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## Original Article

## An observation system to assess physical activity of children with developmental disabilities and delays in preschool

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## ABSTRACT

**Background:** Physical activity (PA) behaviors during preschool settings can influence the health and development of children with developmental disabilities (DD). There is a need for a direct observation system that simultaneously assesses PA and preschool environmental contexts.

**Objective:** The purpose of this study was to develop an observation instrument for measuring PA and related contextual factors of preschoolers with DD, and to establish content validity and reliability.

**Methods:** Content validity was established through consultation with experts, informal observations in inclusive and special education preschools, and literature reviews. Categories and codes were identified and modified from existing observational systems for young children. Reliability was assessed in a convenience sample of preschool children with DD using a cross-sectional design. Data were collected using a momentary time sampling system (5-sec observe, 25-sec record) following a focal child. Inter-rater reliability was assessed during 20% of the observation sessions.

**Results:** The instrument development process resulted in ten coding categories that accounted for PA levels, types, and social and physical environmental contexts relevant to preschoolers with disabilities. Observers completed 137.5 observation sessions, yielding 5498 30-s observation intervals. Interval-by-interval percent agreement was excellent (91%–100%) and kappa values were high (0.82–0.99).

**Conclusions:** The instrument was found to be a reliable measure of PA of preschoolers with DD and provided important contextual information about PA behaviors in early childhood special education settings. Additionally, it allowed for the simultaneous measurement of specific types and contexts of PA behaviors of preschoolers with DD and will be useful for describing PA and informing future interventions.

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## Introduction

Physical activity promotion among young children is a significant public health priority that aims to curb childhood obesity and prevent the development of other chronic diseases later in life.<sup>1</sup> It is recommended that preschool-aged children (ages 3–5 years)

accumulate at least 3 h of total physical activity (light, moderate, and vigorous) per day, and approximately half of preschoolers do not meet these guidelines.<sup>1,2</sup> Similarly, most children with developmental disabilities fail to meet physical activity guidelines.<sup>3–5</sup> Developmental disabilities (e.g., autism, intellectual disability, Down syndrome, cerebral palsy) are characterized by impairments in several domains including, but not limited to, self-care, receptive and expressive language, mobility, self-direction, and learning.<sup>6</sup> Studies specific to physical activity in preschool-aged children with developmental disabilities are sparse, as most prioritize youth and adolescents, and they offer limited insight into the contextual circumstances (i.e., physical and social environmental factors) that influence physical activity behaviors.<sup>7–9</sup> Identifying these contextual circumstances will aid in revealing important correlates of physical activity behaviors among this population.

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Direct observation has been widely used to assess typically developing children's physical activity and related contextual circumstances and is considered a gold standard.<sup>10</sup> However, few instruments have been used among preschool-aged children with developmental disabilities. The Behaviors of Eating and Activity for Children's Health Evaluation Survey (BEACHES) was used to investigate contextual factors at home and school that influence physical activity of children ( $n = 35$ ; mean age =  $15.7 \pm 4.3$  years; 28.6% = ages 4–6 years) with physical disabilities<sup>11,12</sup> and was validated in a small sample of children ( $n = 5$ ; ages 6–12 years) with cerebral palsy.<sup>13</sup> The Children's Activity Rating Scale (CARS) records children's physical activity on a scale of 1–5 and has been validated among preschoolers and a small sample of children with intellectual disabilities.<sup>14,15</sup> These physical activity codes are also used in the Observational System for Recording Activity in Children – Preschool version (OSRAC-P), a momentary time sampling system that allows for simultaneous recording of physical activity level and features of the physical (i.e., location, indoor and outdoor contexts) and social (i.e., activity initiator, group composition, physical activity prompts) environment.<sup>16</sup>

The OSRAC-P has been used to evaluate the influence of the social environment on physical activity behaviors of preschool-aged children with autism during inclusive summer camp.<sup>17</sup> Children with autism were significantly less physically active in social group settings compared with solitary settings during free play, however the degree to which the children were interacting within social groups is unknown.<sup>17</sup> Both instruments offer insights into contextual circumstances surrounding physical activity, but they were designed for use with typically developing children and lack contextual factors unique to children with developmental disabilities. Therefore, there is a need for an observation instrument that addresses these factors and can be used in common settings for young children with disabilities.

Most young children, including those with developmental disabilities, spend a large portion of the day in structured childcare program.<sup>18,19</sup> As such, childcare and preschool settings pose a unique opportunity to investigate physical activity behaviors of young children with developmental disabilities and related physical and social environmental contexts. To our knowledge, there is no direct observation instrument that sufficiently captures physical activity behaviors and contextual factors of inclusive and special education preschool environments. Therefore, the purpose of this study was two-fold: 1) to develop an instrument for direct observation of physical activity and related contextual factors in preschool children with developmental disabilities, and 2) to establish the content validity and reliability of the instrument.

## Methods

This study was conducted in two distinct phases: 1) instrument development, and 2) instrument evaluation.

### Phase 1: Instrument development

Two existing observation instruments have been used to measure physical activity and corresponding environmental contexts of children with disabilities<sup>11,16</sup> and were reviewed for utility in the inclusive and special education preschool settings. Both instruments used a similar coding scheme for recording physical activity intensity, but each captured different levels of detail within social and physical environments. For example, social environment in the OSRAC-P was first defined by interaction (i.e., interaction between the focal child and one or more individuals) and then proximity (i.e.,

if interaction is unclear) whereas BEACHES accounted for both proximity (i.e., individuals within three feet of focal child) and interaction (physical or verbal). Overall, the OSRAC-P provided the most detailed account of preschool behavioral settings, or the specific settings in which children and the environment interact and engage in physical activity behaviors. As such, it was selected to serve as the foundation of the new instrument, which we will refer to as the Observational System for Recording Activity in Children – Developmental Disabilities version (OSRAC-DD).

Content validity for the OSRAC-DD was established through visits to 10 preschool classrooms, discussions with preschool directors, teachers and therapists, and literature reviews. Preschool teachers and directors provided researchers with typical classroom schedules and discussed the various child behaviors and important preschool contexts that occur during the day. During field observations, researchers recorded observed child-level behaviors (e.g., stimming, hand flapping, body rocking), preschool behavioral settings (e.g., therapy sessions, sensory rooms), and social circumstances (e.g., one-on-one sessions with therapists, interactions with clinical students and volunteers) unique to inclusive and special education classrooms. Based on the observations, the decision was made to retain the original eight coding categories of the OSRAC-P: 1) Physical Activity Level, 2) Physical Activity Type, 3) Location, 4) Indoor Activity Context, 5) Outdoor Activity Context, 6) Activity Initiator, 7) Group Composition, and 8) Prompts. The observations and literature reviews also informed modifications to existing definitions, development of new categories, and creation of relevant codes. Specifically, additional codes were added to account for therapy sessions as a behavioral context and the presence of therapists in the social environment. Additionally, a category was created to record repetitive/stereotypic behaviors as some researchers hypothesize that these behaviors contribute to overall levels of physical activity.<sup>20</sup> Lastly, to enhance specificity of the social environment, interaction and engagement categories were developed based in the Individual Child Engagement Record – Revised version (ICER-R), a valid and reliable observation instrument used in inclusive and special education school settings.<sup>21</sup>

The preliminary version of the OSRAC-DD was comprised of 11 categories, including three categories specific to the new instrument: 1) Repetitive Behavior/Stereotypy, 2) Engagement, and 3) Interaction. As with other OSRAC instruments, the OSRAC-DD employed momentary time-sampling procedures to observe a focal child for 20-min observation sessions. These sessions were comprised of 30-s coding intervals (5-s observe, 25-s record intervals) and were repeated continuously during 20-min observation sessions. A research assistant with prior experience working with preschoolers with disabilities was trained to utilize the OSRAC-DD. Research assistant training was modeled off the training protocol described by Brown et al. and consisted of: 1) orientation sessions to introduce the instrument and methodology, 2) reviewing the training manual, protocols, and codes daily, 3) memorizing operational definitions, 4) completing written assessments, 5) coding videos of preschoolers with disabilities in preschool settings, 6) reviewing and discussing codes and protocol, 7) informally observing inclusive special education preschools, 8) conducting *in situ* observations in pairs and debriefing, and 9) conducting independent observations in an inclusive and special education classroom.<sup>16</sup> Independent observation sessions were repeated until the research assistant achieved at least 80% agreement in all OSRAC-DD coding categories.<sup>16</sup> Following observer training, which occurred daily for approximately two weeks, reliability of the OSRAC-DD was established through field testing in inclusive and special education classrooms.

## Phase 2: Instrument evaluation

A cross-sectional pilot study was conducted to evaluate the instrument's reliability and was approved by the University of South Carolina's Institutional Review Board. A convenience sample of 25 preschool-aged children with developmental disabilities and delays were recruited from an early childhood center and a special education daycare setting. Most participants (80%) were enrolled in a special education classroom whereas the remaining students were in an inclusive classroom environment. Six children were excluded from the study because they had not yet been formally diagnosed with developmental disability or delays, or they had a medical concern that could impair independent movement. Therefore, 19 children were eligible for the study (see Table 1).

Parents and guardians provided consent prior to the study and were asked to complete a brief parent survey. The survey queried parents on the age, gender, and diagnosis of the participating child. Parents also reported on the source of their child's diagnosis (e.g., pediatrician, psychologist, specialist), past and current special education services, and current therapy services based on items from the National Survey of Children's Health.<sup>22</sup> Participants (mean age = 4.76 ± 0.7 years; 57.0% white) were primarily male (68.4%) and most were diagnosed with autism (78.9%). At the time of the study, 47.4% of parents reported that their child was receiving early intervention services through an Individualized Family Service Plan and 61.1% of children received these services before age 3. All children were receiving at least one form of therapy including speech therapy (89.5%), occupational therapy (68.4%), physical therapy (36.8%), or other therapies such as cognitive therapy and applied behavioral analysis (52.6%). After completing the survey, parents received a modest stipend to thank them for their time and effort.

Trained research assistants observed participating children using a focal child, momentary time-sampling protocol consisting of 30-s observation intervals (5-s observe, 25-s record). Observation sessions were 20-min in duration and yielded 40 observation

intervals per session. Daily schedules were obtained from preschool teachers and children were randomly allocated to observation time slots, excluding planned nap and mealtimes. Participants were observed approximately eight times, and research assistants were randomly assigned to observation sessions. Data were entered into tablet computers which were equipped with the Multi-Option Observation System for Experimental Studies (MOOSES) program and corresponding LILY data collection software.<sup>23</sup> OSRAC-DD categories and codes were organized in columns on a single screen and a timed audio prompt indicated when the observer should observe and record the data. OSRAC-DD categories are mutually exclusive and during each interval, observers independently recorded the highest estimate of physical activity intensity followed by the corresponding physical activity type and social and physical environmental contexts. Inter-rater reliability assessment was planned for at least 20% of the observation sessions. Pairs of research assistants simultaneously, but independently, observed the same focal child during these sessions using split headphones and auditory prompts.

Physical activity levels were aggregated to provide estimates of sedentary (levels 1 and 2 combined), light (level 3) and moderate-to-vigorous (levels 4 and 5 combined; MVPA) physical activity. The overall percentage of intervals spent in sedentary, light, and MVPA were calculated. The percentage of intervals spent in physical activity by location (indoor, outdoor, transition), type, stereotypic behavior, and environmental context variables (e.g., indoor contexts, outdoor contexts, social group) were also calculated. An additional category, "Reactivity" was included to indicate whether or not participants were reactive to the observers.

Percent agreement for each category was calculated for inter-rater reliability sessions using the following equation:  $[\#agreements/(\#agreements+\#disagreements)] \times 100$ . Cohen's kappa was calculated for all inter-rater reliability assessments (20% of observation sessions). Session-level percent agreements and kappa values were averaged to provide overall mean percent agreement and kappa values and are presented in Table 2.

## Results

The final version of the OSRAC-DD consisted of ten coding categories: 1) Physical Activity Level, 2) Physical Activity Type, 3) Repetitive/Stereotypic Behaviors, 4) Location, 5) Indoor Activity Context, 6) Outdoor/Gym Activity Context, 7) Activity Initiator, 8) Group Composition, 9) Interaction, and 10) Prompts. After the evaluation phase of the study, the Engagement category was excluded from the final instrument due to difficulty in discerning true engagement during physical activity settings (e.g., outdoors during recess, free play in a gym) and the "physical prompt" code was moved from the Engagement to the Interaction category. Table 3 describes the final categories and codes used in the OSRAC-DD.

There were 137.5 observation sessions which yielded 5498 30-s observation intervals. Inter-observer reliability was assessed during 28 observation sessions (20.6% of sessions), yielding 1120 observation intervals. There was a high level of percent agreement between observers for all OSRAC-DD observation categories (range = 91%–100%). Lower scores were observed among Interaction (kappa = 0.82, % agreement = 92.0%), Initiator (kappa = 0.85, % agreement = 94.0%), and Physical Activity Level (kappa = 0.87, % agreement = 91.0%). Physical activity level had the lowest percent agreement largely due to the difficulties in distinguishing between Level 1 (stationary and motionless) and Level 2 (stationary with movement of limbs or trunk) movements. Kappa coefficients were calculated to account for the possibility that observers agreed by chance and mean kappa and standard deviations for each category

**Table 1**  
Demographic characteristics of participating children.

n	19
Gender male, n (%)	13 (68.4)
Age, years (SD)	4.76 (0.7)
Race/Ethnicity, n (%)	
White	11 (57.9)
Black/African American	4 (21.1)
Hispanic/Latino, White	2 (10.5)
Other or more than one race	2 (10.5)
Diagnosis	
Autism	15 (78.9)
Developmental Delay	2 (10.5)
Down Syndrome	2 (10.5)
Diagnosis made by:	
Pediatrician	11 (57.9)
Specialist	5 (26.3)
School Psychologist/Counselor	5 (26.3)
Psychologist	3 (15.8)
Other	8 (42.1)
Classroom Type	
Inclusive	4 (21.5)
Special Education	15 (78.9)
Received Early Intervention Services before age 3yrs	11 (61.1)
Currently Receive Early Intervention Services	9 (47.4)
Receive Special Education Services	12 (63.2)
Currently Receiving Therapy:	
Physical Therapy	7 (36.8)
Speech Therapy	17 (89.5)
Occupational Therapy	13 (68.4)
Other Therapy	10 (52.6)

**Table 2**  
Average kappa coefficients and interobserver percent agreement by OSRAC-DD coding category.

		Mean	SD
Physical Activity Level	Kappa	0.87	0.11
	Percent Agreement	0.91	0.08
Physical Activity Type	Kappa	0.96	0.04
	Percent Agreement	0.96	0.04
Stereotypic/Maladaptive Behavior	Kappa	0.97	0.06
	Percent Agreement	0.97	0.06
Location	Kappa	0.95	0.17
	Percent Agreement	0.99	0.03
Indoor Activity Context	Kappa	0.94	0.10
	Percent Agreement	0.94	0.10
Outdoor Activity Context	Kappa	0.99	0.04
	Percent Agreement	0.99	0.04
Activity Initiator	Kappa	0.85	0.29
	Percent Agreement	0.94	0.12
Group Composition	Kappa	0.92	0.07
	Percent Agreement	0.92	0.06
Interaction	Kappa	0.82	0.16
	Percent Agreement	0.92	0.08
Engagement	Kappa	0.89	0.08
	Percent Agreement	0.93	0.06
Prompts	Kappa	0.96	0.19
	Percent Agreement	1.00	0.01
Reactivity	Kappa	0.99	0.04
	Percent Agreement	0.99	0.04

**Table 3**  
An overview of the OSRAC-DD categories with detailed definitions for novel codes.

Category and Codes	Definition
Physical Activity Level	The level, or intensity, of physical activity on a scale of 1 (stationary) to 5 (fast, or vigorous movement). <sup>16</sup>
Physical Activity Type	The type of physical activity performed (e.g., climb, walk, run, ride, etc.) by the focal child. For a complete list of codes, please refer to Brown et al. <sup>16</sup>
Repetitive Behavior/ Stereotypy	The type of stereotypic, repetitive behavior that occurred during the observation window (i.e., motor, object, vocal, none).
Motor	Repetitive movements of the body without obvious function (e.g., hand flaps, taps surfaces, rocks or swivels, etc.). These may include self-injurious behaviors (e.g., head banging, head rubbing, hair pulling, self-biting, etc.). <sup>29,30</sup>
Object	Repetitive movements that are non-functional and involve at least one object such as a toy, ball, marker, etc. and are not teacher-directed (e.g., bangs or taps objects, rolls or manipulates objects, flips objects). <sup>29,30</sup>
Vocal	Repetitive sounds, words, or vocalizations produced by the child (e.g., echolalia). These are responses that have no apparent function and are not teacher directed. <sup>30</sup>
None	No stereotypy or repetitive behaviors are present.
Location	The geographic location of the focal child (i.e., indoors, outdoors, transitioning between spaces). <sup>16</sup>
Indoor Education/Play Context	The preschool contextual circumstances that occur indoors. This category is based on what the child is doing (i.e., art, gross motor, center time, books/preacademic, etc.) at the time of observation. For a complete list of codes, please refer to Brown et al. <sup>16</sup>
Therapy	Engaging with a therapist in speech, physical, occupational, art, or music therapy activities or engaging with resource personnel in preacademic support activities. May occur in the classroom or outside the classroom.
Outdoor/Cym Education/Play Context	The preschool contextual circumstances that occur outdoors or in a gym setting (i.e., sandbox, portable equipment, open space, ball, etc.) at the time of observation. For a complete list of codes, please refer to Brown et al. <sup>16</sup>
Therapy	Engaging with a therapist in speech, physical, occupational, art, or music therapy activities or engaging with resource personnel in preacademic support activities. May occur outdoors or in a gym setting.
Initiator of Activity	The person or people who selected the activity area or activity in which the focal child is involved (i.e., adult, child, peer, therapist). <sup>16</sup>
Peer	The activity area or the activity in which the focal child is observed was selected by a peer (e.g., during center time a peer asked the focal child to play blocks with her).
Therapist	The activity area or the activity in which the focal child is observed was selected by a therapist or resource personnel (e.g., a speech therapist takes the focal child out of the room for testing).
Group Composition	The social group (i.e., number of children and adults) who are near to or engaged with the focal child. For a complete list of codes, please refer to Brown et al. <sup>16</sup>
1-1 Therapist	Engaging in an activity or in proximity to only one or more therapists or resource personnel (i.e., no peers or other teachers).
Interaction	The verbal or non-verbal communicative exchange or joint cooperative activity between the focal child and another individual. <sup>25</sup>
None	No interaction occurred.
Physical Prompt	A child is physically being touched by a teacher, therapist, or peer in order to be facilitated or guided to the expected behavior. <sup>25</sup>
Teacher	Communicative exchange (verbal or non-verbal) or occurrence of joint, cooperative activity made by or to a teacher. <sup>25</sup>
Peer	Communicative exchange (verbal or non-verbal) or occurrence of joint, cooperative activity made by or to a peer. <sup>25</sup>
Therapist	Communicative exchange (verbal or non-verbal) or occurrence of joint, cooperative activity made by or to a therapist or resource personnel. <sup>25</sup>
Prompt for Physical Activity	The explicit behaviors of adults or children to increase, maintain, or decrease the focal child's physical activity behavior. <sup>16</sup>
Therapist Prompt to Increase	Therapist or resource personnel prompt the focal child to increase or maintain physical activity.
Therapist Prompt to Decrease	Therapist or resource personnel prompt the focal child to decrease physical activity.



are presented in Table 2. Kappa coefficients ranged from 0.82 to 0.99 indicating high levels of interrater reliability across all categories.

Preschoolers with developmental disabilities spent 77.7% of the time in sedentary behavior and engaged in MVPA 4.0% of the time during preschool hours (Table 4). The most frequently observed types of physical activities were sitting/squatting (51.6%) and standing (20.2%), followed by walking (16.7%). Preschoolers spent 85.8% of the time in an indoor education or play context and most of this time was sedentary (84.2%). The most frequently occurring indoor play and educational contexts were group time (19.3%), transition (12.3%), and therapy (10.3%), all of which were mostly sedentary. When in the outdoor or gym environments (10% of the time), children engaged in primarily sedentary (42.5%) or light (41.0%) activities. The most frequently occurring outdoor or gym contexts were open space (8.8%), fixed equipment (3.5%), and ball play (1.3%). Adults initiated activities 49.8% of the time and preschoolers spent most of the time in a group setting with an adult (41.9%) or among a group of peers (16.4%). Within the social group settings, there were no observed interactions during 60.1% of the observation intervals. Prompts to increase physical activity occurred less than 1% of the time.

## Discussion

The primary finding of this study was that the OSRAC-DD is a reliable instrument for assessing the physical activity behaviors and preschool contexts among children with developmental disabilities. There was high inter-rater reliability among all OSRAC-DD coding categories. These results are comparable to those of other direct observation instruments for typically developing preschoolers.<sup>11,16</sup> Brown et al. similarly reported high levels of agreement for all OSRAC-P categories with lower levels observed in the Group Composition, Physical Activity Level, and Initiator categories.<sup>16</sup> In both studies, disagreements between observers in the Physical Activity Level category often occurred between levels 1 (stationary) and 2 (stationary with limb movement), however this was not concerning as these levels are aggregated to determine overall sedentary behavior. As was the case in the Brown et al. study, disagreements in the Initiator category were often the result of missed contextual indicators about who initiated the activity (e.g., who initiated a game of tag), and the same code was recorded across multiple observation intervals.<sup>16</sup> Lastly, levels of agreement in the Interaction category were higher than reported in other studies (kappa = 0.73–0.79).<sup>23,24</sup>

Consistent with other studies of children with and without disabilities, participants were primarily sedentary during the school day.<sup>13,16,26</sup> While both the OSRAC-P and BEACHES provide rich contextual information about physical activity and environmental contexts, neither instrument allows for the recording of additional contexts that are relevant to children with developmental disabilities (e.g., repetitive/stereotypic behaviors, therapy, interactions with therapists). Extensive efforts were taken to identify these important contexts and establish content validity through several literature reviews, discussions with special education preschool directors and therapists, and classroom observations. As such, the OSRAC-DD has considerable advantages over other instruments to assess physical activity among preschoolers with developmental disabilities. Some researchers have hypothesized that the repetitive and stereotypic behaviors often demonstrated by young children with disabilities may contribute to overall physical activity levels<sup>20,27,28</sup> but this has yet to be investigated. Linking the OSRAC-DD physical activity intensity data with that of stereotypic behavior occurrences may help to explore these questions. Additionally, evidence suggests that the social

environment may influence physical activity levels in certain settings<sup>17</sup> and the addition of the Interaction category in the OSRAC-DD will allow for this relationship to be further investigated.

There are several strengths and limitations of the present study. The categories and codes contained in the OSRAC-DD allow for rich, descriptive recording of physical activity behaviors and the contexts during which they occur in inclusive and special education settings. Codes are specific to preschool settings and include relevant contexts for children with developmental disabilities (e.g., repetitive behavior/stereotypy, therapy contexts, interaction with peers or adults). Next, the broad categories and codes within the OSRAC-DD are appropriate for use in both special education and inclusive preschool classrooms, which allows for simultaneous study of physical activity of children with and without developmental disabilities. However, limitations of the instrument should be considered. First, although the physical activity codes used in the OSRAC-DD have been validated for typically developing children,<sup>14</sup> they have only been validated among a small sample of children with intellectual disabilities ( $n = 11$ ;  $r = 0.61$ ).<sup>15</sup> Most participants in our sample had an autism diagnosis and children with other developmental disabilities were largely underrepresented. Future studies should replicate this study and validate physical activity codes with objective measures (e.g., accelerometers) among a larger and more diverse sample of children with disabilities. Another limitation of the OSRAC-DD is that due to the nature of the 5-s observe, 25-s record observation intervals, it provides an estimate and not a direct measure of time spent in physical activity. Next, as with many direct observation systems, the OSRAC-DD is very time- and resource-intensive. In order to establish high levels of reliability, observers spent a considerable amount of time studying the OSRAC-DD manual and conducting field observations in inclusive and special education classrooms. Lastly, observers were unable to be blinded to reliability assessments because audio prompts were delivered using split headphones to ensure simultaneity of observations.

## Conclusions

The OSRAC-DD is a reliable observational instrument which contextualizes physical activity behaviors of preschoolers with developmental disabilities. Observers simultaneously record levels of children's physical activity on a 1 to 5 scale, type of physical activity, repetitive and/or stereotypical behaviors, and the physical (i.e., location, indoor and outdoor contexts) and social environments (i.e., activity initiator, group composition, interaction, physical activity prompts) in which physical activity takes place. This instrument allows for unique insights into the physical activity behaviors of preschoolers with developmental disabilities and can be used in comparative studies between children with and without disabilities. Further, it has the potential to be used for intervention evaluation as well as observational studies that aim to identify social and physical environmental correlates of physical activity among populations with developmental disabilities. Identifying these correlates can aid in the development of more inclusive physical activity practices in preschool settings, resulting in significant health and developmental benefits for children with developmental disabilities.

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**Table 4**  
Observed OSRAC-DD codes and percentages of intervals by activity level.

Percentage of Intervals Categories, Observed Codes	Observed Intervals	Sedentary	Light	MVPA
Total Observed Intervals	5393	77.7	18.2	4.0
<b>Location</b>				
Inside	4617	84.2	13.3	2.5
Outside	546	42.5	41.0	16.5
Transition	230	30.9	63.9	5.2
<b>Physical Activity Type</b>				
Sit/Squat	2880	99.9	0.1	0.0
Stand	1132	99.5	0.5	0.0
Walk	934	0.5	94.2	5.2
Lie Down	122	100.0	0.0	0.0
Run	113	0.0	0.0	100.0
Jump/Skip	72	1.4	36.1	62.5
Ride	31	6.5	67.7	25.8
Climb	21	4.8	95.2	0.0
Crawl	21	33.3	66.7	0.0
Pull/Push	17	35.3	11.8	52.9
Throw	17	76.5	17.6	5.9
Swing	14	100.0	0.0	0.0
Dance	11	36.4	63.6	0.0
<b>Repetitive/Stereotypic Behavior</b>				
None	5205	77.9	18.4	3.7
Object	73	84.9	12.3	2.7
Motor	66	48.5	16.7	34.8
Vocal	46	82.6	17.4	0.0
<b>Indoor Education/Play Contexts</b>				
Group Time	1036	95.2	3.5	1.4
Transition	662	60.6	37.3	2.1
Therapy	556	90.8	9.0	0.2
Manipulative	496	84.7	11.3	4.0
Books/preacademic	464	90.1	9.7	0.2
Videos	323	98.5	1.5	0.0
Snacks	299	98.3	1.7	0.0
Art	154	92.9	6.5	0.6
Sociodramatic	108	88.0	10.2	1.9
Self Care	86	74.4	24.4	1.2
Time Out	47	100.0	0.0	0.0
Large Blocks	26	46.2	42.3	11.5
<b>Outdoor/Gym Education/Play Contexts</b>				
Open Space	475	34.5	42.7	22.7
Fixed	191	53.4	35.1	11.5
Ball	69	44.9	37.7	17.4
Portable	51	58.8	41.2	0.0
Wheel	41	26.8	53.7	19.5
Sandbox	29	86.2	13.8	0.0
Time Out	18	94.4	5.6	0.0
<b>Activity Initiator</b>				
Adult Initiated	2735	85.3	13.2	1.5
Child Initiated	2056	66.1	25.8	8.1
Therapist Initiated	574	85.2	14.6	0.2
Peer Initiated	28	39.3	32.1	28.6
<b>Group Composition</b>				
Group Adult	2348	82.6	14.9	2.5
Group Peer	908	71.9	20.8	7.3
Solitary	715	70.5	22.7	6.9
1-1 Adult	577	74.4	22.5	3.1
1-1 Peer	557	76.7	18.7	4.7
1-1 Therapist	288	82.6	17.0	0.3
<b>Interaction</b>				
No Interaction	3337	79.2	17.3	3.5
Interaction with Adult	712	73.6	24.0	2.4
Interaction with Group	545	76.1	16.1	7.7
Interaction with Peer	486	72.8	18.7	8.4
Interaction with Therapist	312	81.4	17.9	0.6
<b>Engagement</b>				
Active Engagement	3301	69.4	24.8	5.8
Passive Engagement	1194	97.9	1.9	0.2
Passive Non-Engagement	361	98.6	1.4	0.0
Active Non-Engagement	340	72.6	22.1	5.3
Physical Prompt	197	65.0	32.5	2.5
<b>Prompts</b>				
No Prompt	5354	77.9	18.2	3.9
Teacher Prompt - Increase	21	66.7	14.3	19.0
Teacher - Prompt Decrease	10	50.0	20.0	30.0
Therapist Prompt - Increase	6	33.3	66.7	0.0

Table 4 (continued)

Peer Prompt - Increase	1	0.0	0.0	100.0
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## Declaration of competing interest

The authors have no conflicts of interest to declare.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dhjo.2020.101008>.

## References

1. *Physical Activity Guidelines for Americans*. second ed. U.S. Department of Health and Human Services; 2018. [https://health.gov/paguidelines/second-edition/pdf/Physical\\_Activity\\_Guidelines\\_2nd\\_edition.pdf](https://health.gov/paguidelines/second-edition/pdf/Physical_Activity_Guidelines_2nd_edition.pdf).
2. Pate RR, O'Neill JR, Brown WH, Pfeiffer KA, Dowda M, Addy CL. Prevalence of compliance with a new physical activity guideline for preschool-age children. *Child Obes*. 2015;11(4):415–420. <https://doi.org/10.1089/chi.2014.0143>.
3. Carlon SL, Taylor NF, Dodd KJ, Shields N. Differences in habitual physical activity levels of young people with cerebral palsy and their typically developing peers: a systematic review. *Disabil Rehabil*. 2013;35(8):647–655. <https://doi.org/10.3109/09638288.2012.715721>.
4. Einarsson Ip, Á Ólafsson, Hinriksdóttir G, Jóhannsson E, Daly D, Arngrímsson SA. Differences in physical activity among youth with and without intellectual disability. *Med Sci Sports Exerc*. 2015;47(2):411–418. <https://doi.org/10.1249/MSS.0000000000000412>.
5. Pan C-Y, Frey GC. Physical activity patterns in youth with autism spectrum disorders. *J Autism Dev Disord*. 2006;36(5):597–606. <https://doi.org/10.1007/s10803-006-0101-6>.
6. Shevell MI. Present conceptualization of early childhood neurodevelopmental disabilities. *J Child Neurol*. 2010;25(1):120–126. <https://doi.org/10.1177/0883073809336122>.
7. Brown WH, Schenkelberg MA, McIver KL, et al. Physical activity and preschool children with and without developmental delays: a national health challenge. In: *Handbook of Early Childhood Special Education*. Springer International Publishing; 2016:487–500.
8. Hinckson EA, Curtis A. Measuring physical activity in children and youth living with intellectual disabilities: a systematic review. *Res Dev Disabil*. 2013;34(1):72–86. <https://doi.org/10.1016/j.ridd.2012.07.022>.
9. Jones RA, Downing K, Rinehart NJ, et al. Physical activity, sedentary behavior and their correlates in children with Autism Spectrum Disorder: a systematic review. *PLoS One*. 2017;12(2), e0172482. <https://doi.org/10.1371/journal.pone.0172482>.
10. Sirard JR, Pate RR. Physical activity assessment in children and adolescents. *Sports Med*. 2001;31(6):439–454.
11. McKenzie TL, Sallis JF, Nader PR, et al. BEACHES: an observational system for assessing children's eating and physical activity behaviors and associated events. *Appl Behav Anal*. 1991;24(1):141–151.
12. Li R, Sit C, Yu J, et al. Children with physical disabilities at school and home: physical activity and contextual characteristics. *Int J Environ Res Publ Health*. 2017;14(7):687. <https://doi.org/10.3390/ijerph14070687>.
13. Sit C, Capio C, Cerin E, McKenzie T. Assessment of measures of physical activity of children with cerebral palsy at home and school: a pilot study. *Journal of Child and Adolescent Behaviour*. 2013. <https://doi.org/10.4172/2375-4494.1000112>, 01(03).
14. Puhl J, Greaves K, Hoyt M, Baranowski T. Children's activity rating scale (CARS): description and calibration. *Res Q Exerc Sport*. 1990;61(1):26–36. <https://doi.org/10.1080/02701367.1990.10607475>.
15. Taylor CA, Yun J. Psychometric Properties of Two Systematic Observation Techniques for Assessing Physical Activity Levels in Children with Mental Retardation. 2006. <https://doi.org/10.1123/pes.18.4.446>.
16. Brown WH, Pfeiffer KA, McIver KL, Dowda M, Almeida MJCA, Pate RR. Assessing preschool children's physical activity: the Observational System for Recording Physical Activity in children-preschool version. *Res Q Exerc Sport*. 2006;77(2):167–176. <https://doi.org/10.1080/02701367.2006.10599351>.
17. Schenkelberg MA, Rosenkranz RR, Milliken GA, Dzewaltowski DA. Social environmental influences on physical activity of children with autism spectrum disorders. *J Phys Activ Health*. 2015;12(5):636–641. <https://doi.org/10.1123/jpah.2013-0312>.
18. Snyder T, de Brey C, Dillow S. *Digest of Education Statistics 2015 (NCES 2016-014)*. National Center for Education Statistics, Institute of Education Sciences; 2016.
19. Diggs T, Edora F, Flanagan S, May J. *Report Summarizing Services provided under the Individuals with Disabilities Education Act (IDEA) to Preschool Children with Disabilities 2015-16 School Year*. Office of Special Education Services, South Carolina Department of Education; 2017:1–94. <http://ed.sc.gov/districts-schools/special-education-services/programs-and-initiatives-p-i/preschool/>.
20. Ketcheson L, Hauck JL, Ulrich D. The levels of physical activity and motor skills in young children with and without autism spectrum disorder, aged 2–5 years. *Autism*. 2018;22(4):414–423. <https://doi.org/10.1177/1362361316683889>.
21. Kishida Y, Kemp C. The engagement and interaction of children with autism spectrum disorder in segregated and inclusive early childhood center-based settings. *Top Early Child Spec Educ*. 2009;29(2):105–118. <https://doi.org/10.1177/0271121408329172>.
22. 2009- 2010 National survey of children with special health care needs. Published online [http://www.cdc.gov/nchs/data/slaits/NS\\_CSHCN\\_Questionnaire\\_09\\_10.pdf](http://www.cdc.gov/nchs/data/slaits/NS_CSHCN_Questionnaire_09_10.pdf); 2011. Accessed January 31, 2020.
23. Tapp J, Wehby J, Ellis D. A multiple option observation system for experimental studies: MOOSE. Published March <https://link.springer.com/article/10.3758/BF03203616>; 1995. Accessed June 14, 2019.
24. Kemp C, Kishida Y, Carter M, Sweller N. The effect of activity type on the engagement and interaction of young children with disabilities in inclusive childcare settings. *Early Child Res Q*. 2013;28(1):134–143. <https://doi.org/10.1016/j.ecresq.2012.03.003>.
25. Kishida Y, Kemp C, Carter M. Revision and validation of the Individual Child Engagement Record: a practitioner-friendly measure of learning opportunities for children with disabilities in early childhood settings. *J Intellect Dev Disabil*. 2008;33(2):158–170. <https://doi.org/10.1080/13668250802088085>.
26. Sit CHP, McKenzie TL, Cerin E, Chow BC, Huang WY, Yu J. Physical activity and sedentary time among children with disabilities at school. *Med Sci Sports Exerc*. 2017;49(2):292–297. <https://doi.org/10.1249/MSS.0000000000001097>.
27. Bandini LG, Gleason J, Curtin C, et al. Comparison of physical activity between children with autism spectrum disorders and typically developing children. *Autism*. 2013;17(1):44–54. <https://doi.org/10.1177/1362361312437416>.
28. Pan C-Y. Objectively measured physical activity between children with autism spectrum disorders and children without disabilities during inclusive recess settings in Taiwan. *J Autism Dev Disord*. 2008;38(7):1292–1301. <https://doi.org/10.1007/s10803-007-0518-6>.
29. Watt N, Wetherby AM, Barber A, Morgan L. Repetitive and stereotyped behaviors in children with autism spectrum disorders in the second year of life. *J Autism Dev Disord*. 2008;38(8):1518–1533. <https://doi.org/10.1007/s10803-007-0532-8>.
30. Cunningham AB, Schreibman L. Stereotypy in autism: the importance of function. *Res in Autism Spectr Disord*. 2008;2(3):469–479. <https://doi.org/10.1016/j.rasd.2007.09.006>.