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Comparison of Exergaming and Adaptive Physical Education on Physical Activity, On-task Behavior, and Communication in Children with Autism Spectrum Disorder

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Abstract

This study compared objectively-assessed physical activity (PA), on-task behavior, and communication during adaptive physical education (AdPE) and exergaming sessions in children with autism spectrum disorder (ASD). In Spring 2016, five boys with diagnosed ASD in the U.S. (all African American; $\bar{M}$age=6.8±2.1 years) participated in a mixed methods 3-week observational study. Observations were conducted during one AdPE and one exergaming session each week for three consecutive weeks (six total). Accelerometry tracked PA while direct observation assessed on-task behavior and communication between teachers/aides and children. Teachers/aides completed open-ended surveys regarding the facilitators and barriers of our main outcomes during AdPE and exergaming. Compared to AdPE, exergaming had higher moderate-to-vigorous PA duration (16.9 vs. 12.2 min., respectively), but lower durations of light PA (10.8 vs. 13.0 min., respectively) and sedentary behavior (22.3 vs. 24.7 min., respectively). Greater percentages of on-task behavior and communication were seen during AdPE (93.0% and 34.0%, respectively) vs. exergaming (67.0% and 16.1%, respectively). Space allocation/size were barriers during both PA sessions. Observations indicated that AdPE was superior in promoting on-task behavior/communication compared to exergaming. As on-task behavior/communication is vital to promote in children with ASD, exergaming programs in this population are cautioned.

Key words: developmental disorders, pediatrics, active video gaming, accelerometers, direct observation

Résumé

Cette étude a comparé une évaluation objective de l'activité physique (AP), des comportements sur la tâche et de la communication durant des sessions d'éducation physique adaptée (EPad) et de jeux vidéos actifs avec des enfants présentant des troubles autistiques (TA). Durant l'été 2016, cinq garçons diagnostiqués avec des TA aux États-Unis (tous africain-américain; $\bar{M}_{age}$=6.8±2.1 ans) ont participé à une étude observationnelle de trois semaines mobilisant des méthodes mixtes. Les observations ont été conduites durant une session d'EPad et une session de jeux vidéos actifs chaque semaine pendant trois semaines consécutives (c'est-à-dire au total trois sessions d'EPad et trois sessions de jeux vidéos actifs). L'AP a été mesurée par accélérométrie tandis que des observations directes ont évalué les comportements sur la tâche ainsi que la communication entre les enseignants/aides et les enfants. Les enseignants/aides ont complété des enquêtes à base de questions ouvertes au sujet des facilitateurs et des barrières à ces trois variables durant l'EPad et les jeux vidéos actifs. Comparé à l'EPad, les jeux vidéos actifs présentent un temps d'AP modéré à vigoureux plus long (16.9 contre 12.2 min respectivement) mais des temps plus faibles d'AP légère (10.8 contre 13.0 min respectivement) et de comportements sédentaires (22.3 contre 24.7 respectivement). De plus grands pourcentages de comportements sur la tâche et de communication ont été observés durant l'EPad (93.0% and 34.0% respectivement) en comparaison aux jeux vidéos actifs (67.0% and 16.1% respectivement). Les observations ont montré que l'EPad était supérieure pour promouvoir des comportements sur la tâche et de la communication en comparaison avec les jeux vidéos actifs. Dans la mesure où les comportements sur la tâche et la communication sont vitaux pour les enfants atteints de TA, les programmes de jeux vidéos actifs sont à prendre avec précaution avec cette population.

Mots-clés : troubles développementaux, pédiatrie, jeux vidéos actifs, accéléromètres, observations directes

1. Introduction

Overweight and obesity are of public health concern for children (Ogden & al., 2014)—particularly children of minority race/ethnicity (Ogden & al., 2010)—necessitating effective and novel physical activity (PA) and health interventions (Nemet & al., 2005; Simon & al., 2004). For segments of the youth population with intellectual or physical disabilities,

however, the preceding childhood overweight and obesity concerns can be negatively compounded. Indeed, the lack of opportunity for, or capability of, youth with intellectual or physical disabilities to participate in PA often yields health outcomes that are worse than typically-developing children (Grondhuis & Aman, 2014).

Approximately 1 in 59 children have autism spectrum disorder in the U.S. (ASD; Baio & al., 2018), a pervasive developmental disorder (American Psychiatric Association, 2013; Auxter & al., 2010). Frequently, individuals with ASD engage in repetitive behaviors (e.g., flapping of hands, echolalia), demonstrate decreased social interaction/communication, engage in rigid, unchanging behaviors and schedules, and are over- or under-responsive to environmental stimuli. As many children with ASD exhibit lower intellectual capacity (American Psychiatric Association, 2013; Auxter &t al., 2010) and motor skill functioning than their age- and gender-matched typically-developing peers (MacDonald & al., 2013; MacDonald & al., 2014), promoting health-enhancing PA among children with ASD is challenging. These difficulties have resulted in higher risks and rates of overweight and obesity in children and adolescents with ASD compared to typically-developing youth (Srinivasa & al., 2014; Curtin & al., 2010). Overweight and obesity during childhood and adolescence increases risk of premature mortality and cardiometabolic diseases in adulthood (Reilly & Kelly, 2011). Concerted efforts, therefore, must be made to objectively examine potential PA opportunities for children with ASD during utilization of innovative PA options among this population compared to traditional PA programs (e.g., adaptive physical education [AdPE]).

Building upon traditional PA options commonly employed among children with ASD, including bicycle riding (MacDonald & al., 2011; Todd & al., 2010), treadmill walking (Pitetti & al., 2007), and aquatics programs (Lee & Porretta, 2013; Prupas & al., 2006), exergaming (i.e., active video games requiring PA engagement) has shown promise among this population. Research has shown exergaming to stimulate greater attention (measured via gaze duration/time-on-task behaviors) and elicit improved communication (measured via vocal utterances) in children with ASD (Mineo & al., 2009). Studies have also indicated that exergaming has acute effects for reducing repetitive behaviors and improving measures of cognitive functioning among this population (Anderson-Hanley & al., 2011). Finally, literature has noted that exergaming can significantly improve motor skills and agility in children with ASD (Hilton & al., 2014).

Despite the positive results of this small group of studies, three limitations exist. First, previous exergaming studies focused solely on cognitive functioning, motor skills, and

disruptive behaviors in children with ASD, with no known study examining PA levels via objective instruments. Second, these studies did not compare an exergaming session with another PA session, such as an AdPE class, to discern each PA session's PA participation levels, on-task behavior, and/or communication. Evaluation of communication and on-task behavior are important behaviors to consider during any activity employed in children with ASD. These behaviors represent important components of the individual educational plans (IEPs) developed for all children with ASD and are behaviors sought for promotion in AdPE programs (Autism Society, 2016). Thus, if novel PA programs like exergaming are employed among children with ASD, these PA programs need to be evaluated to ensure they are also providing behavioral benefit in this population. Finally, no known study has interviewed teachers/aides of children with ASD to examine these individuals' perception of facilitators and barriers for health promotion which might be present when children with ASD participate in different types of PA sessions (e.g., AdPE or exergaming).

Given the preceding limitations, this observational study sought to answer the following research questions among children with ASD within an urban school setting: (1) Is a difference present in objectively-assessed PA participation, on-task behavior, and communication between exergaming and AdPE sessions?; (2) How much PA do children with ASD participate in during exergaming and AdPE sessions and is this PA of sufficient duration/intensity to improve health (Pescatello & al., 2013; U.S. Department of Health and Human Services, 2018)?; and (3) What factors facilitate/inhibit PA, on-task behavior, and communication among children with ASD within exergaming and AdPE environments? This study is novel in that: (1) this investigation represents the first known study to objectively assess PA (via accelerometry), on-task behavior, and communication concurrently among children with ASD and compare these outcomes between exergaming and AdPE sessions; and (2) this study gathered qualitative information from teachers/aides working with these children regarding the factors which promote and/or hinder physical and psychological development during participation in exergaming or AdPE. Study observations may provide evidence regarding how well an innovative technology-based approach to increasing PA among children with ASD (i.e., exergaming) performs relative to AdPE with respect to the promotion of important physical and behavioral outcomes—data needed to inform the practicality and potential planning and implementation of exergaming on a larger scale among this population.

2. Method

We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines when drafting this manuscript (von Elm & al., 2007).

2.1 Participants and research setting

Five male students with ASD (all African American; $\bar{M}_{age}$= 6.8±2.1 years; age range= 5.5-10.5 years) and no comorbid conditions participated in this mixed methods 3-week observational study of pre-existing AdPE and exergaming programs in Spring 2016. Inclusion criteria included: (1) enrollment in special education; (2) official ASD diagnosis per school records and teacher/aide confirmation; and (3) provided parental consent and personal assent to participate. Exclusion criteria were: (1) inability to participate in PA due to medical condition(s); and (2) student or student's parents/legal guardian declined the child's participation in the study. Students were enrolled at a Title-I public elementary school (U.S. Department of Education, 2015; i.e., ≥ 50% of children receive free or reduced-price meals) in southeastern Minneapolis, MN. The school was comprised of approximately 75% minority students, with most students—regardless of race/ethnicity—of low socioeconomic status. While the race/ethnicity distribution of this school does not well represent the race/ethnicity distribution of most Minnesota schools, Minnesota has among the largest Somali population in the U.S. (Dunbar, 2010), with many Somalis living in the greater Twin Cities area. The study school serves a large percentage of this population's children in the southeast area of Minneapolis—explaining the high-percentage minority population of the school and sample. Notably, all children within the sample were enrolled in Federal Setting 3 special education meaning ≥ 61% of the children's school day was spent in a special education setting and that each child had an individual educational plan (IEP; Minnesota Department of Human Services, 2017). Importantly, no typically-developing children were included in the sample. Multiple attempts were made to acquire each child's IQ and comorbidity information to provide individual-level data on these metrics. Yet, the U.S. political climate at the time of the study—perceived as unfavorable to Somali and other minority populations—resulted in parents' reluctance to release this information. A decision was made, therefore, to respect the parents' wishes and not push for the release of this information. All procedures were approved by the University of Minnesota's Institutional Review Board and school district administrators. Parental consent and child assent were obtained before data collection commenced.

2.2 Measures

2.2.1 Physical activity

Actigraph GT3X accelerometers (Actigraph LLC, Pensacola, FL) assessed children's PA participation during the exergaming and AdPE sessions. Studies have indicated these accelerometers as valid and reliable in PA assessment among children (Evenson & al., 2008) and have been used to evaluate PA during exergaming in previous literature (Huang & Gao, 2013). Children wore accelerometers around the waist above the right hip. Accelerometers were placed on the children before each 50-minute PA session and removed after class. The main outcome variables were children's time spent in sedentary behavior (SB), light PA (LPA), and moderate-to-vigorous PA (MVPA).

2.2.2 On-task behavior and communication

Direct observation evaluated on-task behavior and communication akin to methods used by Gao and associates (2016), with direct observation procedures and coding available in Supplemental File 1. Specifically, we used a whole interval recording method (Jarrett et al., 1998). Observations of individual children were conducted in a predetermined order by two trained observers (XX, XX) for 5 seconds, with the following 5 seconds used to record the observed child's behavior. Each child was observed for one minute, with observation intervals tracked via a prerecorded audio tape. These procedures were carried out during the entirety of the 50-minute exergaming and AdPE sessions and are explained are explained more fully in the "Procedures" subsection below as well as Supplementary File 1. Any behavior wherein the child was actively participating in the teacher-assigned activity or was attentive to the teacher and/or activity was considered on-task behavior (Gao & al., 2016, Grieco & al., 2009). All other behaviors were considered off-task (e.g., gazing off, sitting and not participating in/attentive to the activity, playing with other students when not assigned/arranged by teachers, leaving activity without permission). For each child, the number of intervals the child was deemed on-task was divided by the total number of intervals observed to yield a percentage of on-task behavior during exergaming and AdPE sessions. Communication was evaluated concurrently with on-task behavior. As some of the children had speech difficulties, communication was evaluated only as any vocal utterance a child made when attempting to communicate with a teacher/aide while on task *and* when making eye contact with the teacher/aide. We therefore recorded all intervals during which the child made any vocal utterance. Following the 50-minute observation

period, we examined whether a given vocal utterance was made when the child was on- or off-task, with all off-task vocal utterances excluded from analyses and all on-task vocal utterances made *without* eye contact with a teacher/aide excluded as well. After completing the preceding vetting process, the same method used to calculate percentage of on-task behavior was employed to calculate percentage of communication during the exergaming and AdPE sessions (i.e., number of intervals the child was deemed as making a valid vocal utterance while on task divided by the total number of intervals). These detailed procedures were employed as we believed it important to examine whether exergaming was able to promote communication and on-task behavior to the same degree as AdPE—providing clinicians/researchers the ability to make a more informed decision as to the efficacy of including exergaming as part of the special education curriculum. Prior to completing any direct observation sessions, two hour-long training sessions were held that included detailed discussions of coding procedures, role play, and video analysis. We then participated in two weeks of trial observations at the target school. This allowed us to become proficient in direct observation procedures while also allowing children to get used to our presence—reducing potential reactivity bias among children. Following each trial observation, we discussed coding discrepancies, with clarifications made to improve coding accuracy and agreement—congruent with other studies employing direct observation (Gao & al., 2016; Grieco & al., 2009; Mahar & al., 2006). Interobserver agreement (IOA) was calculated after each session, with greater than 90% agreement between observers sought.

2.2.3 Teacher/Aide survey

An anonymous open-ended electronic survey was sent via Qualtrics (Qualtrics Inc., Provo, UT) to the four teachers/aides of the children. Questions asked teachers/aides to report factors within the exergaming or AdPE environment they believed facilitated or hindered children with ASD in engaging in PA, on-task behavior, and communication as well as what they believed to be the ideal exergaming and AdPE environments. The questions included on the survey are available in Table 1. Responses were then thematically analyzed using procedures advocated for by Cresswell (2007). Briefly, we independently coded the survey responses for major and minor themes after which a meeting was held and coding compared. Discrepancies between coding were resolved via consultation with another researcher (XX).

Table I: Teacher/Aide facilitators and barriers survey

Question No.	Question Posed
1	What factors in the exergaming environment do you see as helping to facilitate physical activity participation as well as improved on task behavior and communication among children with ASD?
2	What factors in the physical education environment do you see as helping to facilitate physical activity participation as well as improved on task behavior and communication among children with ASD?
3	What factors in the exergaming environment do you see as acting as a barrier physical activity participation as well as improved on task behavior and communication among children with ASD?
4	What factors in the physical education environment do you see as acting as a barrier physical activity participation as well as improved on task behavior and communication among children with ASD?
5	If you could describe the ideal exergaming environment for children with ASD to participate in physical activity while also learning how to engage in greater amounts of on-task behavior and communication, what would this environment look like?
6	If you could describe the ideal physical education environment for children with ASD to participate in physical activity while also learning how to engage in greater amounts of on-task behavior and communication, what would this environment look like?

2.3 Procedures

Each child was observed participating in three sessions of exergaming and AdPE each (i.e., six total), with all children within the same class and participating simultaneously in the exergaming and AdPE sessions. AdPE sessions were held Monday through Thursday from 1:35pm to 2:25pm while exergaming sessions were held on Friday from 1:35pm to 2:25pm. Therefore, we observed AdPE on Wednesdays of each week and exergaming on Fridays of each week. This occurred over a three-week span, with the consistency of the observations on the same dates and times each week becoming part of the children's routine and expectations. Notably, the children had been participating in the exergaming program for approximately eight months prior to inclusion in the study, with all children having been enrolled in AdPE at least as long as they had been participating in exergaming. During all

PA sessions, we placed accelerometers on the children upon arrival to the session and collected the accelerometers following each session. Data from accelerometers was downloaded and saved immediately after each session for later analysis. Regarding direct observation procedures, we selected a predetermined order in which the children would be observed prior to each session and synchronized audio players used to provide “observe”, “record”, and “switch children” cues. In detail, we were cued by the audio file to “observe” the selected child for five seconds after which we would “record” the child’s behavior for five seconds. This pattern was repeated five more times (i.e., a total of 60 seconds or 6 cycles). After one minute, the audio file would directed us to “switch children” at which point we would shift our attention to observing the next child on the predetermined list. We conducted these observations at a location within the room which offered an unobstructed view of the children, but was out of the way of each session’s activities.

Exergaming sessions were held in a 20-foot long by 20-foot wide (see Figure 1) section of a modified classroom housing eight Wii stations. Children had the autonomy to pick from several games including Wii Sports and Wii Just Dance Kids. Wii Sports allowed participants to play five different sports (i.e., tennis, baseball, golf, bowling, boxing). Wii Just Dance Kids included age-appropriate songs popular with children to which they danced. Both games required children’s full body movement tracked via the Wii remote. Better game performance was associated with greater movement precision. However, teachers/aides did not emphasize game performance, and instead strove to allow the children to have fun. Indeed, getting the children to have fun and be active was the overall objective of the exergaming program, with additional objectives being: (1) to require children to communicate with the teachers/aides the assistance they needed during gameplay (i.e., promotion of

communication); and (2) to require children to stay concentrated on gameplay throughout the session (i.e., promotion of on-task behavior). Teachers/aides assisted children in the setup of the games after which children typically played the game for the session's duration. It is noteworthy that two to three children per session played exergames while bouncing on a trampoline to promote greater attentiveness to the exergames. Children were selected to participate in exergaming while bouncing on a trampoline based upon teacher/aide assessment of each child's behavior and, specifically, the child's difficulty paying attention on any given day.

AdPE was held in a medium-sized 70-foot long by 52-foot wide gymnasium. The equipment used during AdPE included tricycles, scooters, a parachute, rubber balls, basketballs, and a large foam-matted cylinder. The first 10 minutes of AdPE sessions began with children and teachers/aides using the parachute to catapult different balls and toys into the air after which teachers/aides would provide the children with their choice of equipment/games to play for the remainder of the session. Importantly, while children had their choice of equipment/games, teachers at the study school had two objectives with these games—reflective of the larger overall AdPE program mission. First, teachers/aides desired to promote increased PA among children using equipment the children found most interesting and appealing. Second, teachers/aides sought to engage children in games and activities that require cooperation and some communication between children or between teachers and children. During the exergaming and AdPE sessions, the teacher/aide to student ratio averaged 1:1 or 1:2. Finally, open-ended surveys were sent electronically via Qualtrics to the children's teachers/aides with instructions to provide as detailed information as possible regarding the survey's questions. These answers were downloaded, coded, and analyzed for major and minor themes.

2.4 Data analyses

Accelerometry data were used to calculate average minutes spent in SB, LPA, and MVPA during each session, with direct observation data used to calculate percentage of time engaged in on-task behavior and communication. Given the small sample size, data were only analyzed descriptively via calculation of frequencies, means, and standard deviations using SPSS 23.0 (IBM Inc., Armonk, NY). Finally, previously described thematic analyses were reported in aggregate based on the common major and minor themes identified by researchers when analyzing teacher/aide survey responses.

3. Results

While seven children were recruited, two eligible children's parents did not consent to their child's participation in the study, resulting in a sample size of five students (71.4% of eligible sample). Of note, one of the two children not receiving consent to participate was a female, so no girls were included in this study.

3.1 PA, on-task behavior, and communication

Table 2 lists all summary statistics for PA, on-task behavior, and communication during exergaming and AdPE sessions, while table 3 separates PA results by participant.

Table II : Descriptives for PA, On-Task Behavior, and Communication during Exergaming and AdPE

	Exergaming	AdPE
Moderate-to-Vigorous PA (min.)	16.9 ± 7.5 (*6.7 – 27.7*)	12.2 ± 6.6 (*5.4 – 30.3*)
Light PA (min.)	10.8 ± 2.8 (*6.1 – 14.3*)	13.0 ± 2.4 (*7.9 – 16.0*)
Sedentary Behavior (min.)	22.3 ± 6.9 (*12.3 – 33.2*)	24.7 ± 5.1 (*11.8 – 32.2*)
On-Task Behavior (%)	67.0 ± 8.9 (*58.3 – 78.3*)	93.0 ± 6.2 (*85.4 – 100.0*)
Communication (%)	16.1 ± 10.1 (*6.7 – 26.7*)	34.0 ± 11.8 (*18.4 – 45.8*)

Note : Values are average ± standard deviation, with range located in *italicized* parenthetical statements; AdPE = Adaptive Physical Education; PA = Physical Activity.

Table III : Duration of Sedentary Behavior, Light PA, and Moderate-to-Vigorous PA by Participant during Exergaming and AdPE

*All duration values are average ± standard deviation.

Note : PA = Physical Activity; AdPE = Adaptive Physical Education

	Session	Sedentary Behavior Duration (min.)*	Light PA Duration (min.)*	Moderate-to-Vigorous PA Duration (min.)*
Participant #1	*Exergaming*	16.5 ± 3.9	10.8 ± 0.8	22.7 ± 4.8
	AdPE	27.0 ± 5.0	11.8 ± 0.6	11.2 ± 5.4
Participant #2	*Exergaming*	33.0 ± 0.2	9.7 ± 0.5	7.4 ± 0.7
	AdPE	27.2 ± 0.6	15.1 ± 0.5	7.7 ± 1.1
Participant #3	*Exergaming*	27.6 ± 1.4	13.5 ± 1.0	8.9 ± 0.4
	AdPE	26.9 ± 1.9	13.9 ± 1.5	9.2 ± 1.4
Participant #4	*Exergaming*	17.8 ± 4.0	13.7 ± 0.7	18.5 ± 4.1
	AdPE	25.7 ± 3.2	13.9 ± 1.8	10.3 ± 2.3
Participant #5	*Exergaming*	19.6 ± 3.2	6.6 ± 0.5	23.8 ± 3.7
	AdPE	16.7 ± 4.2	10.4 ± 3.5	22.9 ± 6.9

Overall, results indicated differences between exergaming and AdPE for MVPA, with smaller differences between exergaming and AdPE for LPA and SB. Specifically, compared to AdPE, exergaming had higher average minutes of MVPA (16.9 min. vs. 12.2 min., respectively), but lower average minutes of LPA (10.8 min. vs. 13.0 min., respectively) and SB (22.3 min. vs. 24.7 min., respectively). As shown in Table 3, however, both AdPE and exergaming demonstrated wide ranges of SB duration (AdPE: 16.7-27.2 minutes; Exergaming: 16.5-33.0 minutes), LPA duration (AdPE: 11.8-15.1 minutes; Exergaming: 6.6-13.7 minutes), and MVPA duration (AdPE: 7.7-22.9 minutes; Exergaming: 7.4-23.8 minutes). Direct observation revealed greater percentages of on-task behavior during AdPE compared to exergaming (93.0% vs. 67.0%, respectively), with a higher percentage of communication also seen during AdPE versus exergaming (34.0% vs. 16.1%, respectively).

IOAs for direct observation were all approximately 95%. No missing data were present in the above analyses.

3.2 Facilitators, barriers, and ideal exergaming and AdPE sessions

Facilitators for both PA sessions were customizability and variety. Explicitly, teachers/aides remarked that both exergaming and AdPE offered the ability to customize the activities to each child's interests through a variety of games and equipment. Teacher/Aide A remarked:

> *"They get to use individual gaming stations, so those who want to dance, can dance, and those who want to bowl can do that. These games have high interest for most of the kids."*

For exergaming, the stimulation provided by the lights, colors, songs, and noises of the exergames facilitated PA, on-task behavior, and communication while increased ability for children to interact with teachers/aides was a unique facilitator of these outcomes during AdPE.

No common barrier was seen between exergaming and AdPE. For exergaming, the stated major theme for barriers was the complexity of the gaming consoles and exergames. The children needed help running the gaming console and sometimes required assistance to participate in gameplay. Teacher/Aide C stated:

> *"Some of the Wii games are too hard/complex for the students to use on their own. Students are at very different levels [of ASD severity] and need to be met there [at their developmental level]."*

Additionally, the exergaming session was held in a 20-foot long by 20-foot wide section of shared space which included other exercise equipment that sometimes distracted the children. Within AdPE, major barriers included lack of equipment and space. Specifically, most children enjoyed riding the tricycles, but only two tricycles were available. Moreover, lack of space made it difficult for children to participate in different PAs within the same space (e.g., children riding tricycles while others shot the basketball).

Aligned with the barriers above, a common major theme for what an ideal exergaming or AdPE session might include was space allocation/size. Briefly, teachers/aides stated that an exergaming space free of any other exercise equipment would be ideal while an AdPE space large enough to designate certain gym spaces for certain activities was desired. Teacher/Aid D described the environment he envisioned:

> *"I picture a somewhat large space that is divided into sections: 1) An exergaming area with mini-trampolines; 2) a biking, scooter and 'wheels' area*

with hard floors; 3) an area with mats and soft obstacles to climb and crawl on; and 4) an open space to set up specific activities (i.e., bowling, kickball, parachute, etc.) that can also be used to run around in."

Notably, for exergaming, teachers/aides also stated that easier-to-play exergames for children with ASD would ideally promote PA, on-task behavior, and communication whereas more equipment which appeals to all children would achieve the same outcomes in AdPE.

4. Discussion

To our knowledge, the current study is the first to investigate differences between objectively-assessed PA as well as directly observed on-task behavior and communication between exergaming and AdPE among children with ASD. Observations suggested exergaming sessions elicited greater average minutes of MVPA while AdPE sessions observed higher average minutes of LPA and SB. Noteworthy, however, is the fact AdPE facilitated higher percentages of on-task behavior and communication. Teacher/aide survey responses suggested the customizability and variety of activities for both exergaming and AdPE facilitated the preceding outcomes but that these outcomes were hindered by video game complexity during exergaming and lack of space and equipment during AdPE.

Despite the fact accelerometry data indicated children spent 16.9 and 12.2 minutes in MVPA during exergaming and AdPE, respectively, these values are below national recommendations which state 50% of a physical education class's duration should be spent in MVPA (U.S. Department of Health and Human Services, 2010). As the PA sessions were 50 min. in duration, ≥ 25 min. of MVPA would have been needed to meet this recommendation. This observation suggested that, regardless of whether children were participating in exergaming or AdPE, greater promotion of MVPA may be needed for to promote optimal health benefits. Noteworthy, however, is the observation of higher MVPA during exergaming compared to AdPE. This observation may be attributable to two factors. First, exergaming sessions required less set-up time than AdPE. During AdPE, teachers/aides spent time setting up the necessary equipment and explaining game options to children. Second, two to three children during each exergaming session self-stimulated by bouncing on a trampoline while playing the exergames—potentially biasing MVPA levels upward during the exergaming sessions relative to AdPE.

Although trampoline use may have biased our study's PA observations, it should be noted that promotion of motor skill development is an important part of IEPs (Autism Society, 2016), with motor skill functioning associated with ASD severity/symptomology in young children (MacDonald & al., 2014). As trampolines are sometimes used during occupational therapy with children with ASD, an argument could be made that using trampolines during exergaming play may have not only facilitated self-stimulation, but may have also assisted in the promotion balance and coordination in these children during this activity. Nonetheless, while the current study was observational in design with no control of how the exergaming or AdPE sessions were implemented, future studies should consider standardizing trampoline use or non-use across both conditions to facilitate more accurate PA comparisons.

Observations indicated AdPE resulted in greater on-task behavior and communication than exergaming. While previous research has shown exergaming interventions to improve on-task behavior and communication over time (Prupas & al., 2006; Mineo & al., 2009), this study represents the first to compare these two behaviors between exergaming and AdPE. Although novel observations, the preceding findings are logical for two reasons. First, given school space limitations, on-task behavior percentages were likely lower during exergaming than AdPE as the children played exergames in a designated 20-foot long by 20-foot wide section of a modified classroom housing other traditional gym equipment (e.g., weight machines, stability balls, and treadmills). While the teachers/aides were able to keep children off this equipment, this equipment still acted as a distraction to the children curious to look at/walk over to the machines on the other side of the room. Second, decreased communication during exergaming compared to AdPE is likely attributable to the fact that once the exergames were set up, children could play with minimal assistance aside from selecting and setting up a new game. Indeed, AdPE resulted in higher on-task behavior and communication given all activities were teacher/aide-directed. Given that promotion of on-task behavior and communication are critical objectives when developing IEPs for children with ASD (Autism Society, 2016; MacDonald & al., 2014), teachers/aids desiring to utilize exergaming to supplement traditional AdPE should find creative ways to interact with children during gameplay—preferably in a room free of distractions. Otherwise, the use of exergaming in children with ASD should be employed sparingly.

Open-ended surveys indicated that both PA sessions offered customizability and variety to children—acting as potential facilitators of PA, on-task behavior, and communication. Directives for IEPs for children with ASD highlight the need to be able to customize activities

to each child (Autism Society, 2016). Thus, it is promising that AdPE and exergaming both provide variety and customizability. However, while children enjoyed the exergames—with a particular affinity for Wii Just Dance for Kids—the complexity of some of the exergames was a noted barrier for some children. As such, special educators with any desire to employ exergaming in children with ASD might want to consider: (1) using simpler games; and/or (2) advocating for game developers to design exergames specifically for populations with ASD. Finally, special educators at an underfunded school akin to that of the current study might consider external grant opportunities for teaching resources as lack of proper equipment which children enjoyed (e.g., tricycles in AdPE) and space limitations/allocation were stated by teachers/aides to hinder PA, on-task behavior, and communication during both exergaming and AdPE.

This study's strengths included: (1) conducted with minority sample of boys with ASD attending a Title-I public elementary school; (2) first known study to objectively assess PA in children with ASD using accelerometry and compare these measurements between exergaming and AdPE; and (3) first known study to conduct qualitative surveys with teachers/aides of children with ASD regarding facilitators and barriers of PA, on-task behavior, and communication. As children with ASD from lower socioeconomic backgrounds may be disproportionately negatively affected by lack of PA opportunities, these data objectively note what PA options may provide the most physical and behavioral health benefits. These data are also important as the input from teachers/aides regarding the different PA environments observed (i.e., exergaming and AdPE environments) may improve future implementation of AdPE and/or exergaming programs in children with ASD. Taken together, these data can assist in ensuring the best PA option is ultimately implemented in accordance to what might most benefit the children.

Limitations were present which warrant mention. First, despite the researchers seeking to recruit all children with ASD within the school (n = 7), the small sample size limits the generalizability of the findings—particularly given the known diversity of ASD severity and associated behaviors (American Psychiatric Association, 2013). Notably, due to the needs of children with ASD, it may not be feasible to increase the number of children with ASD in future studies within a single school as a near equal student-to-teacher/aide ratio is desired when working with this population. Recruiting from multiple schools should therefore be explored in future studies. A larger sample size would also facilitate the ability to use inferential statistics to discern more specifically the differences in PA, communication, and on-task behavior between two PA modalities like exergaming and AdPE. Second, while the

current U.S. cultural climate made acquisition of individual-level IQ and comorbidity data unachievable due to families' concerns about the release of such data, future studies should examine how individual-level ASD severity impacts PA, communication, and on-task behavior differentially during exergaming and AdPE. Third, the use of trampolines to keep some children stimulated during exergaming play may have biased exergaming MVPA measurements upwards compared to AdPE where this apparatus was not used. While trampoline use may provide an opportunity for children with ASD to engage in motor skill-building activities (Autism Society, 2016; MacDonald & al., 2014), future studies should standardize trampoline use or non-use during different PA sessions to limit biased PA measurements. Finally, as the study setting was an urban Title-I elementary school with limited space and resources, teacher/aide survey responses may not be generalizable to schools of higher endowment.

Children with ASD often exhibit lower intellectual capabilities (American Psychiatric Association, 2013; Auxter & al., 2010), reduced motor skill development (MacDonald & al., 2013; MacDonald & al., 2014), and higher rates of obesity compared to typically-developing peers (Curtin & al., 2010). Therefore, development of PA programs to promote greater attentional capacity and communication, in addition to physical activity, are warranted, with exergaming posited as a viable approach (Mineo & al., 2009; Hilton & al., 2014). This study observed exergaming to promote slightly higher MVPA and lower SB among children with ASD compared to AdPE. However, AdPE was more effective at promoting on-task behavior and communication. Thus, educators implementing exergaming among children with ASD are advised to develop programs which can promote on-task behavior and communication while maintaining higher rates of MVPA participation. Nonetheless, it appears that, for now, exergaming should be used sparingly among children with ASD, with AdPE the preferred method of health promotion among this population given AdPE's ability to promote important behavioral outcomes (i.e., on-task behavior, communication) among this population.

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