title:** High-active Preschoolers

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**What is already known about this subject:**

- Many preschool children do not participate in adequate physical activity, despite physical activity being a critical behavior for obesity prevention.
- Environmental factors such as indoor and outdoor settings affect physical activity levels.
- Direct observation and accelerometry are valid and complimentary methods for assessing physical activity.

**What this study adds:**

- This study uses both direct observation and accelerometry to describe a unique pattern of physical activity in high-active children.
- High-active children are more active than lower-active children while indoors.
- High-active children participate in different movement types throughout the school day compared to lower-active children.



1 **Abstract**

2 **Background:** Understanding physical activity behavior of young children who are highly active  
3 may provide important guidance for promoting physical activity in preschools.

4 **Objectives:** To describe the movement characteristics of high-active (HA) children during  
5 attendance at preschools.

6

7 **Methods:** Children in 20 preschools (n=231) wore accelerometers and were classified into  
8 tertiles of moderate-to-vigorous physical activity (MVPA). Children's movement characteristics  
9 were observed using the Observational System for Recording Physical Activity in Children –  
10 Preschool Version (OSRAC-P). Mixed-model analyses compared movement types between  
11 high-active (HA) children and lower-active (LA) children during the total school day.

12

13 **Results:** HA (n=77) children were observed to be more active than LA children (n=154) indoors  
14 ( $p<0.001$ ), but no differences were observed outdoors. HA children were more frequently  
15 observed running, crawling, climbing, jumping, skipping, swinging, and throwing across the  
16 total school day than LA children. Outdoors, HA children participated in more swinging and  
17 throwing and less jumping or skipping than LA children. Indoors, HA children spent more time  
18 pulling, pushing and running and less time walking than LA children.

19

20 **Conclusion:** HA children have unique activity patterns. Further interventions to increase  
21 physical activity of all preschoolers should increase the time spent outside and include varied  
22 activity types throughout the entire school day.

23

24

## 1 **Introduction**

2 More than one in five children ages 2 to 5 are at risk for overweight (1), and overweight and  
3 obesity have significant negative health consequences in children (2-4). Physical activity is a  
4 critical health behavior for obesity prevention (5). Recent guidelines from the United States (6),  
5 Australia (7), the United Kingdom (8), recommend three hours per day of physical activity for  
6 young children. Unfortunately, a majority of preschool children do not meet any of these  
7 guidelines (9,10). A review of 39 studies found that only 54 percent of young children  
8 accumulated 60 minutes of moderate-to-vigorous (MVPA) physical activity per day (11).

9       Because a large percentage of children ages 3 to 5 attends preschool, the preschool  
10 setting has the potential to contribute significantly to young children's physical activity levels  
11 (12). However, previous studies have found that children are primarily inactive while attending  
12 preschools (9-11,13). One study found that only 13.7 percent of preschools provided  
13 opportunities for 120 minutes of physical activity per day (14) and, on average, children  
14 accumulated less than 60 minutes of physical activity in childcare settings (10). Despite these  
15 overall low levels of physical activity, some young children are very active during preschool  
16 (11). Much less is known about the mode of physical activity in young children than the  
17 intensity, frequency and duration (Reilly 2010; Oliver 2007). By learning more about the  
18 context of high-active preschoolers' physical activity, future interventions can select and create  
19 programs and environments best conducive to these types of physical activity. For example,  
20 interventions can include more of the types of activities that high-active children participate in  
21 and select group contexts that are more likely to lead to higher levels of physical activity.

22       In addition, information about the environment in which physical activity occurs is  
23 important because the environment plays a role in physical activity levels of young children (15).

1 One environmental context that influences physical activity in children is the indoor versus  
2 outdoor setting. Studies of both preschool and elementary students have shown that children are  
3 more active when outside than when inside (16-19). Alhassan et al. (20) suggested that low  
4 levels of recess activity may result from the types of physical activities that preschool children  
5 participate in while on the playground. High-active (HA) children may participate in different  
6 types of movement (e.g., walking, running, crawling), particularly while outside (21).  
7 Understanding these differences may inform future interventions what types of activities to  
8 include specifically for indoor or outdoor settings. .

9         Several methods have been used to measure physical activity in young children (9,22),  
10 including accelerometry and direct observation. Both are objective, valid measures of physical  
11 activity, and each method has unique strengths and limitations. Using both methods provides a  
12 more complete description of physical activity, yet few studies have used the two objective  
13 measures. This study used both accelerometry to objectively measure physical activity  
14 throughout the school day and direct observation to describe behavioral and contextual factors of  
15 young children's physical activity.

16

17 **The purpose of this study was to describe the physical activity behavior of high-active**  
18 **children while directly observed in indoor and outdoor preschool settings. To accomplish**  
19 **this, we utilized two objective measures of physical activity, accelerometry to identify high-**  
20 **active (HA) and lower-active (LA) children and direct observation to compare the types**  
21 **and intensities of activities in which HA and LA children participate.** A clearer  
22 understanding of the physical activity behavior of high-active young children may provide

1 important information to policy makers and preschool administrators and teachers about the ideal  
2 types and settings for physical activity in young children.

3

#### 4 **Methods**

5 The 20 participating preschools were part of the Children's Activity and Movement in Preschool  
6 Study (CHAMPS). The preschools included commercial childcare centers, church-affiliated  
7 preschools and Head Start Centers. The children ranged in age from three to five and typically  
8 attended preschool for three or more days per week for more than four hours per day. Cross-  
9 sectional data were collected in two waves over two and a half years. Parents provided informed  
10 consent for all children who participated in the data collection. The University of South Carolina  
11 Institutional Review Board approved the study.

12

#### 13 *Accelerometers*

14 Physical activity during the school day was measured across two weeks using ActiGraph  
15 accelerometers (model 7164; ActiGraph, Pensacola, FL) (23). Parents were instructed to have the  
16 child wear the accelerometer during all waking hours, except during bathing and swimming, for  
17 two weeks. Data collectors recorded arrival and dismissal times. Sixty minutes of consecutive  
18 zeros were considered non-wear time. Participants with at least three complete days of data were  
19 included in the analyses. A 15-second sampling epoch was used to better capture the short bursts  
20 of activity typically performed by children in this age group (24). Moderate-to-vigorous physical  
21 activity (MVPA) was defined as  $\geq 420$  counts per 15 seconds from cutoffs developed specifically  
22 for 3-5 year-old children (23).

23

1 ***Observational System for Recording Physical Activity in Children – Preschool Version***  
2 ***(OSRAC-P)***

3 The Observational System for Recording Physical Activity in Children – Preschool Version  
4 (OSRAC-P) is a validated momentary time sampling direct observation system (25). This focal-  
5 child system uses a 5-second observe interval, followed by a 25-second record interval, for each  
6 30-second observation interval. Each child was observed for 10 to 12 30-minute sessions,  
7 resulting in 600 to 720 30-second intervals observed per child. Staff coded each observation for  
8 intensity (ranging from 1-5), type, and location of physical activity as well as social and  
9 environmental contexts, including equipment use, play in open space and group composition.  
10 Inter-observer reliability for OSRAC-P has been previously reported to be above 0.80 across  
11 children, preschools and time of day (26).

12

13 Parents completed a survey that included age and demographic information (gender, race, and  
14 parent education). Height was measured to the nearest 0.1 cm using a portable stadiometer  
15 (Shorr Productions, Olney, MD). Weight was measured to the nearest 0.1 kg using an electronic  
16 scale (Model 770; Seca, Hamburg, Germany). BMI was calculated from these heights and  
17 weights ( $\text{kg}/\text{m}^2$ ).

18

19

20

## 1 ***Analysis***

2 Descriptive statistics were calculated using SAS 9.2. Only children who had three days of  
3 accelerometry data and complete direct observation data were included in the analysis. First,  
4 accelerometry data were used to classify children into sex-specific activity tertiles. As the  
5 physical activity data was negatively skewed, children were split into tertiles of physical activity  
6 based on minutes of MVPA per hour (upper tertile; >10.17 min/hr MVPA, lowest tertile; <6.03  
7 min/hr MVPA). Then, children were classified as high-active (HA; upper tertile) or lower-active  
8 (LA; middle and lower tertiles). The direct observation data from OSRAC-P were then used to  
9 compare physical activity types, behaviors, and contexts between the HA and LA groups.

10

11 Mixed-model analysis of variance was used to compare OSRAC-P data between HA and LA  
12 children. The dependent variables were directly-observed intensity levels, movement types, and  
13 socio-environmental contexts. Separate analyses were performed for observations during the  
14 total school day, while children were indoors and while outdoors. Preschool center was included  
15 as a random variable to control for the clustering within preschools. A separate analysis was  
16 performed to compare physical activity behaviors while children were observed being physically  
17 active. For this analysis, only observations that were coded as non-sedentary behaviors with  
18 OSRAC-P (3-slow easy movement; 4-moderate movement; 5-fast movement) were included.  
19 Models were adjusted for sex, race, and parent education.

20

## 21 **Results**

22 A total of 231 children wore accelerometers and were directly observed using the OSRAC-P.  
23 The average accelerometer wear time was 8.03 (1.59) hours per day on 7.20 (2.00) days. The

1 average age was 4.2 years in the HA group and 4.3 in the LA group ( $p=0.77$ ). There were no  
2 differences between the HA and LA groups in sex, racial distribution, or BMI (see Table 1).  
3 Parent education was equal between the two activity groups, with over 50 percent of parents  
4 completing at least a two-year college degree.

5  
6 *Intensity of Activity*-Based on the observational data, HA children participated in higher intensity  
7 activity than LA children while in indoor settings (3.60% time spent in MVPA vs. 2.70%,  
8  $p<0.0001$ ). In outdoor settings, the activity intensity did not differ between HA and LA children  
9 (17.81% vs. 19.14%,  $p=.50$ ).

10

11 *Type of Movement*- The observational data showed that both the HA and LA groups spent the  
12 majority of time in sedentary movement types (sitting and standing), with no significant  
13 differences in the percentage of sedentary behaviors observed between the two groups. HA  
14 children spent more time than LA children engaged in higher intensity movement types during  
15 the total school day, including running, climbing, jumping and swinging, and throwing. The  
16 only gender difference was for throwing, with high-active boys having the highest percentage of  
17 intervals throwing ( $p=.01$ ).

18

19 *Distribution of Active Movement Types*- When children were active (light, moderate or vigorous  
20 activity) during the total school day, HA children were observed more frequently swinging and  
21 throwing and less frequently walking than LA children (See Table 2). When they were active  
22 outside, HA children were observed swinging and throwing more and jumping/skipping less than

1 LA children. When active inside, HA children spent more time pulling or pushing and running  
2 and less time walking than LA children.

3  
4 *Socio-environmental Context-* HA children played more on fixed equipment, and less in open  
5 spaces, and played individually more often than LA children during the total school day,  
6 although the differences were not statistically significant (See Table 3).

## 7 **Discussion**

9 This study identified distinct physical activity behaviors in HA children. As expected, staff  
10 observed HA children participating in higher intensity activities, but only while indoors. This  
11 study provides additional support for including more time for outdoor play in preschools. Not  
12 only are children overall more active while outdoors (18), but because HA and LA children were  
13 equally active while outdoors, providing children with more outside time may level the playing  
14 field and help all children increase physical activity levels. Unfortunately, very little time is  
15 spent outside during preschool (18,19). Despite the reported feasibility and acceptability to  
16 parents of increasing outdoor time during school (27), increasing time outdoors requires  
17 overcoming many teacher barriers (28). The most common reported barriers include a lack of  
18 resources and time often due to academic conflicts (29,30). Many teachers and directors are also  
19 cautious of including physical activity, such as running, in the classroom (30). Interventions  
20 including physical activity with rules and expectations may be a useful tool to teach self-control  
21 and has been successfully included in preschool interventions (31). Notwithstanding, outdoor  
22 physical activity may be more acceptable to current centers. Despite outdoor activity being more  
23 acceptable to teachers and children have higher levels of physical activity outside than inside,

1 children are still are not sufficiently active while outdoors. A previous report on the children  
2 included in the current study found that young children spent only 17 percent of time outdoors in  
3 moderate-to-vigorous physical activity (18). To increase overall levels of physical activity,  
4 preschools should increase the time children spend outdoors as well as increase physical activity  
5 opportunities throughout the school day (14,32). Interventions should reduce barriers to  
6 including physical activity indoors.

7 When children are physically active, HA children appear to choose different movement types  
8 than LA children. In this study, HA children engaged in a wider variety of activities, confirming  
9 previous results from a small sensitivity analysis in the home environment (21). HA children  
10 may prefer different activities and resulting movement types. Although this study did not  
11 examine reasons for these differences, evidence from elementary-age children suggests that HA  
12 and LA children have different determinants of physical activity (33). Other factors may  
13 uniquely influence preschool children such as differences in motor skills (34,35), personality and  
14 other factors intrinsic to the child (36). Other influences include the preschool center. Children  
15 in preschools with physical activity promoting policies and practices typically have higher  
16 physical activity levels (37). While the analysis controlled for the preschool center, specific  
17 differences, such as equipment and physical resources was not directly accounted for.

18 HA children participated more in some movement types that are low intensity, including  
19 throwing, crawling and lying down, which was unexpected. These behaviors may be indicative  
20 of more active forms of play, such as sports games, organized play, falling on the ground while  
21 playing tag, etc. These forms of play, rather than the specific movement type, may lead to higher  
22 overall physical activity levels. Thus teachers and future interventions should encourage overall  
23 active play instead of focusing on specific higher intensity activities.

1 The preschool children in this study participated in these play-like activities such as crawling and  
2 climbing, which is in contrast to older children. To understand the types of physical activities  
3 older children participated in, Sleaf et al. (38) used direct observation, similar to the current  
4 study. In contrast to the current study, however, they found that older children participated  
5 mostly in organized running and chasing games. Teachers and adults should encourage  
6 developmentally appropriate activities. In addition, due to the potential increased role of  
7 alternate activity types such as crawling, climbing, and jumping in young children compared to  
8 adults, researchers need methods to detect these activity modes when measuring physical activity  
9 in young children.

10 Strengths of this study include a racially and socioeconomically diverse sample of children in  
11 various types of preschools. This study used multiple measures to assess the broad construct of  
12 physical activity (39). Both accelerometry and direct observation, which are considered to be  
13 two of the most valid measures of physical activity in children (40), were used to describe the  
14 unique physical activity patterns of HA and LA children.

15 However, both methods also have limitations that were attenuated by including both methods.  
16 While accelerometers do not accurately detect all patterns of movement and underestimate upper  
17 body movements typical in this population of young children, direct observation confirmed that  
18 HA children were more active than LA children. Because direct observation was limited to the  
19 time the children were in school, analysis was limited to physical activity during the school day.  
20 Children may have different physical activity patterns at home (e.g., participating in afterschool  
21 activities, daycare, or sports). Limited evidence, however, suggests that participation in  
22 organized activities, which makes up a large percentage of out of school time, is not associated  
23 with increased levels of physical activity in preschoolers (41).The low frequency that some

1 activity codes were observed in this sample may have resulted in reduced statistical power.  
2 Behavior in young children occurs in short bouts (25), which may make it more difficult to  
3 capture. Additionally, there was a small amount of time spent outdoors over the total sample,  
4 again decreasing the ability to detect differences. However, the large sample size and reliable  
5 measures increased the power to detect these differences.

6 In conclusion, HA children participated in a different pattern of physical activity than LA  
7 children. Future physical activity interventions in preschools should include more outdoor time  
8 and encourage a wide variety of physical activity types. Further research is needed to determine  
9 whether group or individual contexts promote physical activity in young children.

10

1 **Conflict of Interest**

2 The authors have no known conflict of interest.

3

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12

13 RP, WB, and MD conceived the study and supervised experiments. MD and EH analyzed data.  
14 KM carried out experiments. All authors were involved in writing the paper and had final  
15 approval of the submitted and published versions.

16

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7

8

1  
2**Table 1:** Sex-specific characteristics of preschool children in study

<i>Characteristic</i>	<b>High-Active (n=77)</b>	<b>Lower-Active (n=154)</b>	<i>p-value</i>
	<i>(Mean (SD) or Percent)</i>		
<b>Age (years)</b>	4.3 (0.69)	4.2 (0.67)	0.48
<b>Gender</b>			0.93
<b>Females</b>	49.4%	48.7%	
<b>Race</b>			0.07
<b>Black</b>	46.8%	42.9%	
<b>White</b>	3.9%	13.6%	
<b>Other</b>	49.4%	43.5%	
<b>BMI</b>	16.9 (3.08)	16.7 (2.84)	0.57
<b>Weight (kg)</b>	19.1 (4.37)	18.1 (4.04)	0.08
<b>Height (cm)</b>	106.1 (6.47)	103.9 (6.37)	0.01
<b>Parent Education</b>			0.71
<b>Some college or below</b>	44.2%	46.8%	
<b>2 year college degree or above</b>	55.8%	53.3%	



**Table 2:** Mixed-model analysis for percentage of time observed in movement types limited to intervals coded as light, moderate and vigorous activity. Models are adjusted for parent education, race, bmi, and preschool.

<i>Movement Type</i>	<i>Total School Day</i>			<i>Outside</i>			<i>Inside</i>		
	<i>% Intervals Observed (SE)</i>			<i>% Intervals Observed (SE)</i>			<i>% Intervals Observed (SE)</i>		
	<b>HA</b>	<b>LA</b>	<b>p-value</b>	<b>HA</b>	<b>LA</b>	<b>p-value</b>	<b>HA</b>	<b>LA</b>	<b>p-value</b>
<i>Climb</i>	3.97 (.75)	2.83 (.60)	.09	8.14 (1.42)	6.00 (1.07)	.13	.35 (.28)	.50 (.21)	.61
<i>Crawl</i>	3.02 (.57)	2.56 (.45)	.38	1.22 (.44)	.85 (.35)	.36	5.05 (.88)	3.96 (.64)	.22
<i>Dance</i>	.66 (.19)	.50 (.13)	.41	.02 (.11)	.18 (.08)	.26	1.58 (.40)	.93 (.29)	.13
<i>Jump/Skip</i>	5.14 (.60)	4.39 (.42)	.25	<b>2.23 (.91)</b>	<b>4.07 (.68)</b>	<b>.04</b>	6.47 (.89)	5.47 (.63)	.30
<i>Pull/ push</i>	.96 (.23)	.79 (.18)	.42	1.39 (.47)	1.39 (.34)	.999	<b>.76 (.15)</b>	<b>.28 (.11)</b>	<b>.01</b>
<i>R&amp;T</i>	.15 (.14)	.25 (.10)	.45	.09 (.16)	.33 (.12)	.19	.15 (.15)	.20 (.11)	.73
<i>Ride</i>	1.29 (.71)	1.08 (.54)	.76	2.30 (1.41)	2.39 (1.06)	.95			
<i>Rock</i>	.10 (.19)	.25 (.14)	.48	.08 (.44)	.50 (.31)	.38	.06 (.20)	.16 (.14)	.64
<i>Roll</i>	.24 (.12)	.21 (.10)	.80	.23 (.15)	.16 (.11)	.68	.26 (.18)	.24 (.15)	.90
<i>Run</i>	14.60 (1.07)	13.37 (.80)	.25	25.56 (2.46)	24.91 (1.73)	.81	<b>6.82 (.78)</b>	<b>5.15 (.58)</b>	<b>.04</b>
<i>Swing (on equipment)</i>	<b>2.09 (.63)</b>	<b>.77 (.49)</b>	<b>.03</b>	<b>3.75 (1.14)</b>	<b>1.54 (.90)</b>	<b>.04</b>			
<i>Throw</i>	<b>.71 (.16)</b>	<b>.35 (.11)</b>	<b>.04</b>	<b>1.10 (.26)</b>	<b>.47 (.18)</b>	<b>.02</b>	.11 (.08)	.12 (.06)	.93
<i>Walk</i>	<b>63.64 (1.76)</b>	<b>69.66 (1.33)</b>	<b>&lt;.001</b>	50.92 (3.04)	54.82 (2.19)	.22	<b>74.67 (1.73)</b>	<b>79.36 (1.23)</b>	<b>.01</b>

Abbreviations: HA- High-Active Children, LA- Lower-Active Children

**Table 3:** Percentage of intervals observed in outdoor, indoor, and group contexts

		% Intervals Observed (SE)		p-value
		High-Active	Lower- Active	
<b>Outdoor Context</b>	Balls	7.91 (2.39)	7.05 (1.78)	0.72
	Fixed Equipment	29.23 (2.94)	26.52 (2.05)	0.39
	Open Space	42.29 (3.70)	48.12 (2.80)	0.11
	Sociodramatic Props	4.38 (1.46)	3.54 (1.05)	0.58
	Wheels	3.85 (1.79)	4.43 (1.38)	0.73
<b>Indoor Context</b>	Group Time	12.65 (2.35)	12.37 (2.08)	0.86
	Manipulatives	5.87 (.97)	5.28 (.73)	0.54
	Sociodramatic Play	3.25 (.93)	3.67 (.76)	0.60
	Video	4.26 (.91)	3.44 (.75)	0.28
<b>Group</b>	Solitary	7.99 (1.21)	6.12 (.93)	0.11
	Multiple Children	50.95 (2.35)	52.26 (1.98)	0.49
	Adult Involvement	41.08 (2.48)	41.57 (2.20)	0.78