Active Video Gaming Compared to Unstructured, Outdoor Play in Children: Measurements of Estimated Energy Expenditure and Measured Percent Time in Moderate-to-Vigorous Physical Activity

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Abstract

It is recommended that children and adolescents participate in ≥ 60 minutes of moderate-to-vigorous physical activity (MVPA) per day. Despite the current recommendations and positive health benefits, many children and adolescents still do not engage in regular physical activity (PA).

One challenge for assisting children in becoming more active is sedentary screen-based activities (SBAs), such as watching television (TV), using computers, and playing sedentary video games (VGs), as SBAs may compete with time for being physically active in children. One modification to sedentary VGs that may increase PA in children is to alter them so that the VGs actually provide an option to engage in PA. These types of VGs are called active video games (AVG) or "Exer-gaming." Studies have found that playing AVGs can produce the estimated energy expenditure (EE) comparable to moderate-intensity structured PAs, such as moderate-intensity treadmill walking and self-paced walking, but significantly less EE as compared to vigorous-intensity PAs, such as running. To determine if AVGs can provide a good source of PA in young children, it is important to note that young children acquire much of their PA through play rather than structured PA. Children's play consists of short intermittent bouts of activity with frequent rest periods. Children are more active in unstructured, outdoor play areas where they can freely engage in activities requiring running, jumping and chasing. Thus to determine if AVGs are a good source of PA for young children, AVGs should be compared to unstructured play, rather than structured PA. Only one study has compared AVGs to unstructured PA in children and has used pedometry to assess PA. Thus, the purpose of this investigation was to compare AVG to unstructured outdoor play, as assessed by accelerometery and direct observation (DO), using a within-subjects design.

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CHAPTER I: LITERATURE REVIEW

Pediatric Obesity and Physical Activity

The increasing prevalence of childhood obesity is a serious public health issue [1]. The 2007-2008 National Health and Nutrition Examination Survey (NHANES) data report that an estimated 16.9% of children and adolescents aged 2- to 19- years are obese (body mass index [BMI] $\geq$ 95th percentile) [2]. Data from the 2003-2004 NHANES survey assessing physical activity (PA) from accelerometers revealed that, in children (6- to 11- years), only 42% achieved the recommended amount of $\geq$ 60 minutes of moderate-to-vigorous physical activity (MVPA) on 5 of the 7 days, whereas, in adolescents (12- to 19- years), only 8% achieved this goal [3]. Therefore, one contributing factor to the rise in childhood obesity is a lack of PA. Research has shown that engaging in regular PA enhances health and reduces the risks of obesity-related metabolic complications [4, 5]. In addition, setting a foundation for being active during childhood may assist individuals with being active as adults. The *2008 Physical Activity Guidelines for Americans* states that engaging in physically active lifestyles helps build strong bones and healthy joints, sustains good mental health, increases cardiovascular fitness, and maintains a stable weight over time, which may prevent an individual from becoming overweight and obese [6].

Despite the positive health benefits, many children do not engage in regular PA [7-9]. Increasing use of sedentary screen-based activities (SBAs) has been most recently blamed for children and adolescents' lack of engagement in PA [7-9]. Sedentary SBAs that children most frequently engage in are watching television (TV), using computers, and playing sedentary video games (VGs) [7-10]. Anderson et al. reported that 65% of children aged 4- to 11- years spend, on average, 2 hours per day watching TV or playing computer games [10]. As longitudinal studies have found there is a decrease in PA from childhood into adolescence, immediate efforts, which

may include reducing time in sedentary SBAs, need to be made to assist children in developing healthful PA habits that can be carried into adulthood [7-10].

Are Children Meeting the Recommendations for Physical Activity?

MVPA is defined as any activity that increases heart rate and periodically causes shortness of breath [6]. It is recommended that children participate in ≥ 60 minutes of MVPA per day [6]. However, it appears that many children are not meeting recommendations. For example, a study by Pate et al. examined PA, assessed via accelerometry over 7 days in girls who were in sixth through eighth grades (n=1578) [11]. Overall, on a daily basis, girls spent 459.9 minutes in sedentary activity, 341.6 minutes in light activity, 18.1 minutes in MVPA and 5.6 minutes in vigorous PA (VPA) [11]. These findings suggest that most sixth through eighth grade girls are well below the public health guidelines for PA [11].

Furthermore, a cohort study by Adams et al. sought to identify the amount of time overweight adolescents spent in different activity levels, as well as to determine the steps per day children need to meet their 60 minutes per day of MVPA [12]. Forty overweight adolescents aged 11- to 16- years participated in the study [12]. Activity levels were measured by accelerometers. The participants were instructed to wear the accelerometers for at least 10 hours/day for 7 days [12]. The study used two different Metabolic Equivalent (MET) criteria, 3/6 METs and 4/7 METs, to define MVPA [12]. MET is the energy cost of the activity expressed as kilocalories expended per kilogram of body weight per hour of activity [12]. Normally, activity is categorized using the 3/6 METs criteria for light (< 2.9 MET), moderate (3-5.9 MET), and vigorous activity (6-11 METs) [12]. However, past research suggests that the 3- and 6- METs threshold values for moderate PA and VPA appear to misclassify light activity as moderate PA and thus, overestimate MVPA [12]. To examine this issue, the 4- and 7- METs criteria were used by increasing threshold counts for light (< 3.9 METs), moderate (4-6.9 METs), and vigorous

activity (7-11 METs) [12]. Results indicated for the 3/6 METs criteria, participants averaged 7.9 hrs/day of inactivity, 4.5 hrs/day of light activity, 66.2 min/day of MVPA, with 9930 steps/day needed to meet the MVPA recommendations [12]. Under the 3/6 METs criteria, 48% of participants met MVPA recommendations [12]. Data from the 4/7 METs criteria revealed participants averaged 7.9 hrs/day of inactivity, 5.1 hrs./day of light activity, 29.4 min/day of MVPA, with 11,714 steps/day needed to meet the MVPA recommendations [12]. With the 4/7 METs criteria, only 10% of participants met the MVPA recommendations [12]. Thus, using both methods to determine MVPA recommendations, less than 50% of the adolescents met recommendations.

Not only are older children not meeting the PA recommendations of $\geq$ 60 minutes of MVPA per day, younger children also appear not to be meeting PA recommendations. It is recommended that preschool-aged children participate in 120 minutes of PA per day, with 60 minutes spent in structured activity and 60 minutes spent in an unstructured free-play setting (5-7). Pate et al. examined the PA levels of 247 children aged 3- to 5- years in three different preschools [13]. Activity was measured via accelerometer with a 15 second interval [13]. Results indicated children spent, on average, 7.7 minutes per hour engaging in MVPA while in the preschool setting. Therefore, a child who attends a preschool for 8 hours a day would engage in only 60 minutes of MVPA and not the recommended 120 minutes per day of PA [13].

Similar to Pate et al., a study by Salbe et al. investigated physical activity levels (PAL) in 127, 5- year old children [14]. Forty-three children were white American and 84 children were native Pima Indians of Arizona [14]. Measurements in the study included anthropometrics, total energy expenditure (TEE), and resting metabolic rate (RMR) [14]. TEE was assessed by doubly-labeled water [14]. PAL was calculated from the TEE/RMR ratio [14]. Both groups of children

reported a PAL of 1.35, which was 20-30% lower than The World Health Organization (WHO) recommended PAL of 1.7-2.0 [14]. This study indicates that young children also have low levels of PA [14].

Measuring Physical Activity in Children

There are many methods to assess PA in children. These methods include self-report, accelerometery, and direct observation (DO). Each method has its strengths and weaknesses and can provide different types of information regarding PA.

Self-Report Assessment of Physical Activity:

The assessment of PA in young children by self-report is a convenient measure due to its low cost, ease of administration, and ability to collect descriptive data on activity patterns [15]. However, for young children, self-report is problematic due to its high respondent burden, the need for literacy, changes in memory due to perceptions and biases, difficulty in correctly identifying variable intensity levels of PA, social desirability issues, the need for parental involvement (depending on the age of the child), and incorrectly following directions on self-report questionnaires [15]. Additionally, unlike PA in adults, PA in children tends to be conducted in sporadic bouts, which makes children's PA hard to recall, quantify, and categorize [15, 16]. Self-report questionnaires for assessing children's PA generally collects PA over a one- or seven-day period [15, 16]. The Previous Day Physical Activity Recall (PDPAR), the Self-Administered Physical Activity Checklist (SAPAC), and the Yesterday Activity Checklist are self-report questionnaires that measure one day of PA [17-19]. Self-report instruments measuring one week of PA are the Weekly Activity Sum, the Weekly Activity Checklist, the 7-Day Activity Tally, and the Physical Activity Questionnaire for Older Children (PAQ-C) [20].

Sallis conducted a literature review, assessing the validity and reliability of self-reported child PA, with either the child or an adult reporting on child's PA [15]. Self-report measures

were compared to objective direct measures, such as observation or activity monitoring, or objective indirect measures, such as maximal oxygen consumption (VO_2 max), of PA to determine validity [15]. Only studies reporting data on children aged 3- to 18- years were examined. Studies were categorized into four groups based on their self-report assessment tool: 1) Self-Administered Recall -- children report their own activities on a preprinted form; 2) Interview-Administered Recall -- interviewers administer a structured interview with the child; 3) Diary -- children record their activity throughout the day; and 4) Proxy Reports -- a parent or teacher reports the child's activity. Results indicated that nine studies of self-administered recall measures showed reliability to be high in children aged 8- to 17- years, but not in younger children [15]. Validity data were limited in both younger and older children [15]. Six studies used an interviewer administered recall, specifically the Seven-Day Physical Activity Recall, and included samples that contained children as young as 8- years of age [15]. Measures reported low reliability, but strong validity [15]. Two studies of the PA diaries reported high validity and reliability in children > 10- years of age [15]. Five studies examined the measures from proxy reports and found the data to show low reliability and validity due to the adult's limited knowledge of the child's constant behavior [15].

Sallis concluded that while diaries have the strongest validity, the high respondent burden of diaries can make compliance poor [15]. Age was the strongest predictor of reliable and valid PA assessment, with studies revealing that children under the age of 10- years do not provide reliable or valid information in recalls or diaries [15]. Therefore, when PA is assessed in children under the age of 10- years, objective measures, like DO and/or accelerometery, should be considered.

Accelerometery:

Accelerometery is another established tool to measure PA. Accelerometery estimates PA from the measurement of the body's movements by calculating the change in velocity over time (acceleration), enabling the intensity of the activity to be measured [21]. The recorded accelerations give an accurate description of the frequency, duration, and intensity of the activity performed by the body's movements [22]. The recorded accelerations are converted into "activity counts." Activity counts are summed and stored in an epoch. An epoch is the amount of time (seconds) over which the movements (activity counts) are stored [23]. The sum of activity counts per epoch is linearly related to activity intensity; therefore, as activity intensity increases, so do activity counts. In order to be translated and reported in ways that are biologically meaningful, activity counts have been calibrated against EE to establish cut point thresholds to quantify different activity intensities (METS): sedentary (<1.5 METs), light (1.6- 2.9 MET), moderate (3-5.9 MET), or vigorous (6-11 METs) [21, 22]. Alternatively, the estimated EE can be determined from a prediction equation, incorporating participant age and gender, and the associated cut points. Previous research shows a high correlation between accelerometer measurements and oxygen-uptake, thus confirming accelerometery as a valid measurement to calculate children's PA and estimated EE [22].

Many researchers view accelerometery as the preferred method for objective measurement of PA [21, 24-29]. Some researchers even consider it a quantitative criterion against which other measures of PA can be validated [28, 29]. Furthermore, accelerometers are lightweight, unobtrusive, and relatively inexpensive compared with other objective methods of measuring PA, such as DO or doubly-labeled water [30]. However, while accelerometers might be advantageous in minimizing researcher or participant-reporting bias, they are not without limitations [24, 30]. Accelerometers can only accurately assess movement of the body segment

to which the motion sensor is attached [30]. Therefore, an accelerometer placed at the hip will not accurately assess movement of the arms (e.g., walking vs. rowing), nor will it accurately measure the added EE of carrying a load while moving (e.g., weight lifting and/or walking and carrying a heavy object) [30]. Moreover, accelerometers cannot distinguish between different types of physical activities (e.g., playing soccer vs. dancing) or sedentary behaviors (e.g., painting vs. completing puzzles), which can cause accelerometers to underestimate certain activities [30].

The two most commonly used accelerometers tested on children are the Actical, a multi-axial omindirectional accelerometer that is sensitive to movement in all directions, and the ActiGraph, which can be a uniaxial or triaxial accelerometer, measuring acceleration on either a vertical plane or in three dimensions [23].

One of the greatest disputes of using accelerometers as a PA assessment tool in children is the multiple sets of validated cut points (i.e. counts per unit of time) that report dramatically contrasting estimates of children and youth's PA levels. Cut points are the measured accelerometer data converted into units of estimated EE to classify PA intensity levels [28, 31]. The choice of cut points is of critical importance when trying to determine if a population is meeting PA guidelines and/or the levels of physical (in)activity within a studied population [30, 32, 33]. Despite the numerous validation studies performed to establish set cut points, a consensus has yet to be reached regarding which cut points are most appropriate for children and youth.

It should be recognized that the time period over which activity counts are stored and averaged (an epoch) can affect the interpretation of cut points and thus, lead to misclassification of PA levels. Specifically in children, longer epochs (1 minute) lead to lower cut points which

can misinterpret their PA intensity due to a process called smoothing [23]. Smoothing occurs when a burst of higher intensity PA within a particular epoch is shorter than the width of the epoch, causing the averaged activity count for the epoch to be lower than the actual PA intensity, which results in lower cut points and reports lower estimates of children's PA levels [23].

A meta-analysis by Trost et al. further exposed this problem by revealing 5 sets of youth-specific ActiGraph cut points independently developed and validated in youth [34]. Trost et al. discovered that the methods used to derive these cut points differed dramatically from study to study [34]. For instance, some cut points were derived from samples with a large age range, whereas others were derived from samples with a narrow age or single age group [34]. Also, some studies derived cut points from a single-sex group, whereas others were derived using both sexes [34]. For example, two studies, Freedson et al. [26] and Puyua et al. [35], with slightly different methodologies, published two independent sets of ActiGraph cut points validated in youth . Both studies used EE, measured through indirect calorimetry, as the criterion measure to establish their cut points [26, 35]. Furthermore, both studies gathered data on a similar age population (youth aged 6- to 18- years old), which included male and female participants. Freedson et al. and Puyua et al. collected data using a hip-mounted, uniaxial ActiGraph accelerometer, set at a 60 second epoch, but the environmental conditions in which the activity was assessed varied between the two studies [26, 35]. Freedson et al. derived their cut points' in a laboratory-based setting (i.e., using a treadmill) and Puyau et al.'s (2002) cut points were derived from field-conditions (i.e., free-living activities) [26, 35]. The two studies and their associated cut point measures reported dramatically different estimates of PA levels. Freedson et al. reported $\leq$ 100 counts per minute^{-1} as sedentary activity (SED), > 100 counts per minute^{-1} as low-physical activity (LPA), $\geq$ 2220 counts per minute^{-1} as moderate-physical activity (MPA),

and ≥ 4136 counts per minute^{-1} as vigorous-physical activity (VPA) [26]. In contrast, Puyau et al. (2002) defined intensity levels using < 800 counts per minute^{-1} as SED, ≥ 800 counts per minute^{-1} as LPA, ≥ 3200 counts per minute^{-1} as MPA and ≥ 8200 counts per minute^{-1} as VPA [35]. The difference of at least a 1000 counts between cut points from these studies is enough to cause misclassification of PA levels.

Further misclassification of PA levels also can be caused by large age ranges of participants, which both Freedson et al. and Puyua et al. reported in their investigations [26, 35]. Wide age ranges within sampled participants have the potential of intensity misclassification due to the differences of growth and development on PA intensity [31, 36]. These two studies show the lack of standardization within cut point validation studies, and as a result, report dramatically contrasting estimates of PA intensity levels in youth.

Cut point differences are also found to exist between studies using different accelerometers. Another study by Puyau et al. (2004) used both laboratory and field-conditions to derive cut points for children 7- to 18- years of age [25]. Data were validated via indirect calorimetry and collected using a hip-mounted, omnidirectional Actical accelerometer set at a 60 second epoch [25]. Puyau et al. (2004) reported 0-99 counts per minute^{-1}as SED, 100-1499 counts per minute^{-1} as LPA, 1500-6499 counts per minute^{-1} as MPA, and ≥ 6500 counts per minute^{-1}as VPA [25]. Comparing these cut points to Puyua et al.'s ActiGraph (2002) cut points reveals a large range of cut point differences. Both studies used the same epoch interval, age population, and conditions; however, despite consistency between the two studies, cut point differences still appeared between the different accelerometers. Furthermore, similar to the ActiGraph studies, the validity of Puyau et al.'s (2004) cut points derived in the Actical

accelerometer are questionable because of the sample's large age range among participants [25, 26, 35].

Using the same study design as Puyau et al. (2004), Evenson et al. derived cut points from a narrow age range, focusing just on children 5- to 8- years of age [21, 25]. Data were collected in 15 second (15-s^{-1}) intervals on a hip-mounted, omnidirectional Actical accelerometer [21]. Evenson et al. categorized PA intensity as follows: 0-11 counts 15-s^{-1} as SED, 12-507 counts 15-s^{-1} as LPA, 508-718 counts 15-s^{-1} as MPA, and $\geq$ 719 counts 15-s^{-1} defined as VPA [21]. In comparison to the cut points derived by Freedson et al. and Puyau et al. (2002), who collected data using the ActiGraph set at a 60 second epoch on children 6- to 18- years of age, the cut points reported by Evenson et al. on children 5- to 8- years of age were lower [21, 26, 35]. This difference could be due to the age range of the participants, epoch length, accelerometer brand, and/or different types of activities performed due to the study's setting (i.e., laboratory-based vs. field-conditions).

As shown by the number of validated cut points applied within the identified studies, no consensus has been reached on which cut points to recommend for widespread use in children and youth. These studies clearly show the need for a standardized criterion to validate accelerometer data in order to accurately determine age-specific cut points to better classify PA intensity levels in youth. Previous pediatric PA studies have most commonly set monitors to collect data in 1 minute epochs [27, 34-36]. The sporadic and intermittent nature of children's activity, however, has led researchers to recommend the use of shorter epochs, such as 15 seconds to better establish cut points that accurately capture children's high intensity PA levels [21, 32, 34, 37-39].

At this time, the cut points derived by Evenson et al. have been widely used to assess PA behaviors in children, due to the studies' narrow age range of participants, whose growth and development, and activity patterns are more closely related [21]. Furthermore, Evenson et al. collected data using a 15 second epoch, as compared to a 60 second epoch, which has been validated to report a practical representation of children's physical activity levels [21].

Direct Observation:

The assessment of PA can also be measured via DO. DO methods are considered the gold standard and are used to validate other methods of PA and EE assessment (accelerometery) in children [32, 40]. DO provides descriptive and detailed information on the time length and specific type of activity and movement that is being performed, which is useful with young children, because their activity occurs in short bouts and at high intensity with inconsistent gross movement patterns [23, 41]. Moreover, DO has a low participant burden and is not limited by recall or self-report biases [41]. Furthermore, DO does not require any equipment that may hinder movement in children. However, a potential weakness of the DO technique is that it can be time-consuming and require extreme diligence on the part of the observer [41]. Another weakness is the inability of DO to capture activity over a 24-hour period. Also, as a child's PA behavioral patterns are likely to vary from day to day, multiple days of PA assessment are generally encouraged [42]; DO does not lend itself to being conducted over several days [42].

There are several methods for conducting DO of PA in children. One is through the use of the Children's Activity Rating Scale (CARS). CARS uses a rating scale that assigns an activity score representative of the child's intensity level for each activity, which is thereby reflective of EE [41]. The rating scale ranges from 1 to 5, with the ratings representing the following: 1 (stationary/motionless), 2 (stationary/movement only of limbs and trunk), 3

(translocation-slow/easy), 4 (translocation-medium/moderate), and 5 (translocation-fast/strenuous) [41]. To make ratings, an observer watches an individual and rates the observed activity. An activity must occur for at least 3 seconds before that activity level is recorded. If there is a change in activity level and the new activity level is performed for less than 3 seconds, the new activity is not recorded [41]. CARS has been shown to be reliable to assess children's PA, with high inter-rater reliability and within day test-retest repeatability [41]. CARS also has been validated against maximal VO_2 tests and heart rate measurements and has been shown to effectively cover a wide percentage of children's EE [41].

Other DO systems to measure children's activity levels have been developed. Another DO system is the System for Observing Play and Leisure Activity in Youth (SOPLAY), which is designed to obtain observational data about PA on a group of participants during play and leisure activities [43]. Thus, the data are not collected on SOPLAY at the individual-level. SOPLAY has broad categories of activity levels, which do not allow detailed analysis of activity intensities [43]. Of the two DO systems, CARS is considered the best observation tool due to its ability to capture short-term patterns and sudden changes in PA levels, which is crucial for the study of children.

Community-based Strategies to Increase Physical Activity

In efforts to help children meet PA recommendations, numerous interventions have been developed and have resulted in mixed outcomes. For example, the VERB™-*It's what you do*-Campaign was launched in 2002 by the Centers for Disease Control and Prevention [44, 45]. VERB™ used commercial marketing methods targeted at American children aged 9- to 13-years to increase knowledge and improve attitudes about the health benefits of PA and to increase PA in children by promoting by PA as a fun, appealing and easy choice [44, 45]. To evaluate the VERB™ campaign, Huhman et al. performed a 2- year follow-up in 2004,

examining changes in attitude and PA behaviors in children aged 11- to 15- years [44]. Data were collected using a national telephone survey (response rate was 32%) asking children to report their activity levels during non-school hours [44]. Engagement in both free-time PA and organized PA (termed 'sessions') was collected over the previous 7 days [44]. Results indicated that children aware of the VERB™ campaign engaged in 3.9 sessions of PA, whereas children not aware of the campaign efforts engaged in 3.0 sessions of PA [44]. These results revealed a positive relationship between exposure to the campaign and behavioral PA outcomes [44]. As data for the evaluation did not include actual minutes of PA, it is not clear how many minutes of PA children exposed to the VERB campaign were engaging in [44].

DeBate et al. implemented the VERB™ Summer Scorecard (VSS) program, which was a multi-level, community-wide intervention study to increase PA among youth aged 9- to 13- years [46]. The intervention's goal was to meet the following *Healthy People 2010* objectives: 1) increase the proportion of adolescents who participate in MVPA at least 30 minutes per day, 5 or more days per week; and 2) increase the proportion of adolescents who participate in VPA activity promoting cardio-respiratory fitness, 3 or more days per week for at least 20 minutes per occasion [46]. DeBate et al. used an ecological approach, which focused on increasing PA in youth at the community level through informational, behavioral, social, environmental, and policy interventions [46]. The VSS program aimed at increasing PA in youth by creating and improving access to places for PA throughout the summer [46]. The participants monitored their activity on a scorecard by having the scorecard stamped when they were active at designated VSS sites within the community [46]. Space also was placed on the scorecard where parents or caregivers could initial when their child performed 60 minutes of PA [46].

Many community businesses that offered youth-focused activities, such as community pools, sports clinics and dance studios, partnered with the VSS [46]. Two separate county school-districts participated, with one county serving as the VSS intervention and the other as the control [46]. The VSS intervention group (n=1253) was divided into three sub-groups based on their exposure to the VSS program and their participation in the VSS program [46]. Group 1 (n=125) received a VSS but did not participate; Group 2 (n=148) received a VSS and did participate; Group 3 (n=708) did not receive a VSS and did not participate [46]. All three sub-groups were compared to the one control group (n=866) [46]. Results were collected through a survey which measured participants exposed to the VERB™ campaign and the local VSS program, involvement in the VSS program, participation in a new sport or game, and PA frequency [46]. The survey results revealed that the VSS intervention group that received a VSS and participated had more participants meet recommendations for VPA (91.9%) compared to the VSS intervention group that did not receive a VSS (89.1%), the control group (83.4%), and those in the VSS intervention group that received a VSS card, but did not participate (80.8%) [46].

Many school-based interventions aimed at promoting health behavior change have been developed over the past decade [47]. The most successful is the Coordinated Approach to Child Health (CATCH), which uses an ecological approach, incorporating schools, families and the community, in order to teach youth skills and positive behaviors that are needed to lead a healthy and active lifestyle [47]. In the schools, CATCH is designed to target physical education (PE), food service (meals served) and classroom curriculum [47]. A 5-month pilot-study by Kelder et al. used the CATCH PE curriculum when implemented in an after-school program [47, 48]. The CATCH PE curriculum outlines that children spend $\geq$ 50% time in MVPA and $\geq$ 20% in VPA while in PE [47]. PA was measured by DO of MVPA and VPA during free play time. Across the

16 after-school programs in the pilot study, Kelder et al. reported an increase of 44 minutes/day of time children spent in playground time in MVPA.

Another school-based intervention program, the Child and Adolescent Trial for Cardiovascular Health (CATCH), focused on promoting cardiovascular health through a school PE intervention in third- and fifth- grade students. CATCH was a 3- year randomized controlled trial involving 96 elementary schools throughout the United States. The primary focus of CATCH was implementation of a PE curriculum (CATCH PE), which was designed to increase the time children spend in MVPA to at least 40% of PE class time, which translated to 30 to 40 minutes/class for at least 3 classes/week [49].

In an evaluation of CATCH PE, McKenzie et al. reported that 2096 PE lessons were observed over the 3- year study, with 801 observed lessons occurring in the control schools and 1295 observed lessons occurring in the intervention schools [49]. Results indicated that after 3-years, children in the intervention schools maintained the CATCH PE goals of 3 classes/week, while increasing their MVPA from 37.4% at baseline to 51.9% at 3- years during the CATCH PE lessons [49]. This represents a 39% increase in MVPA from baseline for the intervention schools. Therefore, intervention schools increased their time spent in MVPA from 34 minutes/week (11.2 min-per 30-minutes class) at baseline to 47.2 minutes/week (15.6 min-per 30-minutes class) at 3- years. These results demonstrate that the CATCH PE intervention exceeded the *Healthy People 2000* objective for children to spend 50% of PE class time in MVPA [49]. Despite the increase in activity level, this study shows that school PE is providing only 15 minutes of recommended MVPA 3 days/week, which is below the recommendations of $\geq$ 60 minutes per day of MVPA, indicating that acquiring MVPA from school PE alone will not fulfill the PA recommendations.

A study by Kelder et al. examined institutionalization of the CATCH PE curriculum 5-years post-intervention [50]. Fifty-six former intervention (FI) schools and 20 former control (FC) schools participated [50]. In addition, 12 new unexposed control (UC) schools, which had no prior involvement in CATCH, were recruited to provide a non-biased comparison of the CATCH PE curriculum [50]. A total of 645 PE classes were observed in third-, fourth-, and fifth-grade students. Results indicated students in the FI schools spent more class time in MVPA (45.36 minutes/week) and VPA (15.87 minutes/week) than students in the FC and UC schools; however, these results were not statistically significant [50]. Notably, the FI met the *Healthy People 2010* objective that 50% of PE class time should be spent in MVPA and thereby maintained this goal 5 years post-intervention by adhering to the CATCH PE curriculum [50].

The results from McKenzie et al. and Kelder et al. indicate that PE class time can be increased through implementation of the CATCH PE curriculum [49, 50]. Both studies reveal how schools can be an effective environment for promoting PA in young children; however, despite program efforts children are still not meeting PA recommendations. Thus, providing quality, mandated PE should be considered as only one of many potential strategies for promoting children's PA.

Physical Inactivity and Sedentary Behaviors

One barrier children may encounter in getting more PA, is the amount of time they spend in sedentary behaviors. Anderson et al. analyzed data from NHANES 2001-2004 to assess the proportion of children in the United States who report low levels of PA and high levels of sedentary SBAs [10]. PA was assessed by parents reporting the number of times per week (frequency not duration) their child played or was actively engaged in exercise that caused sweating or hard breathing. Researchers categorized a low level of active play as < 7 times per week. Sedentary SBAs, also were measured by parents reporting the average hours per day their

child sat and watched TV and used and/or played the computer. High levels of sedentary SBAs were defined by researchers as > 2 hours per day. The study included 2964 children aged 4- to 11- years who reported low-levels of PA, high-levels of sedentary SBA use, or both low-levels of PA and high-levels of sedentary SBAs [10]. Aligning with national standards, in this study Anderson et al. classified children as obese if BMI was ≥ 95% for age [10].

Results indicated that 37.3% of the children had low levels of PA [10]. Sixty-five percent of the children had high levels of sedentary SBAs [10]. Moreover, 26.3% of the children had both low levels of PA and high levels of sedentary SBAs [10]. Among children aged 4- to 5- and 6- to 8- years, approximately 15% were classified as obese, as were 20% of children aged 9- to 11- years [10]. When PA and sedentary SBAs were examined by weight status, Anderson et al. found differences in obese as compared to nonobese (BMI < 95th percentile) children [10]. A greater percentage of obese as compared to nonobese girls had high levels of sedentary SBAs (72.0% vs. 60.7%, respectively) [10]. For the combination of both behaviors, obese girls (38.1%) were more likely than nonobese girls (27.5%) to have lower levels of PA and high sedentary SBAs [10]. The only differences in boys of differing weight status were found in the 9- to 11-year-olds, with more obese boys (53.3%) reporting lower levels of PA as compared to nonobese boys (36.5%) [10]. Overall, results showed that obese children were more likely to have low levels of PA, high levels of sedentary SBA or have both behaviors, as compared to nonobese children [10].

Koezuka et al. examined various types of leisure-time sedentary activities and physical inactivity among Canadian youth [51]. Researchers conducted a secondary data analysis of the 2000-2001 Canadian Community Health Survey of 7982 youth, aged 12- to 19- years to address the question of physical inactivity, as well as sedentary activities among Canadian youth, and to

examine the relationship between various types of leisure-time sedentary activities and physical inactivity among Canadian youth [51]. Leisure-time sedentary SBAs were assessed by questionnaire and defined as number of hours per week spent during leisure-time engaged in: computer use, sedentary VG playing, TV viewing, and reading [51]. Physical inactivity was measured by a PA questionnaire, which included the type(s) of activities, frequency of engagement in the activities and the average length of time spent on these activities over the last 3 months [51]. EE for each PA was calculated and assigned a MET value. Koezuka et al. then classified children as inactive, a mean daily MET value for activities < 3, or active, a mean daily MET value for activities ≥ 3 METs [51]. The results showed that for females and males, 67.8% and 50.3% were classified as inactive, respectively [51]. Examining the sample as a whole, males spent more of their sedentary leisure-time playing sedentary VGs, using the computer or watching TV, as compared to females, who reported spending more time reading [51].

Results also are revealed as the *relationship* between time spent in SBAs and physical inactivity [51]. Males revealed a positive association between TV viewing time and levels of physical inactivity, such that more TV viewing was related to more time being sedentary and less time spent being physically active (≥ 3 MET) [51]. Notably, an inverse association was found between PA and VG play and computer usage [51]. Males who reported < 5 hours/week of VG play and those who reported < 6 hours/week of computer usage were more likely to be active than males who reported time watching TV. Males who reported watching TV > 21 hours/week were significantly more likely to be inactive than males who just played sedentary VGs or used the computer. Results did not show a significant association between males who spent time reading and their physical inactivity levels. Alternatively, females who reported more time spent reading (≥ 15 hours/week) or using the computer (< 6 hours/week and ≥ 15 hours/week) were

also more likely to spend time being active compared to those females who reported time spent watching TV or playing sedentary VGs [51]. Overall, TV viewing was the only sedentary activity that was significantly associated with physical inactivity for both males and females.

A study conducted by Salmon et al. also revealed a similar relationship between time spent watching TV and physical inactivity in 1560 children (613 aged 5- to 6- years, and 947 aged 10- to 12- years) [52]. The study asked parents to report from the previous 7 days the time their child spent watching TV to indicate if viewing time was a strong indicator of poor diet, physical inactivity, and increased weight status [52]. Parents' reported their child's intake from the previous week using a Food Frequency Questionnaire (FFQ) [52]. Similarly parents reported their child's frequency of participation in PA using a questionnaire; the child's activity also was objectively measured via accelerometer [52]. To estimate time per day and activity levels, accelerometer cut points were set at 3.0-5.9 METs for MVPA and 6.0 METs for VPA [52]. The study revealed that only 41% of girls aged 10- to 12- years spent $\geq$ 2 hours/day in MVPA, whereas 84% of girls 10- to 12- years reported watching > 2 hours/day of TV [52]. Results further revealed positive associations between time spent watching TV and poor diet, low-levels of PA, and obesity [52].

Vandewater et al. discovered a strong relationship between sedentary VG play, but not TV time, and a child's weight status [51-53]. The study examined 2831 children aged 1- to 12-years, with the objective to examine the relations between children's media use and physical activities to their weight status [53]. Media use was classified as TV use, electronic games use, computer use and reading material [53]. PA level was based on participation in highly active, moderate and sedentary activities [53]. Children's weight status was measured using the standard BMI-for-age growth charts [53]. To collect data, Vanderwater et al. used two-24-hour time use

diaries (one-weekend and one-weekday) to estimate the amount of TV viewing time and time spent playing VGs, as well as the time children spent in physical activities [53]. Findings revealed a positive linear relationship between time spent in sedentary behavior and weight statues, showing children with a higher BMI were more likely to spend time in sedentary activities than those with a lower BMI [53]. Interestingly, the study portrayed a linear correlation between VG play, but not TV time, and weight status [53]. Thus, it appeared that VG play but not TV usage was replacing the time children could be spending in active play.

As a whole, these studies suggest that in children, spending more time engaging in sedentary SBAs is related to low PA levels and, potentially, increased weight status [51-53]. Moreover, these studies indicate the vast majority of children spend a large amount of time in sedentary SBAs, and the sedentary SBAs appear to compete for time to engage in PA.

Understanding the Relationship between Physical Activity and Sedentary Screen-Based Activities

Behavioral economics theory can provide a framework for understanding the relationship between PA and sedentary behaviors. PA and sedentary behaviors appear to have a relationship with each other such that they are substitute behaviors (i.e., as one behavior increases, the other behavior decreases). Thus, if sedentary behavior is a substitute for PA, to help increase PA, strategies need to be put into place that help to decrease sedentary behaviors. For example, one method may be to reduce access to competing sedentary SBAs, thereby increasing the likelihood that PA will occur [54]. A study by Raynor et al. examined sedentary participants to determine how convenience, through proximity of physical activity and sedentary alternatives, would affect their choice in behavior [54]. Thirty-four, nonobese (defined as not greater than 20% over ideal weight for height), sedentary, college-aged males participated in the study [54]. The participants were randomly assigned to one of the four conditions: 1) both physically active and sedentary

alternatives were convenient-proximal; 2) the physically active alternatives were convenient-proximal and sedentary options were inconvenient-distal; 3) the physically active alternatives were inconvenient-distal and the sedentary options were convenient-proximal; and 4) both the physically active and sedentary options were inconvenient-distal [54]. Results from the study revealed how convenience, dictated by proximity, determined which activity the sedentary males chose [54]. When sedentary options were further away and made inconvenient, and the physically active alternatives were convenient, as they were close by, the participants chose to engage in the physically active alternative, and thus, were more active in the session [54]. Likewise, when the sedentary options were more convenient and close by, the participants chose to engage in the sedentary activities, and thus were more sedentary in the session [54]. Notably, when both physically active and sedentary options were made inconvenient because they were far away, the participants chose to be active 42% of the time [54]. The study demonstrates how changing variables related to PA and sedentary behaviors can influence the choice to be physically active or engage in sedentary behaviors. Importantly, the behavioral economic framework emphasizes that if modifications are made regarding the sedentary behavior, PA could increase.

Active Video Game Play

One modification to sedentary VGs that may increase PA in children is to alter sedentary VGs, so that the VGs actually provide an option to engage in PA, rather than to be sedentary. These types of games then do not compete with PA, but actually are a source of PA. These types of VGs are called active video games (AVGs) or “Exer-gaming” [55]. As these new types of VGs have been developed, the amount of PA they can provide is being evaluated. A study by Leatherdale et al. examined EE in 51 college-aged students playing AVGs, such as Nintendo Wii®, Sony Dance Dance Revolution® (DDR) or Guitar Hero®, and compared these AVGs to

traditional sedentary VGs [55]. EE was measured by participants wearing a heart rate monitor (HR) and a SenseWear armband to record change in body temperature [55]. Participants played 30 minutes on each game, AVG and sedentary VG, with a 5 minute break to allow the heart to return to its resting state [55]. Leatherdale et al. revealed that EE and time spent being active was greater when playing the AVG compared to the sedentary VG [55]. Leatherdale et al. estimated that if males substituted 1 hour of AVG play for sedentary play, they would expend an additional 483 kcal per week [55]. This difference in EE equates to a 7.2 lbs per year of weight loss [55]. This study suggests that greater EE and PA can be achieved when AVG play is replaced with sedentary VG play.

A study by Graft et al. examined EE in 23 children aged 10- to 13- years playing AVGs, such as Wii Sports and DDR, and compared these games to treadmill walking [56]. EE, HR, step rate and perceive energy exertion were measured in participants while watching TV at rest; playing Wii bowling and Wii boxing; playing DDR at skill levels I and II; and walking on a treadmill, performed at three interval rates of 2.6, 4.2 and 5.7 km/hr, with 4.2-5.7 km/hr seen as a moderate-intense activity for children [56]. Graft et al. revealed that highest rates of EE were achieved at the DDR level II and treadmill walking at 5.7 km/hr [56]. This study revealed that playing AVGs can elicit an EE comparable to moderate-intensity treadmill walking [56].

Complementing Graft et al.'s findings, a study by Bailey et al. also reported that EE in AVG play is comparable to moderate-intensity treadmill walking, and that AVG play can elicit an EE greater than moderate-intensity treadmill walking [57]. Bailey et al. examined the overall EE in 39 children age 9- to 13- years old, playing 6 different AVGs, such as Sony® DDR, LightSpace® (Bug Invasion), Nintendo® Wii (Boxing) Cybex Trazer® (Goalie Wars), Sportswall®, and Xavix® (J-Mat), and compared these AVGs to rest and treadmill walking, set

at 3 km/hr [57]. AVG enjoyment related to body composition also was assessed as a secondary measure [57].

EE was measured via indirect calorimetry throughout the study [57]. All participants completed the study in the same order [57]. The study began by measuring the children's seated, resting EE for 15 minutes [57]. Following the measurements of rested EE, EE during the 7 activities (1 treadmill walking and 6 AVGs) were measured [57]. Participants were given 5 minutes to rest between each activity, at which time water was offered and they could drink ad labitum [57]. All participants performed the 6 AVGs in the same order and on the same designated levels chosen by the researchers prior to the study's beginning, for each game [57]. Results revealed significantly greater EE during all activities as compared to rest [57]. Further, AVG play compared favorably with walking on the treadmill at 3 km/hr, with 4 out of the 6 AVGs resulting in significantly higher EE than treadmill walking at 3 km/hr [57]. Nintendo® Wii Boxing and Sony® DDR reported the lowest EE of 16.7 $kJ \cdot min^{-1}$ and 20. $kJ \cdot min^{-1}$ compared to treadmill walking of 18.5 $kJ \cdot min^{-1}$,while LightSpace® (Bug Invasion), Cybex Trazer® (Goalie Wars), Sportswall®, and Xavix® (J-Mat) reported higher levels of EE at 22.9 $kJ \cdot min^{-}1$, 23.8 $kJ \cdot min^{-}1$, 26.0 $kJ \cdot min^{-}1$, and 28.1 $kJ \cdot min^{-1}$, compared to treadmill walking [57].

As a secondary measure, Bailey et al. also assessed participant enjoyment of the games compared to body composition [57]. Results showed that children who were at risk for becoming overweight or who were overweight ($\geq 85^{th}$ %) enjoyed playing the AVGs to a greater extent that did the children with a BMI < the 85% [57]. This study shows how AVGs can be a novel method to increase PA in children, reduce sedentary time, and promote enjoyment of physical activity, specifically in children with higher BMIs.

To challenge the findings that EE in AVG play is comparable to moderate-intensity treadmill walking, White et al. compared intensity levels, HR, and EE in sedentary SBAs (resting, watching TV, and playing a VG) to playing AVGs (Nintendo® Wii Sports Bowling, Boxing, and, Tennis; and Wii Fit Skiing and Step), self-paced walking around a track, and running, which included a 20m-shuttle run fitness test [56, 58]. The purpose of the study was to measure the EE, via indirect calorimetry, and intensity during AVG play and to determine whether the EE released during AVG is due to AVG experience or fitness level [58]. Twenty-six boys, aged 11- years participated [58]. Participants were divided into three groups based on their prior Wii Sports/Fit experience obtained from a pre-study questionnaire [58]. Non-users (NU, n=11) were those who had never played Wii Sports/Fit [58]. Non-frequent users (NF, n=6) were those that played less than once per week, and frequent users (FU, n=9) were those that played Wii Sports/Fit more than once per week [58]. Participants attended three testing sessions on three different days [58]. During session one, height, weight, BMI, resting metabolic rate (RMR) and resting heart rate (HR) were assessed [58]. Participants then completed a 3-part series of aerobic testing where VO_2 and HR were assessed [58]. In test one, participants were asked to walk around a 50 m indoor track for 3 minutes at a normal self-paced walk. For test two, following a 3 minute rest period, participants were asked to run the same 50 m track for 3 minutes at a pace they could maintain for this 3 minute duration [58]. Finally, for test three, which was followed by another 3 minute rest period, participants performed a 20 m shuttle-run to assess cardiovascular fitness [58]. During sessions two and three, RMR was assessed at the beginning of each session. Thereafter, one 10 minute sedentary SBA was performed (watching TV or playing a sedentary VG) and two AVGs were randomly selected for each participant to play, each for 10 minutes [58]. Breaks were allowed between the AVG play. Similar to Graft et al.,

White et al. found that the EE during all AVGs was higher than all sedentary behaviors [56, 58]. The AVG yielding the highest EE was Nintendo® Wii Boxing (411 $\pm$100J $kg^{-1}min^{-1}$), followed by Nintendo® Wii Fit Step (350 +149J $kg^{1}min^{-1}$), which were comparable to self-paced walking (403 $\pm$ 97J $kg^{-1}min^{-1}$), but significantly less than EE performed during running (768 $\pm$ 200J $kg^{-1}min^{-1}$) [58]. The participants' prior AVG experience had no effect on EE during sedentary SBAs, walking, running or any AVG. Also, no effects on metabolic responses were seen based on fitness between the three groups [58]. The EE released during AVG was significantly higher than resting or playing sedentary SBAs (watching TV or playing VGs) and was independent of gaming experience or fitness level [58].

The previous studies reported compared the EE in AVG play to the EE in other SBAs, and structured activities, such as treadmill walking. A study by Duncan et al. examined PA levels during AVG play compared to children's free-play during a child's school recess/lunch break [59]. Duncan et al. used a quasi-experimental intervention design, where 40 British children aged 6- to 10- years were randomly assigned to a control or intervention group [59]. The control group took part in its normal weekly activity, whereas the children in the intervention group participated in two weekly sessions of AVG play over the course of the 6-week intervention [59].

During AVG play sessions, the intervention group used the Xbox 360® game console and the Gamercize Power Stepper®, a mat that the gamer must step on at a set cadence of 30 steps/minute in order for the controller to remain active, and thus enable the gamer to continue playing the game [59]. A set rotation of 6 games were used throughout the study [59]. Each game was assigned to one week during the 6 week intervention; therefore, all children played the same game during their twice weekly sessions [59]. Game order along with their assigned week was: Week 1 Sega Superstars®, Week 2 Tennis®, Week 3 Fifa 09'®, Week 4 Proevolution

Soccer®, Week 5 Sega Rally®, and Week 6 Lego Batman® [59]. PA sessions and AVGs sessions were set at 30 minutes across both groups [59]. The three dependent variables (DVs) assessed were steps/minute, percent of time spent in MVPA, and average HR [59]. The percent time engaged in MVPA was measured using HR. Heart rate reserve (HRR) values of 50 (HRR_{50}) and 75 (HRR_{75}) percent were used as threshold values to represent MVPA [59]. Steps/minute were measured at the first, third and sixth weeks, while percent of time spent in MVPA and average HR were measured at the first and sixth weeks, of the 6-week study for both groups [59].

Results revealed the number of steps/minutes were significantly greater for the AVG group (52.9 steps/min) compared to the control group (46.5 steps/min) during week 1 of the study [59]. However, at weeks 3 and 6, there were no differences in steps/minutes between the groups. Also there were no differences in percent time spent in MVPA at weeks 1 and 6 between the two conditions [59]. These results suggest that AVGs may be an alternative source of PA for children.

Currently, 65% of children aged 4- to 11- years spend, on average, 2 hours per day watching TV or playing computer games [10]. Therefore, a potential solution to decrease physical inactivity may lie in the use of AVGs. The present studies have shown that AVGs expend more energy than their sedentary counterparts. However, there are mixed findings regarding if AVGs expend as much energy as structured PA. Additionally, one study compared unstructured outdoor play to AVG play, and did not find differences between the conditions for most measures related to PA. Thus, these studies suggest that AVGs may be a source of PA for children.

Activity Patterns of Young Children

PA in young children usually occurs during free play rather than during structured activities, and this play consists of short intermittent bouts of activity with frequent rest periods

[60]. Due to children's quick bursts of activity and overall variability in PA characteristics, the time children spend in different activity levels greatly differs compared to adults. Hoos et al. examined daily PA patterns via accelerometery in 20 children, with a mean age of 8.6 ± 3.3 years, compared to previously obtained accelerometer data in adults [61]. Results show that children spent 56% of their activity time in low-PA (LPA), 25% in MVPA, and 19% in VPA [61]. The LPA was significantly lower in children (56%) than adults (65%); however, the time spent in VPA was higher in children (19%) than in adults (9%) [61]. Thus, this difference in activity levels between children and adults reflects the different activity patterns among children, which are characterized by short, frequent bouts of VPA.

Furthermore, compared to PA in adults, children are more active in unstructured, outdoor play areas where they can freely engaged in activities requiring running, jumping and chasing [62]. In children, time spent outdoors remains a main correlate of higher PA levels. Research shows among young children, PA is higher during outdoor play than during indoor play [61-63]. Cleland et al. examined whether the time children spent outdoors was associated with PA levels [63]. PA was objectively measured by accelerometery for 8 days [63]. Accelerometer reliability was examined through a survey administered to parents asking them to estimate the total hours per week their child spent outdoors [63]. Participants included 188, 5- to 6- year-old children and 360, 10- to 12- year-old children (n=548) [63]. Researchers found that each extra hour of time spent outdoors on weekends and weekdays was associated with an extra 26.5 min/week of MVPA for girls and an extra 21.0 min/week of MVPA for boys [63]. Therefore, for some children, increasing the amount of time they spend outdoors by this amount of time each week could increase their level of PA and help in the attainment of meeting the recommended levels of weekly PA [63].

Examining the spontaneity in children's play and PA intensity, Oliver et al. observed unstructured, outdoor play in a playground setting and PA participation in children aged 3- to 4-years [32]. Using accelerometery set at a 15 second epoch interval and DO to measure PA, researchers found that children spent 75% of outdoor play in one intensity level for $\leq$ 5 seconds, with a mean duration time of 2 seconds [32]. The majority of the play time was spent in sedentary and light activity that was interspersed with short bursts of MVPA and VPA [32]. Thus, through the accumulation of shorts bouts of activity and the variable PA characteristics observed outdoors, children are able to achieve high levels of PA.

As it has been observed, prolonged, structured activity periods are not typically associated with childhood behavior patterns. Children are more active in unstructured, spontaneous play and less interested in concentrating on a single activity. As such, activity types and sustained durations commonly used in activity testing for children are unlikely to be replicated in the natural environments of young children. Therefore, great discrepancy exists between children's natural, unstructured behaviors and those structured behaviors used for activity testing, causing measurements to misclassify children's natural behavioral patterns and activity level [32, 40]. For this reason, the only way to accurately measure normal, unstructured PA levels in children participating in free play is to observe them in their natural setting.

Summary

The rates of overweight and obesity in children have increased dramatically [1]. Physical inactivity appears to be one factor contributing to the rise in childhood obesity. Regular PA enhances health and reduces the risks of obesity-related metabolic complications. Despite the known positive health benefits, many children do not meet the recommendation of $\geq$ 60 minutes of MVPA per day [6]. To increase PA in children and adolescents, multi-level community intervention programs have been established; however, despite program efforts children are still

not meeting the recommendation for PA. Perhaps most worrisome is the combination of low levels of active play and a greater involvement in sedentary SBAs.

The increasing use of sedentary SBAs recently has been most blamed for children and adolescents' lack of engagement in PA. Studies indicate a large portion of children participate in high-levels of sedentary SBAs, and the sedentary SBAs appear to compete for time to engage in PA. If sedentary behavior is a substitute for PA, to help increase PA, strategies need to be put into place that help to decrease sedentary behaviors.

One modification to sedentary VGs that may increase PA in children is to alter sedentary VGs so that the VGs actually provide an option to engage in PA, rather than to be sedentary. These types of games then do not compete with PA, but actually are a source of PA. These types of VGs are called AVGs or "Exer-gaming." Previous research demonstrates that EE in AVG play is comparable to moderate-intensity walking and unstructured outside play and produces greater EE than sedentary SBAs. However, previous studies of AVGs in children have been limited to the following: 1) measuring EE in AVGs and comparing this to EE acquired with walking on a treadmill or in a structured setting; and 2) measuring physical activity levels in AVGs compared to the physical activity levels in outdoor play, using step-count by pedometry in a between-subjects study design. Studies have not investigated the estimated EE of AVG play compared to the estimated EE in unstructured outdoor play, using a within-subjects study design. Thus, the purpose of this study was to assess estimated EE during AVG play and compare it to estimate EE acquired in unstructured, outdoor play in children as measured via accelerometry and DO using a within-subjects study design.

Specific Aims:

1.) To compare in 5- to 8- year-old children estimated EE acquired from 15 minutes of AVG play to 15 minutes of unstructured outdoor play.

2.) To compare in 5- to 8- year-old children the percent of time engaged in MVPA (MET value >3) during 15 minutes of AVG play to 15 minutes of unstructured outdoor play.

CHAPTER II: MANUSCRIPT

Abstract

Background: Active video games (AVGs) may be a source of physical activity (PA) for young children. This study compared AVGs to unstructured outdoor play (OP) via accelerometery and direct observation (DO) for estimated energy expenditure (EE) and percent time engaged in moderate-to vigorous-intensity physical activity (% MVPA) in two, 15 minute sessions.

Methods: Sixteen, normal-weight, young children (6.4 $\pm$ 0.8 yrs, 62.5 % male, 100% white, standardized body mass index (zBMI) = -0.18 $\pm$ 0.66) completed two sessions of AVG and OP. Morning sessions were counterbalanced (order 1 = OP, AVG; order 2 = AVG, OP). An Actical accelerometer on the left hip, and left and right wrists measured estimated EE and %MVPA. DO was conducted using the Children's Activity Rating Scale from which %MVPA was coded.

Results: Controlling for order differences in percent relative humidity in all analyses, no differences were found in estimated EE between OP (left hip = 15.5 $\pm$ 7.7 kcal; left wrist = 26.5 $\pm$ 14.7 kcal; right wrist = 27.9 $\pm$ 16.3 kcal) and AVG (left hip = 16.9 $\pm$ 7.0 kcal; left wrist = 24.6 $\pm$ 16.1 kcal; right wrist = 24.3 $\pm$ 15.5 kcal). No differences were found for %MVPA assessed by the accelerometers on the wrists (OP: left wrist = 85.4 $\pm$ 23.8%; right wrist = 86.2 $\pm$ 23.7% vs. AVG: left wrist = 83.7 $\pm$ 32.0%; right wrist = 84.5 $\pm$ 31.3%). For %MVPA, a significant ($p < 0.05$) order x condition interaction occurred for the accelerometer on the left hip with AVG significantly greater in order 2 than order 1 (74.5 $\pm$ 31.0% vs. 67.5 $\pm$ 32.1%, $p < 0.05$), and in order 2, AVG significantly greater than OP (90.0 $\pm$ 10.6% vs. 59.1 $\pm$ 37.6%, $p < 0.05$). A significant ($p < 0.05$) order x condition interaction also occurred for %MVPA from DO, with AVG significantly greater in order 2 than order 1 (23.8 $\pm$ 12.4% vs. 13.2 $\pm$ 12.9%, $p < 0.05$).

Conclusion: These findings suggest that AVGs and OP are comparable physical activities, and that AVGs may be a source of PA for young children.

Introduction

The rates of overweight and obesity in children have increased dramatically [1]. Physical inactivity appears to be one factor contributing to the rise in childhood obesity. The *2008 Physical Activity Guidelines for Americans* state that engaging in physically active lifestyles enhances health and reduces the risks of obesity-related metabolic complications [6] . In addition, setting a foundation for being active during childhood may assist individuals with being active as adults.

Moderate-to-vigorous physical activity (MVPA) is defined as any activity that increases heart rate and periodically causes shortness of breath [6]. It is recommended that children and adolescents participate in $\geq$ 60 minutes of MVPA per day [6]. However, it appears that many children and adolescents are not meeting recommendations. It is recommended that preschool-aged children participate in 120 minutes of PA per day, with 60 minutes spent in structured activity and 60 minutes spent in an unstructured free-play setting [5-7]. Despite the current recommendations and positive health benefits, many children and adolescents still do not engage in regular PA [7-9].

In efforts to help children meet PA recommendations interventions have been designed using community-based and school-based strategies. Interventions using community-based strategies to increase PA have reported weak results in increasing overall PA in children [29, 30, 34]. However, school-based interventions using an ecological approach, incorporating schools, families and the community, have shown a greater likelihood of increasing children's PA levels specifically by increasing time in MVPA [47]. However, despite intervention settings and program efforts, children are still not meeting PA recommendations. One challenge for assisting

children in becoming more active may be greater use of sedentary screen-based activities (SBAs), as SBAs may compete with time for being physically active.

SBAs that children most frequently engage in are watching television (TV), using computers, and playing sedentary video games (VGs) [7-10]. Reports indicate that 65% of children aged 4- to 11- years spend, on average, 2 hours per day watching TV or playing computer games [10]. These studies suggest that the vast majority of children participate in a large amount of time in sedentary SBAs and the sedentary SBAs appear to compete for time for PA [7-10]. Additionally, a positive relationship between time spent in sedentary behaviors and weight status indicates that children with a higher body mass index (BMI) are more likely to spend time in sedentary activities than those with a lower BMI [53].

One modification to sedentary VGs that may increase PA in children is to alter sedentary VGs so that the VGs actually provide an option to engage in PA, rather than to be sedentary. These types of VGs then become a source of PA, and are called active video games (AVGs) or "Exer-gaming" [55]. Studies measuring energy expenditure (EE) and PA using AVGs, such as Sony® Dance Dance Revolution (DDR); Nintendo® Wii Sports Bowling, Boxing, and Tennis; and Wii Fit Skiing, have found that greater EE and PA can be achieved when sedentary VG play is replaced with AVG play [55, 58]. Other studies have examined EE in children playing AVGs and compared these games to the EE in structured PA (i.e., treadmill walking, self-paced walking, and a shuttle run fitness test) [55-58]. These studies have found that playing AVGs can produce an EE comparable to moderate-intensity structured PA, such as moderate-intensity treadmill walking and self-paced walking, but significantly less EE as compared to vigorous-intensity PA, such as running [55-58]. Thus, a novel solution to decrease physical inactivity may lie in the use of AVGs.

However, structured activity may not be the best comparison for evaluating AVGs for EE and %MVPA in young children [32, 40]. PA in young children usually occurs during free play rather than during structured activities, and play consists of short intermittent bouts of activity with frequent periods of rest [60]. Moreover, young children are more active in unstructured, outdoor play areas where they can freely engage in activities requiring running, jumping and chasing [62]. As prolonged, structured activity periods are not typically associated with childhood physical activity patterns, activity types and sustained durations commonly used in activity testing for young children are unlikely to replicate the natural play of young children.

Only one study has examined PA levels during AVG play compared to school-aged children's free-play during a child's school recess/lunch break [59]. In this study, 40 British school children aged 6- to 10- years were randomly assigned to a control or intervention group [59]. The control group took part in its normal weekly activity; whereas the children in the intervention group participated in two weekly sessions of AVG play over the course of the 6-week intervention [59]. PA sessions and AVG sessions were set at 30 minutes and occurred during the recess/lunch break. PA was assessed with a pedometer and a heart rate (HR) monitor. Results revealed the number of steps/minutes were significantly greater for the AVG group (52.9 steps/min), compared to the control group (46.5 steps/min) during week 1 of the study [59]. However, at weeks 3 and 6, there were no differences in steps/minutes between the groups. Also there were no differences in % time spent in MVPA at weeks 1 and 6 between the two conditions [59]. Thus, it appears that AVGs may be an alternative source of PA for school-aged children.

Therefore, the purpose of this investigation was to build upon the research regarding comparisons of AVG and outside play in young children using additional measures of PA. This investigation compared AVG play to unstructured outdoor play using accelerometery and direct

observation (DO). Additionally, this investigation used a within-subjects, rather than a between-subjects, design in young children aged 5- to 8- years.

Methods

Study Design

The study was a 2 x 2 counter-balanced design, with order as the between-subjects factor, and condition [outdoor play (OP) vs. Kinect Adventures!® (River Rush (RR) (AVG)] as the within-subjects factor. Participants were randomly assigned to an order where they completed two conditions (Appendix A, Table 1). The dependent variables (DVs) of activity counts/min, percent time engaged in MVPA (%MVPA) and estimated EE from MET values (EE) were measured via accelerometry and DO.

Participants

Recruitment

A convenience sample of 16 young children, aged 5- to 8- years, were recruited from the Early Learning Center (ELC), located on White Avenue, near the University of Tennessee campus. All children who met the age criteria for the study at the ELC were asked to participate. A letter was sent home to all parents with children between the ages of 5- to 8- years old explaining the study. Attached to the letter was a packet that included two parental consent forms, a contact information sheet and an eligibility questionnaire. The letter and packet were placed in the child's mailbox, which is standard protocol for parents to receive information from the ELC, and has been the procedure for previous studies. A week following the initial letter and packet, a reminder letter regarding the study was sent home. All interested parents and children were encouraged to call the primary investigator (PI) with any questions, comments, or concerns the parent and/or child might have regarding the study prior to signing the consent form, or

completing the eligibility questionnaire. Children and parents interested in participating returned the completed packet, sealed in the provided manila envelope, to the ELC. Packets were collected by a research assistant as they arrived. Informed consent forms were approved by the University of Tennessee-Knoxville Institutional Review Board (IRB). This study was registered through ClinicalTrials, NCT01430715.

Eligibility

Participants had to meet the following criteria:

1) Child aged 5- to 8- years old
2) Enrolled in the ELC
3) Returned the signed parental consent form
4) Gave assent prior to the start of every session
5) Healthy, with an absence of any known cardiopulmonary, metabolic, or orthopedic disease condition or aliment that would limit their PA
6) BMI-for-age percentile between $\geq$ 5% to < 85%.
7) Agreed to be observed during outdoor activity and while playing the video game
8) Completed the second session within 3-weeks of the initial session

Criteria upon which participants were excluded:

1) Children older than 8- years of age
2) BMI < 5% or $\geq$ 85%
3) Unable to contact to schedule sessions
4) Failed to complete the second session within three-weeks of the initial session
5) Grass allergy
6) Sensitivity to sunlight

Between July 2011 and October 2011, 26 informed consent forms were returned by parents who expressed interest in having their child participate in this study, and along with the consent forms, 24 complete packets were returned. Out of the 24 children with complete packets, 8 did not meet eligibility for the following reasons: 2 children were too old; 1 child had a BMI above the inclusion range, 3 children had a BMI below the inclusion range, 1 child failed to complete the second session 3-weeks after the first session, and 1 child was not able to be recontacted. Overall, 16 young children remained and completed all portions of the study.

Sample Size

To detect a difference in objectively measured PA between any of the two conditions, with at least 15 participants, power set at 80%, an alpha level of 5% (α=0.05), and using a two-sided hypothesis test, an effect size of d = 0.75 was needed. As at the start of this investigation no study had previously been conducted that compared unstructured outdoor play to an AVG in young children, and the AVG used in this investigation had no data published on %MVPA, no effect size could be calculated from previous studies. Therefore, in this study, the effect size needed to detect a true difference was estimated after the study.

Procedure

Parents who returned the completed packet and provided consent were contacted in the evenings to schedule their child's two sessions and answer any remaining questions the parent(s) and/or child had regarding the study. All sessions took place in the mornings between 7:30 am and 9:30 am during the weekdays; this was an open free time prior to scheduled activities at the ELC. All sessions were scheduled within 3-weeks of the child's initial session. While scheduling the sessions, parents were asked that on the morning of each session to have their child maintain his or her normal breakfast intake and record their child's dietary intake on the form provided in

the packet. Children were randomized, before the initial session, using a random numbers table, to an order in which they engaged in the activity sessions. Once scheduled, a reminder call was made to the parent(s) the day before each scheduled session. Missed sessions or sessions canceled due to inclement weather were rescheduled by phone and/or email.

Parents of eligible and consented children were sent a second packet containing four questionnaires assessing demographics, dietary intake, video game experience, and PA behaviors. Parents were asked to complete the questionnaires and return them on the morning of their child's first scheduled session.

For each session, dietary measures were collected from the parents. Participants were escorted to an empty classroom in the ELC, where verbal assent was obtained and documented by the PI. Participants then were asked to report how they were feeling physically. Next, the procedure for that session was reviewed with the participant and all questions were answered. Participants were made aware that water was available to them during the session. Regardless of session order, anthropometrics were collected in the first session. In the first session, participants were introduced to the accelerometers (i.e., what they measure and how to wear them) and the liking ratings to be utilized during the protocol. In both sessions, participants wore four accelerometers, three Acticals and one ActiGraph. One Actical and the ActiGraph, were placed on an elastic strap, worn around the waist. The other two Actical accelerometers were placed on both wrists of the participants, to detect upper body movement. Following placement of the accelerometers, participants were given a 5 minute "warm-up" period in their activity session (this allowed the child to become familiar with the AVG, as well as allowed them to get involved with the OP activity). Following the "warm-up," participants engaged in 15 minutes of activity that was measured. During the measurement period, two trained Children's Activity Rating Scale

(CARS) observers, simultaneously, conducted DO [41]. After the 15 minute measurement period was complete, the accelerometers were removed and children were asked to rate their liking and enjoyment of the activity, using a modified Physical Activity Enjoyment Scale (PACES) [64]. Each session took approximately 50 minutes. At the completion of each session the child had the choice to choose from a variety of age-appropriate books to take home.

Description of Activities

Unstructured Outdoor Play

The assessment of unstructured outdoor play took place on the playground of the ELC. The playground was a spacious fenced in activity area that included two grassy areas to run, play and chase; a climbing tree; one small, square pavement area; hula-hoops; and various sizes and assortments of balls (i.e., soccer and kick balls). The ELC's playground equipment was made available and in sight to the child and his or her peers throughout the unstructured outdoor play session. To supervise the children's playground activity, the ELC's teachers**,** who were adults**,** were present at all times. Per typical ELC protocol, adults are always standing and observing in the playground area, thus research assistants engaging in the DO did not appear to disturb the children's play**.** The research assistants conducting DO did not stand close to the participating child; rather, they were always in another, unobtrusive, parameter area on the playground.

To maintain consistency amongst sessions during the unstructured outdoor play activity, a minimum of 4 other children were always on the playground, with the studied participant. A person-minimum was established to ensure natural play would be elicited. Children were neither encouraged nor discouraged to play outside; rather, all children were instructed to, "Show me what you do out here."

Active Video Game Play

For the AVG, participants were taken to a room in the ELC that was approximately 15 ft. x 25 ft. and contained a 40-inch television. This room was large enough to not restrict participants' movements while they engaged in the AVG and to allow the two trained CARS observers to be in the room to observe and code data. Because some participants did not have previous experience with AVGs, such as the Nintendo® Wii games (Nintendo Wii, Nintendo Co. Ltd., Minami-ku Kyoto, Japan), a "warm-up" period of 5 minutes was permitted. This allowed each participant the opportunity to play and become comfortable with the AVG [65]. Instructions regarding the AVG were delivered by the PI, prior to the child's practice with the AVG. The AVG was set at the level in which data were collected. Following the practice round the participant engaged in 15 minutes of measured AVG play.

The new Xbox 360 Kinect®, is a controller-free gaming system where children are required to engage in standing, full body play [66]. Gamers must stand in front of the Kinect sensor where they are captured digitally and actually placed on the television screen [66]. The Xbox 360 Kinect® gets the whole body in the game due to is unique capabilities of motion sensors and skeletal tracking [66].

Motion Sensors: Unlike traditional VGs, that only involves the hands and wrist, the Xbox 360 Kinect® senses the entire body, making the gaming experience all about the gamer [66]. Because the sensors track the entire body, the games incorporate all parts of the body, including the head, arms, legs, knees, waist, hips, and so on.

Skeletal Tracking: The Xbox 360 Kinect® creates a digital skeleton of the gamer based on depth data [66]. So when the gamer moves left or right or jumps around, the sensor will capture the movement, putting the gamer into the video game.

Due to the increased interest in AVGs or VGs that require movement, the Xbox 360 Kinect® was chosen because it is the most up-to-date AVG and no known studies have been published using the Xbox 360 Kinect® gaming system.

For this study, the game chosen was Kinect Adventures!® (River Rush (RR)), which is an active rafting exploration game [66]. The gamer moves his or her head, arms, and body to direct the digital character, around a virtual reality course by navigating the raft through roaring rapids [66]. Additional points are earned by collecting coins, which can be earned by the gamer jumping, dodging, crouching, waving his or her arms, and moving the entire body. RR has been rated by the Entertainment Software Rating Board as "E" for everyone.

The RR game comes with multiple levels within each game. To ensure greater internal control of the study, during the study protocol all participants played the same AVG with the same game settings and levels. The multiple levels within the RR game range from very easy and not aerobically challenging to more difficult and intensely aerobically challenging. For consistency throughout the study, the RR video game was set at the "Basic" level, where the gamer played solo on a single player mode. The RR games were played in approximately 3 minute blocks with 30 second rests between each game. This short duration of play appropriately mimics play patterns common among young children 5- to 8- years of age. Children were told that they did not have to be active the entire 15 minute session and were allowed to stop and rest at any point within the session if they felt tired. A few children did sit down to rest during their gaming session.

Measures

Questionnaires

Eligibility Questionnaire.

The eligibility questionnaire was designed to assess the following: age of the child; physiological ailments that could limit PA; known allergies, and the child's weight and height (see Appendix B).

Parental Questionnaires.

Parents of consented children were asked to complete two questionnaires: a demographic questionnaire and an Eating and Activity Questionnaire (EAQ) [67] (see Appendix B). The demographic questionnaire had questions about the parent and child's backgrounds including questions on parent education level, race and ethnicity. The EAQ, developed by Raynor et al. [67], was used to measure the parent's report of the child's leisure-time activity. Activity habits were assessed as to how often per week, including weekends, their child played/exercised hard enough to cause sweating and hard breathing. Additionally, parents were asked to rate how active they thought their child was compared to other children. Sedentary activity was assessed by asking parents to report the time their child spent (in hours) on weekdays and weekends watching TV, videos or DVDs and typical time spent using the computer (for non-school work). Moreover, parents were asked if their child had a TV in their bedroom. Finally, the child's activity preference was assessed by asking parents to respond to the statement, "My child would rather watch TV or play in the house rather than play outside."

Experience with Active Video Games (AVGs).

Parents were asked to report (yes, no) if their child had experience playing either the Kinect Adventures!® (RR) or any other Kinect® games (see Appendix B). Parents also were asked to

report if their child had any previous experience playing any other active video gaming systems, and AVGs, such as Nintendo® Wii (Nintendo Wii, Nintendo Co. Ltd., Minami-ku Kyoto, Japan), EyeToy™ or Sony Dance Dance Revolution® (Sony Computer Entertainment) [65, 68, 69]. If "yes," then parents were asked to document both the AVG system(s) and game(s). Participant's VG experience was not part of the eligibility criteria for the investigation.

Pediatric Quality of Life Inventory 4.0 (PedsQL™ 4.0).

Each session began by asking the child to report how they were physically feeling using a modified PedsQL™ 4.0 [70]. The PedsQL™ 4.0 Generic Core Scales was developed by Varni et al., and was designed to assess pediatric populations, children and adolescents aged 2- to 18-years, for acute and chronic health conditions [70]. The PedsQL™ 4.0 consists of 23 items, applicable in clinical trials, research, clinical practice, school health settings and community populations [70]. The PedsQL™ 4.0 questionnaire divides the 23-items into 4-scales: 1 Physical Functioning (8 items), 2 Emotional Functioning (5 items), 3 Social Functioning (5 items), and 4 School Functioning (5 items). Each scale contains specific questions related to that scale [70]. A modified PedsQL™ 4.0 (see Appendix B), with 6-items from the original 8-items Physical Functional scale were included in this study. Children were asked to rate their physical functioning from the following statements: 1) It is hard for me to walk more than one block; 2) It is hard for me to run; 3) It is hard for me to do sports activity or exercise; 4) It is hard for me to lift something heavy; 5) I hurt or ache; and 6) I have low energy [70]. A 3-point response scale was used (0=not at all a problem; 2= sometimes a problem; 4 = a lot of a problem), with each response choice anchored with happy to sad faces [70]. These 6-items were chosen to relieve participant burden and were the most appropriate to measure feelings that may influence PA in young children 5- to 8- years of age. From the original 8-item questionnaire, the 2 statements

removed were: 1) It is hard to take a bath or shower; and 2) It is hard to do chores around the house. Items were reversed-scored using the following scale, 0=100, 2=50, 4=0, so that a higher score indicates better physical functioning. For each session, a mean of the 6-items was calculated. The reliability and validity of the PedsQL™ 4.0 has been established [70].

Liking of Games: Physical Activity and Enjoyment Scale.

The liking of each session was assessed following each condition using a modified Physical Activity Enjoyment Scale (PACES) (see Appendix B), with 5-items from the original 18-items being measured in the study [64]. These 5-items were chosen to relieve participant burden and were the most appropriate to measure PA enjoyment in young children 5- to 8- years of age. Using a 7-point Likert-scale (see Appendix B), children rated the extent to which they liked both activities (i.e. OP and AVG) from the following statement: Please rate how you feel *at the moment* about the physical activity you have been doing. Item 1 assessed enjoyment, anchored with, “I enjoy it” as point 1 and “I hate it” as point 7. Item 2 assessed the liking of the activity, anchored with, “I dislike it” as point 1 and “I like it” as point 7. Item 3 assessed the fun of the activity, anchored with, “It’s no fun at all” as point 1 and “It’s a lot of fun” as point 7. Item 4 assessed physical feeling anchored with, “I feel good physically while doing it” as point 1 and “I feel bad physically while doing it” as point 7. Item 5 assessed frustration, anchored with, “I am very frustrated by it” as point 1 and “I am not frustrated by it” as point 7 [64]. For the 5-items, items 1 and 4 were reversed scored (i.e., 1=7, 2=6, 3=5, 4=4, 5=3, 6=2, 7=1). Total responses were summed to give a score ranging from 5-35, where a higher score represented greater enjoyment of the activity.

From the original 18-item questionnaire, examples of some of the items removed were: “I am very absorbed in this activity” as point 1 and “ I am not at all absorbed in this activity” as

point 7; “ It makes me depressed” as point 1 and “It makes me happy” as point 7; “ It’s very gratifying” as point 1 and “It’s not at all gratifying” as point 7; “It’s very exhilarating” as point 1 and “ It’s not at all exhilarating” as point 7. The PACES has been found to be both reliable and valid in PA environments [64].

Anthropometrics.

Children were asked to remove shoes along with any excess weighted clothing (i.e., jackets or sweatshirts) before being measured. Weight was measured to a tenth of pound using a portable digital scale (Healthometer Professional, Sunbeam Product Inc. Raton, FL). The height of each child was measured to the nearest eighth of an inch using a portable stadiometer (SECA, ITIN Scale Company, Brooklyn, NY). BMI, which is weight in kilograms divided by height in meters squared, was calculated for each child (see Appendix B). Children’s zBMI was calculated by standardizing the BMI value in relation to the population mean and standard deviation for children’s age and gender [71, 72].

Dietary Intake.

Parents were asked to record the time and what their child ate the morning before each session (see Appendix B). Breakfast recordings were collected before the start of each session. Children, who did not maintain a usual breakfast before their scheduled session, were to be rescheduled. However, no participants had to be rescheduled for this reason during the study. Via parent’s reports, all children maintained normal intake before their two sessions. Additionally, parents who forget to record their child’s breakfast intake were called later in the evening of the session to obtain the recording. Dietary intake was analyzed using the NDS-R computer diet analysis program version 2010 (Nutrition Coordinating Center, University of Minnesota, Minneapolis,

Minnesota). The purpose of the diet recall was to assess the consistency of energy and macronutrient intake prior to each session.

Measures of Temperature and Humidity during Sessions.

Both temperature and humidity were measured in AVG sessions and during unstructured outdoor play (see Appendix B). Measurements were recorded 10- to 15- minutes prior to the start of the sessions. If the outdoor weather conditions were such that temperature was > 95°F and/or humidity was > 100%, the session was rescheduled. No participants had to be rescheduled due to effects from humidity; however, a few children were rescheduled due to inclement weather. All AVG sessions were played in a well-lit room set at a room temperature between 70-75°F. Room temperature and weather conditions were measured using the Speedtech SM-28 Skymaster Windmeter (Ambient Weather, Chandler, AZ).

Physical Activity.

For this study, two accelerometers were used: ActiGraph GT3X+ and Actical. Both monitors were initialized before the participants played outside, and data were uploaded from the monitors to the computer after each data collection session. Activity counts for the Actical monitor were placed at a 15 second epoch, where the ActiGraph GT3X+ recorded the raw activity data at a 30 Hertz (Hz) sample rate.

Three Actical accelerometers were used. One was placed on the hip and two were placed on both wrists. One ActiGraph GT3X+ was used, and it was also placed on the hip. The two accelerometers placed on the hips were worn on the same elastic waist band, and placed on the top of the right and left hips, above the right and left iliac crests. The accelerometers placed on wrists of the participants were able to detect upper body activity, and were secured on the dorsal side of each forearm, proximally from the wrist joint by using adjustable cotton straps.

ActiGraph. The ActiGraph GT3X+ is a new model made by Manufacturing Technologies Inc. Health Systems, Fort Walton Beach, FL, and it is a compact (4.6cm x 3.3com x 1.5cm), lightweight (19g), triaxial accelerometer. Unlike the triaxial ActiGraph GT3X, the ActiGraph GT3X+ can record and store up to 20 days of raw data collected at a 30 Hz sample rate, thus enabling for the continuous collection of activity data. Due to children's spontaneous bursts of activity, continuous sampling might be better adapted to capture their activity patterns. Nonetheless, validation studies have yet to be conducted using the ActiGraph GT3X+. To be able to compare the two sessions and as no validation studies are yet available for this accelerometer, the only DV used from this measure was activity counts/minute.

To calculate the ActiGraph GT3X+'s DV of activity counts/minute, individual data files were uploaded to a computer. Next, the 15 minutes of measured activity data were cut and exported into individual data spreadsheets. Then, the Actilife software, version 5.5.8., reintegrated the raw data into 15 second (15-s^{-1}) epoch intervals for the total 15 minutes of measured data.

The activity counts/minute were collected using all 3 axies on the ActiGraph GT3X+. Therefore, to determine the activity counts/minute for each session, for each participant, the 3 axies were summed and then divided by 15 (i.e. the total counts of measured activity in 15 minutes).

Actical. The Mini-Mitter Actical, made by Respironics Co. Inc., Bend, Oregon, is the most widely used and validated accelerometer used in studies of young children and adolescents (10,11). The Actical activity monitors used for this study were water resistant, lightweight (17g), small (1.14in x 1.45 in x 0.43 in), omindirectional accelerometer. This omnidirectional sensor is sensitive to movement in all directions, but is most sensitive in the direction of a single plane.

Furthermore, the accelerometer can detect low frequency (0.5-3.2Hz) G-forces (0.05-2.0Hz) common to human movement. The DVs from this accelerometer were activity counts/minute, percent (%) time engaged in MVPA, and estimated EE from MET values.

To calculate each DV, individual data files (i.e., collected in 15 second epochs) were uploaded to a computer and integrated (i.e., using the Actical software) into minute-by-minute activity counts, resulting in 15 activity counts measured over 15 minutes. Next, the 15 minutes of measured data were cut and exported into individual data spreadsheets.

Activity counts/minute were determined by averaging the activity counts within the 15 minutes of measured data. This was done by first summing all activity counts and then dividing by 15 (i.e., the total counts of measured activity in 15 minutes).

The following count thresholds were used to categorize PA intensity: 12-507 counts 15-s^{-1} as low-physical activity (LPA), 508-718 counts 15-s^{-1} as MVPA, and $\geq$ 719 counts 15-s^{-1} defined vigorous-physical activity (VPA) [21]. The cut points used were derived by Evenson et al. and have been widely used to assess PA behaviors in young children using the Actical [21].

The measured % time in MVPA was calculated by summing the number of minutes in which the activity counts were $\geq$ 508 counts 15-s^{-1}. The summed counts then were divided by 15 (i.e., minutes of measured data) and then multiplied by 100.

Estimated EE also was reported in minute-by-minute counts. EE prediction equations in the Actical software use the variables of kilocalories, counts per minute and body weight [kilograms (kg)], to determine overall EE. Participant estimated EE was calculated by averaging the 15, minute-by-minute EE counts, as reported by the Actical software. The averaged EE count was found by first summing all the EE counts and then diving by 15 (i.e., the total counts of measured activity in 15 minutes). Next, participant weight (kg) was multiplied by the averaged

EE count. Finally, the product of the averaged EE count x body weight (kg), was multiplied by 15 (i.e., measured time engaged in PA) to determine the estimated EE within 15 minutes:

Estimated EE = [(averaged EE counts/ kg/ minute) x (body weight) (kg)] x 15 minutes (time in measured activity)

Direct Observation. Trained observers used the DO instrument CARS to record each participant's activity levels. CARS has been shown to be reliable to assess children's PA, with high inter-rater reliability (90%) and within day test-retest repeatability [41].

The participant's activity level was recorded every 3 seconds by recording 1 of 5 codes: 1 (stationary/motionless), 2 (stationary/movement only of limbs and trunk), 3 (translocation-slow/easy), 4 (translocation-medium/moderate), and 5 (translocation-fast/strenuous) [41] (see Appendix B). Observers used synchronized mp3-players with a set 3 second beep, as a way to cue when the observers should take measures. Both observers wore earphones in order to hear the beep, and so as not to disturb study participants.

Trained observers watched the child and rated the observed activity as long as the activity occurred for at least 3 seconds. If there was a change in activity level and the new activity level was performed for less than 3 seconds, the new activity was not recorded [41]. Primary and secondary observers worked independently of each other to code each participants activity for the 2 conditions [OP and AVG]. Once coding was initiated for a participant, it was not stopped until 15 minutes of activity data were collected. To ensure observational data were precise, observers synchronized watches with a fixed start and stop time. Watches also were synchronized to the initialized accelerometers, which allowed for accelerometer epochs to correspond with DO recordings. The primary observer coded PA participation for all study participants. The secondary observer independently coded PA participation for a subsample (i.e.,

11 of 16) of participants. Percent mean agreement between the primary and secondary observers was assessed within the two conditions [OP vs. AVG]. Also, using a Kappa coefficient, inter-rater reliability for CARS summary measures was determined.

The five CARS codes have been validated using maximal VO_2 and heart rate measurements [41]. The five codes correspond to measured MET values: LPA = CARS 1.0 - 3.9, MPA = CARS 4.0 - 4.5, and VPA = CARS 4.6 – 5 [41]. Using the CARS criteria for PA intensity, DO was used also to assess the measured % time engaged in MVPA (DO_MVPA) in each session, with codes of $\geq$ 4 counting towards DO_MVPA.

Among all participants, the measured % time engaged in MVPA, was calculated by summing all time codes $\geq$ 4. The summed codes then were divided by 153 (i.e., the number of 3 second DOs in 15 minutes) and next multiplied by 100, resulting in participant % time engaged in DO_MVPA.

Data Analysis

All data analyses were conducted using SPSS (version 19.0), with a significance level set at an alpha < 0.05. For baseline demographic information, independent t-tests (continuous data) and Chi-Squares (X^2) (categorical data) were used to analyze for differences between the orders. Additionally, to determine if potentially confounding factors were different between conditions, room temperature and weather conditions were analyzed with a mixed-factorial analysis of variance (ANOVA), with a between-subject factor of order and a within-subject factor of condition. Furthermore, measures of diet, physical feeling, and liking of the activity, also were analyzed using a mixed-factorial ANOVA, with a between-subject factor of order and the within-subject factors of condition.

A significant difference of humidity was found between the orders within the AVG sessions. To control for this difference, a regression analysis was conducted on the primary DVs, activity counts/min, % time engaged in MVPA, % time engaged in DO_MVPA, and estimated EE from MET values, using humidity as the independent variable for each condition. Residualized values from the regressions were used in the 2 x 2 mixed-factorial ANOVA test with the between-subject factor of order and the within-subject factors of condition. Outcomes from each accelerometer were measured separately. Probability levels were based on the Greenhouse-Geisser test to control for sphericity in the mixed-factor ANOVAs where appropriate. Pairwise comparisons were used to analyze the differences in the sessions between the two orders. A Cohen's *d* test was used to estimate the appropriate effect size for each comparison between the two conditions.

Results

Participant Characteristics

A description of the participants may be found in Appendix A, Table 2. There were no significant differences between the orders in demographics or anthropometrics. Of the 16 participants, 62.5% were male, 81.3 % were white, and 100% were non-Hispanic. The mean age of study participants was 6.4 $\pm$ 0.8 years. Participants' were 47.2 $\pm$ 3.0 inches tall, weighed 48.9 $\pm$ 7.5 pounds, and had a zBMI of -0.18 $\pm$ 0.66.

Physical Activity and TV Questionnaire

Results of the Physical Activity and TV Questionnaire may be found in Appendix A, Table 3. There were no significant differences between the orders in parent's reports of their child's leisure-time activity. Outcomes for sedentary activity indicated that 75.0% of children spent 1 hour or less on weekdays engaging in recreational screen time, while 18.7% of children

spent 1 hour or less on weekend days engaging in recreational screen time. Additionally, 50% of children were reported to 'sometimes' eat while participating in screen time activities, and 93.7% of children were reported to not have a TV in their bedroom. Physical activity outcomes revealed that 56.2% of children were reported to spend 5-6 days per week, including weekends, playing/exercising hard enough to cause sweating and hard breathing. Parent's report of their child's activity level compared to other children revealed that 50.0% of parents believed that their children were just as active as their peers. Children's activity preference was assessed by asking parents to respond to the statement, "My child would rather watch TV or play in the house rather than play outside." Parent's report showed that 56.2 % of them did not agree with that statement. Lastly, for a typical weekday, children were reported to play outside for 139.6 $\pm$ 71.8 minutes per day and for a typical weekend day children played outside for 159.3 $\pm$ 91.7 minutes per day.

Experience with Active Video Games

A description of the Experience with Active Video Games questionnaire may be found in Appendix A, Table 4. There were no significant differences between the orders in parent's reports of their child's experience with AVGs. Outcomes revealed that 81.2% of children had no experience playing the Xbox 360 Kinect®. The number of Xbox 360 Kinect® AVGs the children had experience playing was 0.4 $\pm$ 0.8 games. Only 12.5% of the children reported having previous experience with the Xbox 360 Kinect®, Kinect Adventures! (RR) game. Despite the limited exposure to the Xbox 360 Kinect ®, 68.7% of children reported previous experience playing various other AVG systems and reported playing 2.6 $\pm$ 2.5 AVGs on other AVG systems.

Pediatric Quality of Life Inventory 4.0 (Peds QL™ 4.0)

No significant main effects or interaction in the children's reports of their health-related physical functioning was found in the conditions. The mean report of health-related physical functioning was 99.4 $\pm$ 2.1. See Appendix A, Table 5 for scores for each order by condition.

Dietary Intake

A description of dietary intake for all participants the morning of each condition may be found in Appendix A, Table 6. There were no significant main effects or interaction for total caloric intake (324 $\pm$ 118 Calories), or for percent total Calories from carbohydrates (67.2 $\pm$ 13.4%), fat (21.3. $\pm$ 10.2%), or protein (14.5 $\pm$ 4.7%).

Liking of Games: Physical Activity Enjoyment Scale (PACES)

No significant main effects or interaction in the children's reports of their enjoyment and liking of the activities performed in each condition were found. The mean report of the enjoyment and liking of the activities performed was 34.5 $\pm$ 1.4. See Appendix A, Table 7 for scores for each order by condition.

Weather Conditions

A description of weather conditions measured on-site, prior to the start of each condition may be found in Appendix A, Table 8. No significant main effects or interaction in temperature (72.0 $\pm$ 2.2°F) were found. However, there was a significant main effect of order in the percent relative humidity ($F(1,14) = 9.1$, $p < 0.01$), with a higher humidity in order 1 (74.1 $\pm$ 15.0%) than in order 2 (65.1 $\pm$ 4.2%).

Actical Accelerometer

Activity Counts per Minute

No significant main effects or interaction in participant's activity counts/minute for the accelerometer's located on the left hip (1676.7 $\pm$ 1375.3 activity counts/minute), left wrist (3058.2 $\pm$ 2227.8 activity counts/minute), or right wrist (3171.4 $\pm$ 2238.6 activity counts/minute) were found. Results of the activity counts/minute for each accelerometer placement site comparing the AVG and unstructured outdoor play conditions can be found in Appendix A, Figure 1.

Percent Time Engaged in Moderate-to-Vigorous Physical Activity (MVPA)

No significant main effects or interaction in the % time engaged in MVPA for the accelerometers located on the left wrist (84.5 $\pm$ 27.9 %) or right wrist (85.4 $\pm$ 27.5 %) of participants was found. A significant interaction ($F(1,14) = 5.4$, $p < 0.05$) of order x condition was found for the accelerometer located on the left hip of participants. Pairwise comparisons revealed a difference between the two orders ($p < 0.05$) in the AVG, with a higher % time engaged in MVPA in the AVG session in order 2 (74.5 $\pm$ 31.0%), than in order 1 (67.5 $\pm$ 32.1%). Pairwise comparisons also revealed differences between the AVG and unstructured outdoor play sessions ($p < 0.05$) within order 2, with a higher % time engaged in MVPA in the AVG (90.0 $\pm$ 10.6%) than in the unstructured outdoor play session (59.1 $\pm$ 37.6%). Results of the % time engaged in MVPA each accelerometer placement site comparing the AVG and unstrucutres outdoor play conditions can be found in Appendix A, Figure 2.

Estimated Energy Expenditure

No significant main effect or interaction in the estimated EE for the accelerometers located on the left hip (16.2 $\pm$ 7.4 kcal), left wrist (25.5 $\pm$ 15.5 kcal), or right wrist (26.1 $\pm$ 15.9

kcal) were found. Results of the estimated EE for each accelerometer placement site comparing the AVG and unstructured outdoor play conditions can be found in Appendix A, Figure 3.

ActiGraph GT3X+ Accelerometer

Activity Counts per Minute

No significant main effects or interaction for the ActiGraph's activity counts/minute (5372.3 $\pm$ 2845.7 activity counts/minute) were found. Results of the ActiGraph's activity counts/minute by condition can be found in Appendix A, Figure 4.

Direct Observation

The percent mean agreement between the two raters was 94.4 % and 96.1% for the unstructured outdoor play and AVG conditions, respectively. The mean Kappa coefficient for agreement between all ratings in the outdoor play session was 0.93, with a range from 0.64-1.00, and for the AVG session was 0.93, with a range from 0.69-1.00.

There was a significant interaction ($F(1,14) = 4.895$, $p < 0.05$) of order x condition for the % time children engaged in MVPA using the CARS. Pairwise comparisons revealed differences in the AVG sessions ($p < 0.05$) between the two orders, with a higher % time engaged in MVPA in order 2 (23.8 $\pm$ 12.4%) as compared to order 1 (13.2 $\pm$ 12.9%). Results of the Direct Observation, Children's Activity Rating Scale (CARS): Percent Time Engaged in Moderate-to-Vigorous Physical Activity by condition can be found in Appendix A, Figure 5.

Discussion

This study compared AVGs to unstructured outdoor play as assessed by accelerometery and DO, in young children. The study measured children's activity counts/minute, estimated EE, and % time in MVPA in each condition.

This study found that activity levels, as determined by all measures, were comparable in both conditions of AVG and unstructured outdoor play in young children aged 5- to 8- years. Furthermore, objective measures found participants spent the majority of the time in MVPA in both conditions.

The finding that there was no difference in PA measurements between AVGs and unstructured outdoor play in children are consistent with results from Duncan et al., who also found that AVGs and unstructured outdoor play were comparable physical activities, and that AVGs may be a source of PA for children [59]. However, there are important methodological differences between the two studies. The differences in the two studies include study design, instruments used to assess PA, types of AVG used, length of the time frame of the measures, and repeatability of AVG exposure [59].

In terms of study-design, Duncan et al.'s used a quasi-experimental study design, where participants were placed in either the control or intervention group, and only experienced one condition, while the present study used a within-subjects design, where every participant experienced both conditions, and order was controlled by using a counter-balanced design. A within-subjects design prevents between-subjects variability, which increases consistency between conditions, to allow for greater internal control within the study. A quasi-experimental design does not possess these characteristics. Therefore, using a within-subjects design strengthens the present study and study outcomes.

For instruments used to assess PA, Duncan et al. used pedometry and HR monitors to determine PA [59]. Pedometry is a valid tool to determine average step-count during a designated time; however, pedometers are not the best tool to determine differing intensity levels of PA [73]. Furthermore, Duncan et al. used HR monitors to determine the % time in MVPA and

average HR. HR monitors are able to determine EE during steady-state exercise; however, they are unable to distinguish accurately between light- and moderate- intensity activities or to record frequency of the activity within a limited time frame [73, 74]. As young children tend to engage in sporadic bursts of activity followed by periods of rest during unstructured play, HR monitors are not the most efficient instrument to measure young children's % time in MVPA [59, 73, 74] . The present study used accelerometery and DO as PA measures. Accelerometry is a validated instrument that is more sensitive in assessing young children's PA levels, and provides detailed information regarding the intensity of time spent at different activity levels, and estimated EE [21, 73, 75-77]. Similarly, DO is another validated PA assessment tool that provides detailed information on the time length, and specific type of activity, and active movement being performed [23, 41]. Both accelerometry and DO are validated instruments shown to capture young children's inconsistent PA patterns, and accurately determine their physical activity level, better than either HR or pedometry [21, 23, 25, 35, 38, 59, 73].

The choice of AVG also differed between the two the studies. Duncan et al. used the Xbox 360® gaming console and the Gamerized Power Stepper® AVG, whereas the present study used the Xbox 360 Kinect® gaming console and Kinect Adeventures!® (RR) AVG. Kinect Adventures!® (RR) AVG, is a controller-free gaming system where children are required to engage in standing, full body play [66]. Gamers must stand in front of the Kinect® sensor where they are captured digitally and actually placed on the television screen [66]. The Xbox 360 Kinect® gets the whole body in the game due to is unique capabilities of motion sensors and skeletal tracking [66]. Where full body play is required by the Kinect Adventures!® (RR) AVG, the Gamerized Power Stepper® AVG utilizes just the lower body to activate play within the game. Gamers use an exercise stepping mat as the controller to play the game. Although gamers

remain active playing the Gamerized Power Stepper® AVG, only the lower body is engaged, whereas with the Kinect Adventures! ® (RR) AVG the gamers are required to use the whole body to play.

In terms of length of time frame of measures, Duncan et al. collected data in 30 minute sessions, with the sessions occurring 3 times over 6 weeks, while the present study collected data during 2, 15 minute sessions on 2 different days [59]. Thus the Duncan et al. collected data over a longer session and over a longer exposure time frame than the current investigation, increasing the external validity of the Duncan et al.'s study. [59]. The length of time playing an AVG within a session and over a longer time frame is important to investigate in regards to potential boredom effects. It is theorized that AVGs can offer a variety of gaming options, but one AVG cannot be made different each time it is used, whereas unstructured outdoor play has more options for variability in the types of play activities. For instance, outdoor play can continuously change each time by using different equipment (i.e., jump-rope versus playground balls), playing in a different environment/setting (i.e., a playground with structured equipment versus a swimming pool), or with different people. A weakness of AVG play is the inability to have the amount of control to affect variety as can be done with unstructured outdoor play. Despite the differences of the length of time frame apart and length of data collection, both studies revealed consistent results of AVG play being comparable to unstructured outdoor play.

Results of the study did reveal an order effect, with a higher % time engaged in MVPA in the AVG session in order 2, than in order 1. This outcome may have been due to a novelty effect. Order 2 introduced three novel components in session 1: the AVG (most children in the investigation had not played the AVG used in the investigation); the wearing of four accelerometers; and participating in the study with the investigator. In order 1, as the AVG was

played in the second session, only the AVG was novel. An order effect was not seen in the unstructured outdoor play, potentially as this was an activity that the children regularly engaged in. The familiarity with the unstructured outdoor play may have over-ridden any novelty aspects of wearing the accelerometers and participating in the study with the investigator. It is important to note that for the two activities evaluated in our study, both were well tolerated, and self-reported enjoyment was high in both conditions.

Results also revealed differences in the % time in MVPA between the DO and accelerometry, with a higher % of MVPA occurring as measured via accelerometry than through DO. This difference in % MVPA most likely is due to the difference in the two instruments methodology of assessing PA. For DO, participants' activity level was recorded every 3 seconds [41]. Trained observers watched the child and rated the observed activity as long as the activity occurred for at least 3 seconds. If there was a change in activity level and a new activity level was performed for less than 3 seconds, an activity was not recorded, rather a 0 was coded. Thus, a participant could be engaging in a consistent amount of MVPA, but rapidly changing types of activities (i.e., a quick sprint (code 5) to a slow walk (code 3), causing the data to be coded as a 0 because neither activity lasted 3 seconds. Thus, the methodology of DO used in this investigation may underestimate the children's % time spent in MVPA. In comparison, the accelerometers consistently collected activity data for the entire 15 minutes, contributing to a higher % MVPA.

Strengths of the current study include the use of two validated assessment tools, accelerometry and DO, to measure PA. Using two measurements allowed us to fully capture the changes in the children's activity levels as they occurred, thereby yielding potentially higher measurements of accuracy compared with an approach that uses just one assessment tool. Also, by using two validated assessment tools, the present study measured young children's activity

counts/minute, estimated EE, and % time in MVPA in each condition. Previous literature has evaluated these three measurements when comparing AVGs to PA measured in structured settings (e.g., treadmill walking); however, no other study has evaluated these three measurements to compare AVG to unstructured outdoor play in young children.

This study did not statistically compare accelerometer placements sites. Results did reveal a greater intensity in the wrists accelerometers in all DVs of activity counts/minute, estimated EE, and % in MVPA, and within both conditions, than in the hip accelerometers. It is theorized that this difference was due to the consistent hand motions young children perform, while translocating during play and when standing still.

Another strength is that, to our knowledge, this is the first study to use the new Xbox 360 Kinect® gaming console and Kinect Adventures!® (RR) AVG on children 5- to 8- years of age. The new Xbox 360 Kinect® is a controller-free gaming system where children are required to engage in standing, full body play [66]. Unlike other AVGs such as the Nintendo® Wii, Sony EyeToy™, and Sony DDR®, which do not require full body activity, the Xbox 360 Kinect® senses the entire body due to is unique capabilities of motion sensors and skeletal tracking [66]. Thus, to enable the gamer to play the AVG, a consistent activity level has to be maintained for the game to be played continually, leading to potentially higher activity levels than other AVGs, such as the Nintendo® Wii, Sony® EyeToy™, and Sony DDR®, which do not require consistent, full-body activity.

Additional strengths of the study include controlling for several factors that could influence children's activity level, such as weather conditions, dietary intake in the morning prior to each condition, and health-related physical functioning of the children. As stated previously,

this investigation used a within-subjects design to decrease between-subject variability. Finally, sessions were counter-balanced across participants to control for order effects.

The results of the current study should be interpreted in the context of its limitations. The study used a small, convenience sample size that produced small effect sizes (ActiGraph activity counts/minute = 0.10, and the left hip Actical activity counts/minute = 0.08, %MVPA = 0.22, and the estimated EE = 0.20) and, therefore, had inadequate power to detect differences in both research aims. The study sample consisted of primarily white, non-Hispanic, young children aged 5- to 8- years, within a healthy weight range. Future studies need to recruit a larger and more diverse study population to increase the generalizability of the findings. Additionally, future investigations should examine overweight and obese children, compared to normal weight children to determine if overweight and obese children reveal lower activity levels than normal weight children when playing AVGs.

Moreover, researchers have reported that children differ in their PA levels across different gender and age groups [78, 79]. Future studies might focus on the moderate effects of gender and age on children's activity levels related to AVG and outdoor play. This examination may be especially important during adolescence, when interests in PA and VGs begin to differ between genders.

Another limitation was that this study had a short time frame of the length of measures both within the sessions (i.e., children played the AVG for only 15 minutes) and across time (i.e., children were only exposed to the game once). The present study also offered a limited variety of games, using only one AVG to collect data. Researchers might want to examine children's interests in AVGs over a longer time frame of exposure, recognizing the need to examine variety

of games as a factor for continued play. Importantly, game variety could impose a cost issue which generally does not occur with outside play, and thus should also be examined.

Furthermore, during the AVG condition, each participant played solo on a single player mode. However, in the unstructured OP condition, a minimum of four other children were always on the playground with the participant. A person-minimum was established to ensure natural play would be elicited, as it as was common for the studied sample to engage with their peers while playing outside. As it was observed, the studied children eagerly engaged with their peers in various activities, such as chase, hula-hoop contests, and ball associated games (e.g., soccer, basketball, and bouncing/throwing the ball back-and-forth). Children, also became engrossed with their peers in their own imaginations' by engaging in pretend play with each other where they would 'fly' around the playground as airplanes; crouch, anxiously digging in the dirt in search of unique rocks; or stomp, run, or fly around the playground completely absorbed in the imaginative world they had created with their peer. To elicit these same peer-associated behaviors, future studies should run participants in pairs while playing AVGs. A study by Fairclough et al., determined that team-based games (i.e., soccer and football) usually promote relatively high activity levels due to the comradery and overall enjoyment of playing with one's peers [80]. Future studies could examine also the effects of AVGs on PA levels while gamers play competitive games set on a two-player mode, where participants would be actively competing against each other to achieve the higher score.

In conclusion, results revealed no differences between the conditions in the measured activity counts/minute, estimated EE, and % time engaged in MVPA. These results suggest that AVGs and unstructured outdoor play are comparable physical activities, and that AVGs may be a supplemental source of PA for children; however, future studies should examine issues of long-

term adherence to AVG play to determine if factors such as boredom and/or lack of variety in children's activity decreases over time.

Application

Physical inactivity in children and youth remains a significant health issue. New generation AVGs are an emerging technology that may serve as a means to increase PA in children, by altering normal sedentary VGs so that the VGs actually provide an option to engage in PA, rather than to be sedentary. New AVGs are designed to engage both the upper and lower body while providing opportunities for multiplayer participation that may improve the quality and enjoyment of this activity. AVGs also offer a continuous variety of gaming options appealing to multiple interests.

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APPENDICES

APPENDIX A: TABLES & FIGURES

Table 1: Overall Study Design

	Condition 1	**Condition 2**
Order 1	OP	AVG
Order 2	AVG	OP

Note: Outdoor play (OP), Active video game (AVG).

Table 2: Participant Characteristics (M ± SD)

Measures	Order 1 (n=8)	Order 2 (n=8)
Age (y)	6.5 ± 0.6	6.2 ± 0.8
Gender [n (%)]		
Boys	5 (62.5)	5 (62.5)
Girls	3 (37.5)	3 (37.5)
Race-ethnicity [n (%)]		
Asian	1 (12.5)	1 (12.5)
White	7 (87.5)	6 (75.0)
Black/African American	0 (0.0)	1 (12.5)
Ethnicity [n (%)]		
Hispanic or Latino	0 (0.0)	0 (0.0)
Height (in)	48.6 ± 2.6	45.9 ± 3.4
Weight (lbs)	51.5 ± 5.9	46.4 ± 8.9
zBMI	-0.17 ± 0.6	-0.19 ± 0.6

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP); y=years; in=inches; lbs=pounds; zBMI=BMI z-score.

Table 3: Physical Activity and TV Questionnaire Table [n (%)]

Questionnaire Items	Order 1 (n=8)	Order 2 (n=8)
1. Average recreational screen time per week day		
(1) 1 hour or less	5 (62.5)	7 (87.5)
(2) 2 hours	3 (37.5)	0 (0.0)
(3) 3 hours	0 (0.0)	1 (12.5)
(4) 4 hours	0 (0.0)	0 (0.0)
(5) 5 hours or more	0 (0.0)	0 (0.0)
2. Average recreational screen time per weekend day		
(1) 1 hour or less	0 (0.0)	3 (37.5)
(2) 2 hours	4 (50.0)	1 (12.5)
(3) 3 hours	4 (50.0)	3 (37.5)
(4) 4 hours	0 (0.0)	1 (12.5)
(5) 5 hours or more	0 (0.0)	0 (0.0)
3. Pairing of eating habits with recreational screen time		
(1) Never	0 (0.0)	1 (12.5)
(2) Almost never	1 (12.5)	3 (37.5)
(3) Sometimes	7 (87.5)	1 (12.5)
(4) Frequently	0 (0.0)	3 (37.5)
(5) Always	0 (0.0)	0 (0.0)
4. TVs located in children's bedroom		
(1) Yes	0 (0.0)	1 (12.5)
(2) No	8 (100.0)	7 (87.5)
5. Activity level of child compared to other children		
(1) Much less active	0 (0.0)	0 (0.0)
(2) A little less active	1 (12.5)	0 (0.0)
(3) Just as active	3 (37.5)	5 (62.5)
(4) A little more active	4 (50.0)	3 (37.5)

6. Average time per week children spend playing or exercising enough to sweat and breath hard		
(1) More than once a day	1 (12.5)	1 (12.5)
(2) Daily (7 days/week)	2 (25.0)	1 (12.5)
(3) 5-6 days/week	3 (37.5)	6 (75.0)
(4) 3-4 days/week	2 (25.0)	0 (0.0)
(5) 1-2 days/week	0 (0.0)	0 (0.0)
(6) < 1 day/week	0 (0.0)	0 (0.0)
(7) Never	0 (0.0)	0 (0.0)
7. Activity preference, watching TV and playing inside rather than play outside		
(1) Completely True	0 (0.0)	1 (12.5)
(2)	3 (37.5)	3 (37.5)
(3)	3 (37.5)	4 (50.0)
(4) Completely False	2 (25.0)	0 (0.0)
8. Average outside play time per week day. (minutes) (M ± SD)	150.0 ± 80.1	129.3 ± 63.6
9. Average outside play time per weekend day (minutes) (M ± SD)	170.6 ± 112.5	148.1 ± 71.0

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP).

Table 4: Experience with Active Video Games

Questionnaire Items	Order 1 (n=8)	Order 2 (n=8)
Children with no experience playing the Xbox 360 Kinect® (n,%)	6, 75.0	7, 87.5
Number of active video games played on the Xbox 360 Kinect® (M ± SD)	0.5 ± 0.9	0.3 ± 0.7
Children with no experience playing the Xbox 360 Kinect®, Kinect Adventures! (River Rush!) video game (n,%)	6, 75.0	8, 100.0
Children with experience playing other active video gaming systems (n,%)	5, 62.5	6, 75.0
Number of active gaming systems children had experience playing (M ± SD)	0.6 ± 0.5	0.8 ± 0.6
Number of active video games children had experience playing excluding Xbox 360 Kinect® games (M ± SD)	3.0 ± 3.4	2.3 ± 1.6

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP).

Table 5: Pediatric Quality of Life Inventory 4.0 (PedsQL™ 4.0) (M ± SD)

	Order 1 (n=8)		**Order 2 (n=8)**	
Questionnaire	**Session 1: OP**	**Session 2: AVG**	**Session 1: OP**	**Session 2: AVG**
PedsQL™ 4.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	97.9 ± 5.9

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP).

Table 6: Dietary Intake for All Participants the Morning of Each Session (M ± SD)

	Order 1 (n=8)		**Order 2 (n=8)**	
Measures	**OP**	**AVG**	**OP**	**AVG**
Total Calories	306 ± 142	326 ± 98	358 ± 148	305 ± 81
% Kcals CHO	68.3 ± 11.9	67.9 ± 13.8	65.4 ± 15.3	67.1 ± 14.3
% Kcals Protein	13.8 + 4.4	15.2 ± 3.7	16.0 ± 4.3	13.1 ± 6.3
% Kcals Fat	20.5 ± 10.5	20.1 ± 11.1	22.3 ± 10.1	22.5 ± 10.5

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP); CHO = Carbohydrate; % Kcals = Percent Calories.

Table 7: Physical Activity Enjoyment Scale (PACES) (M ± SD)

	Order 1 (n=8)		**Order 2 (n=8)**	
Questionnaire	**Session 1: OP**	**Session 2: AVG**	**Session 1: OP**	**Session 2: AVG**
PACES	34.8 ± 0.4	34.5 ± 1.4	35.0 ± 0.0	33.7 ± 2.6

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP).

Table 8: Weather Conditions during Each Session (M ± SD)

	Order 1 (n=8)		**Order 2 (n=8)**	
Measures	**Session 1: OP**	**Session 2: AVG**	**Session 1: OP**	**Session 2: AVG**
Temperature (°F)	72.5 ± 2.3	71.8 ± 3.6	71.8 ± 0.7	71.9 ± 2.0
% Relative Humidity	79.0 ± 11.9	69.3 ± 17.0	64.8 ± 4.5	65.4 ± 4.3

Note: Order 1= Session 1 outdoor play (OP) and Session 2 active video game (AVG); Order 2 = Session 1 active video game (AVG) and Session 2 outdoor play (OP).

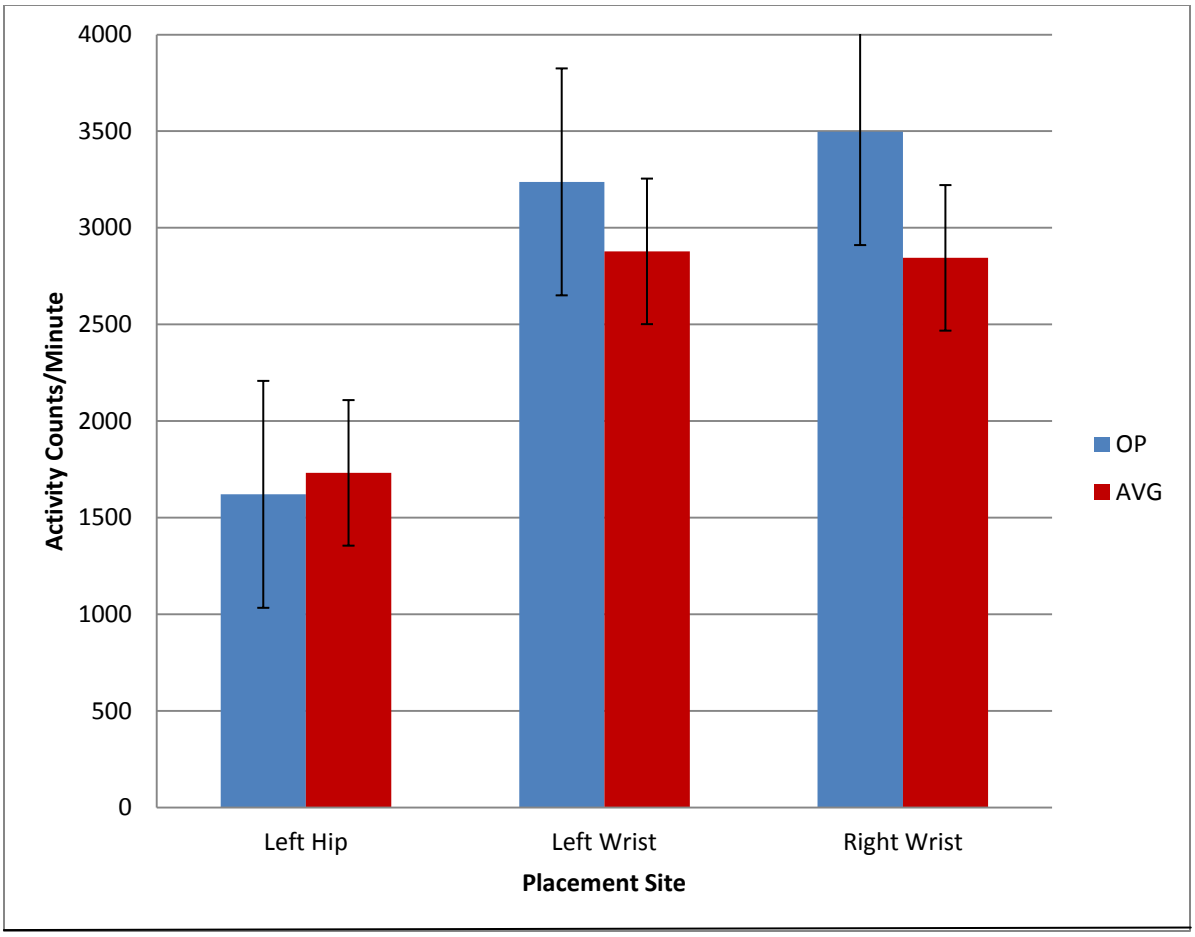

Figure 1: Actical Accelerometer Activity Counts per Minute (M ± SD).

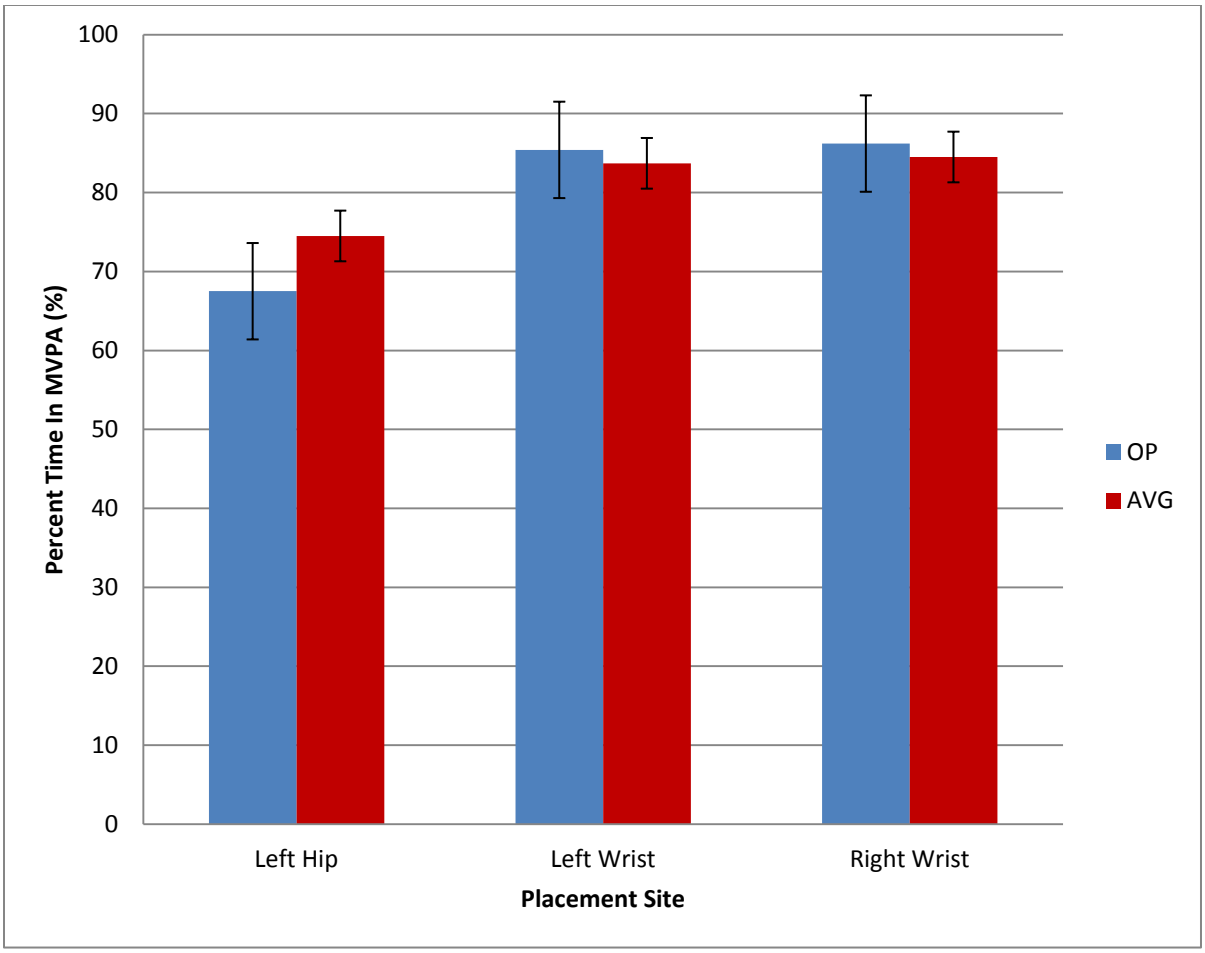

Figure 2: Actical Accelerometer Percent Time Engaged in Moderate-to-Vigorous Physical Activity (MVPA) (M ± SD).

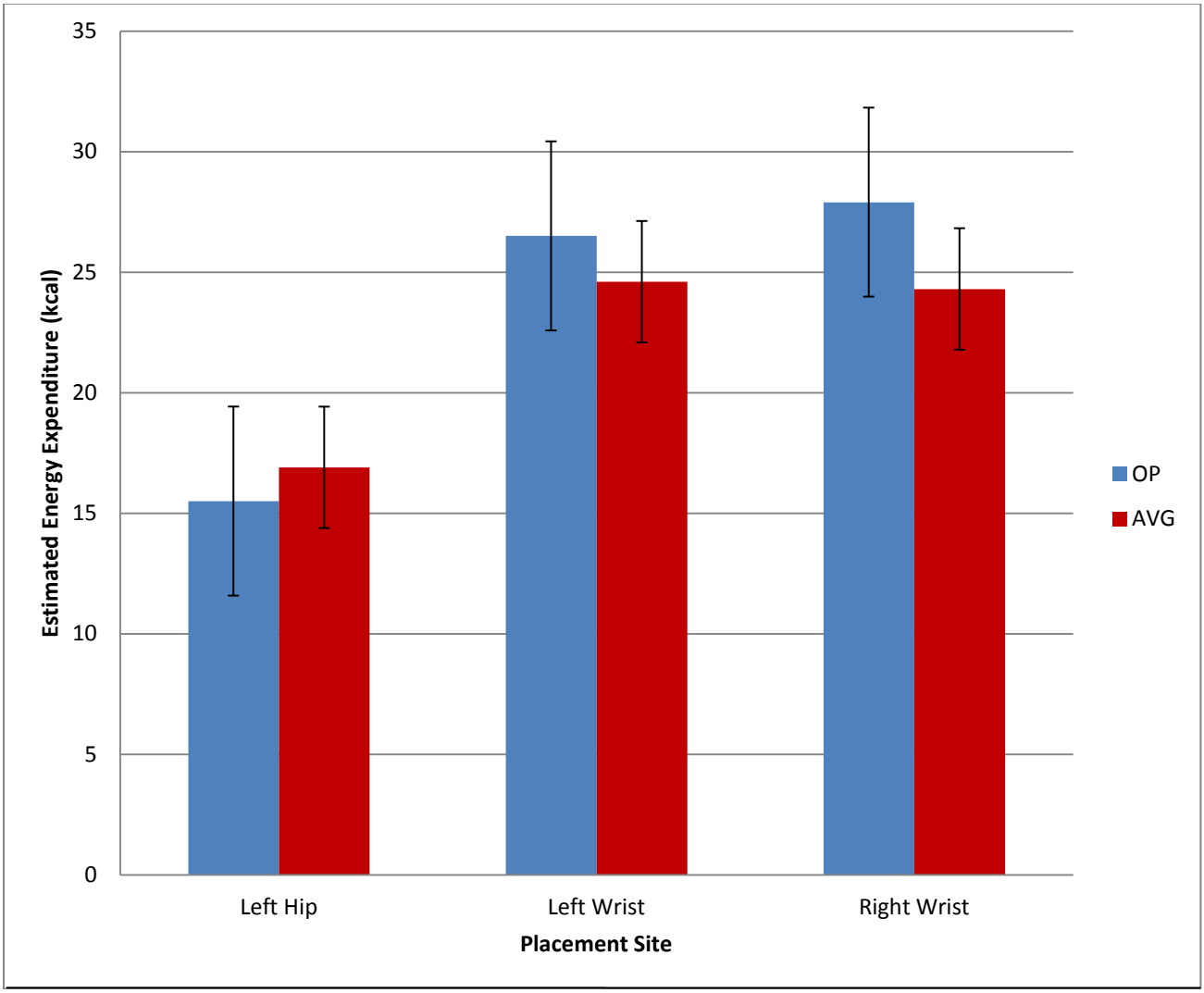

Figure 3: Actical Accelerometer Estimated Energy Expenditure (M ± SD).

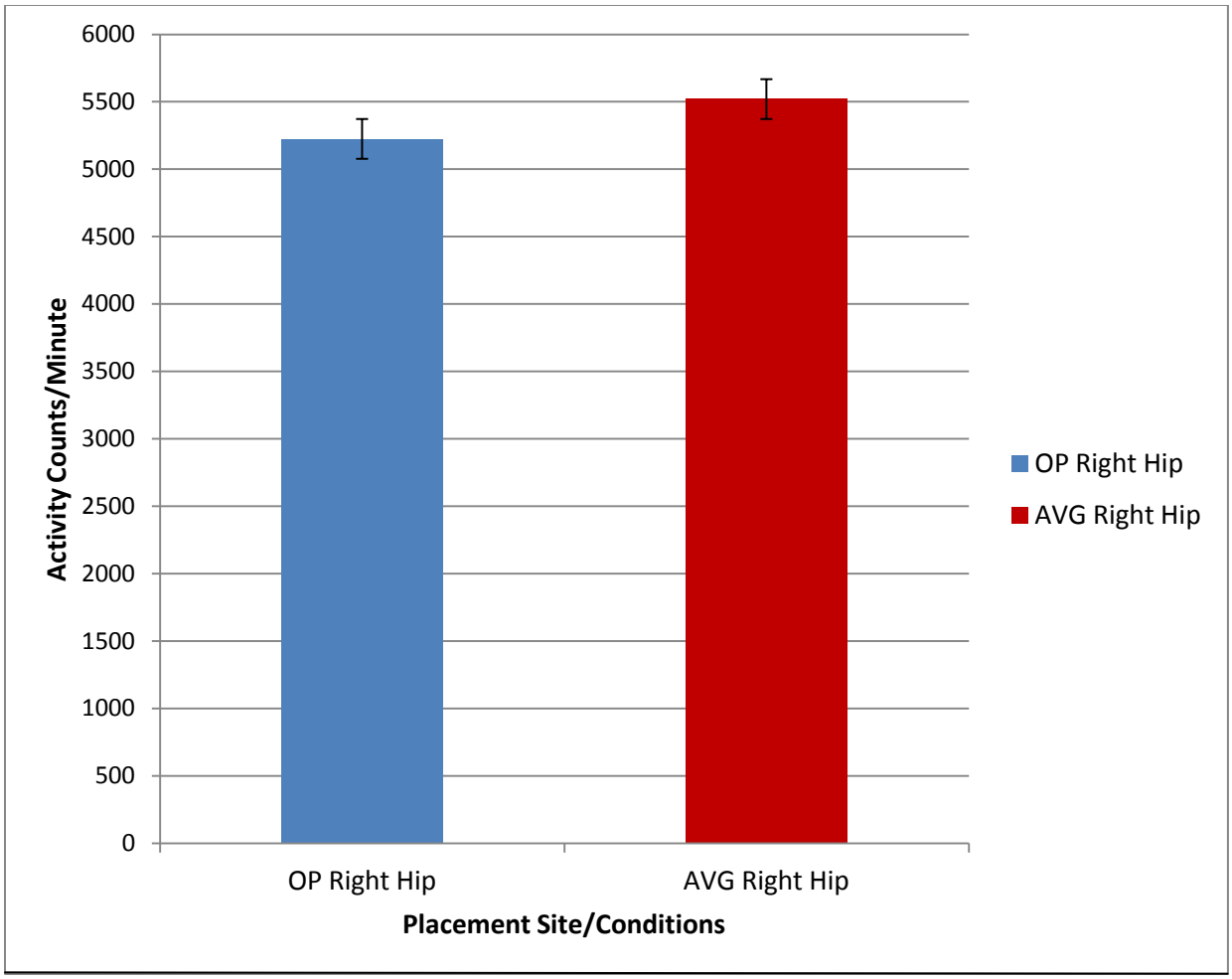

Figure 4: ActiGraph GT3X+ Accelerometer Activity Counts per Minute (M ± SD).

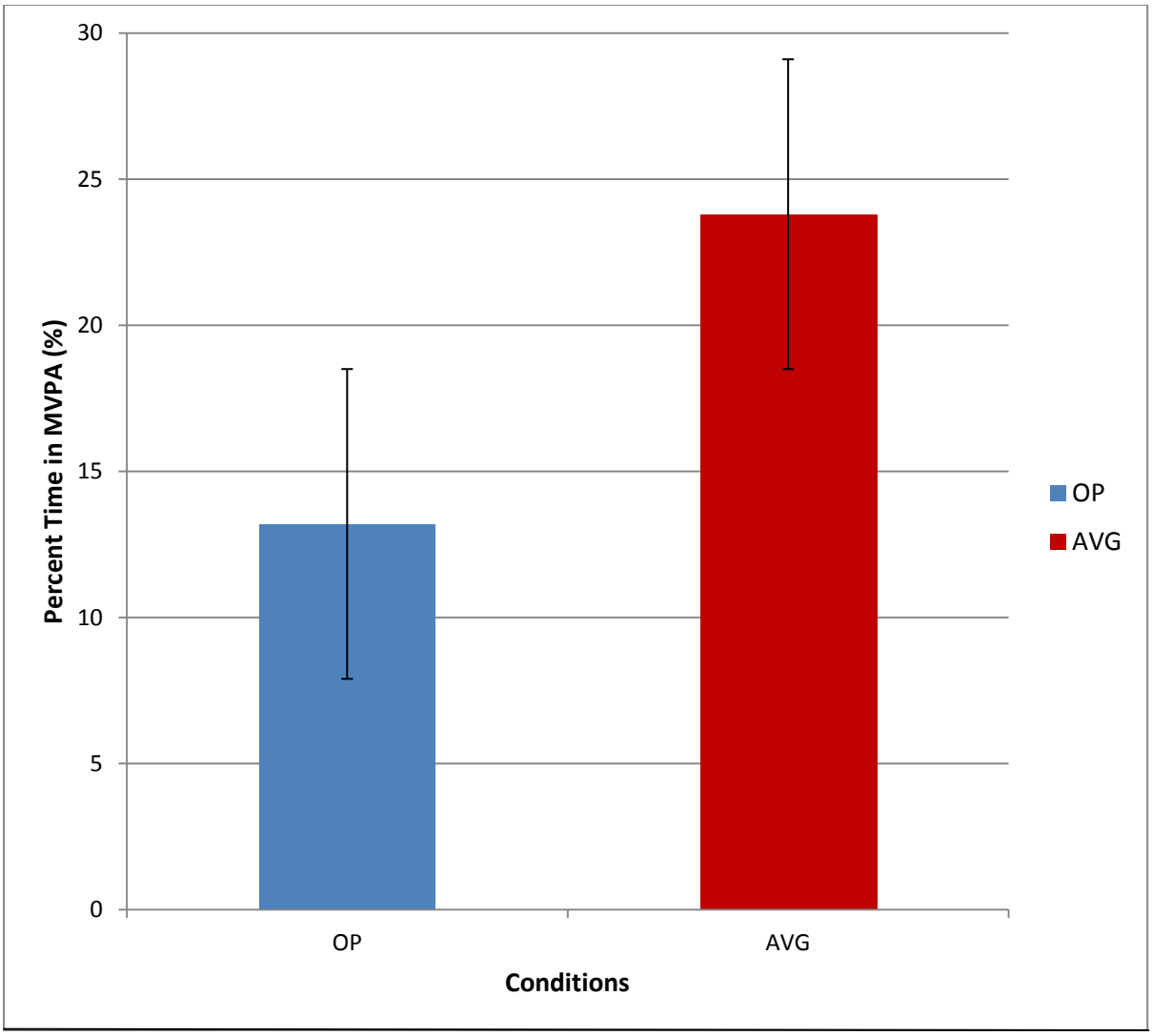

Figure 5: Direct Observation, Children's Activity rating Scale (CARS): Percent Time Engaged in Moderate-to-Vigorous Physical Activity (M ± SD).

APPENDIX B: FORMS

Packet 1: Checklist

Please complete and return the following forms to your child's teacher by_____:

___ Parent Consent (2)-keep one for records

___ Contact Information Sheet

___ Criteria for Eligibility Questionnaire

INFORMED CONSENT STATEMENT

Active Video Games Compared to Free-Living Outdoor Play: Measurements of Energy Expenditure and Percent Time in Moderate-to-Vigorous Physical Activity

INTRODUCTION

Your son/daughter has been invited to participate in a research study conducted at the University of Tennessee. For my study, I am trying to learn more about how much energy children use when they are playing. I want to learn about this because it is important that children get enough active play time every day.

In order to measure the amount of energy expended by children when they play, children will be asked to participate in two activities, 1) play the Xbox 360 Kinect ® Kinect Adventures! (River Rush) video game, and 2) engage in unstructured, outdoor play. Children will perform these two activities at the ELC. Your child's performance will not be measured in either activity, only their energy used in each activity, and the types of activity they do in each session, will be measured. The activities will take place in two sessions on two different days. The two sessions will be 50 minutes each. The study sessions will take place Mondays through Fridays, in the mornings from 7:30am- 9:30am during the following months; June, July, August and September of 2011.

If you and your child agree to participate your child will be placed in one of two groups. Both groups will come visit me two times. If you and your son/daughter are placed in group 1, your child will play outside the first time they visit me. As they are playing outside I will be outside with them, watching. My research assistance will also be watching. While watching your child play, we will also be writing down your child's activities. Then the second time your child visits with me, he/she will play the Xbox 360 Kinect ® Kinect Adventures! (River Rush) video game. When your child is playing the video game both researchers will be in the room observing and coding your child's physical activity. Data from the secondary observer will be used to assess for reliability. Both researchers will sign a pledge of confidentiality stating that all information collected and observed will be kept confidential. If you and your child are placed in group 2, your child will play the video game the time he/ she comes to visit me. Then the second time your child visits, he/she will play outside.

This form explains the study. Please read this form and contact the researcher with any questions. Britt MacArthur (865-974-0754). If you decide to allow your child to participate in the study, please initial each page of the form with your full signature on the last page.

Britt MacArthur, a graduate student at the University of Tennessee, advised by Dr. Hollie Raynor, an Associate Professor in the Department of Nutrition at the University of Tennessee, is doing a study to learn more about how much energy children use when playing the Xbox 360 Kinect ® Kinect Adventures! (River Rush) video game and engaging in unstructured, outdoor play. It is estimated that 15 children, who attend the Early Learning Center on White Avenue and who are 5- to 8- years of age, will participate in the study

You and your child have been asked to participate in the study because your child attends school at the Early Learning Center on White Avenue and meets the age eligibility criteria of being 5- to 8- years old. Additional eligibility criteria include no impairments to engage in physical activity, no allergies to grass, no sensitivity to sunlight, and being of a healthy weight.

INFORMATION ABOUT PARTICIPANTS' INVOLVEMENT IN THE STUDY

If you decide to have your child participate in the study, please return a signed and initialed consent form, a contact information sheet, and the criteria for eligibility questionnaire, sealed, in the manila envelope provided to your child's teacher at the Early Learning Center on White Avenue. If your child meets eligibility requirements, a second packet containing four questionnaires assessing demographics, dietary intake, video game experience, and physical activity behaviors will be sent home. It will take you about 25 minutes to complete the questionnaires. Please complete the questionnaires and return them to the research assistant on the morning of your child's first scheduled session.

After your forms have been completed and returned to the Early Learning Center, you will receive a call from a trained research team from the Healthy Eating and Activity Laboratory (HEAL), which is direct by Dr. Raynor, at the University of Tennessee. This phone call will be delivered to schedule the 2 sessions, and give you and your child the opportunity to ask any additional questions or express any concerns both you and your child may have regarding the study. While scheduling the sessions, parents will be asked that on the morning of each session to have their child maintain their usual breakfast intake and record the child's intake on the dietary form included in the packet. A reminder call will be delivered the day before each session to remind parents of their child's scheduled session and to remind parents to have their child maintain usual breakfast intake and record the child's intake. Dietary forms will be collected at the beginning of each session.

All measurements will take place in an empty classroom at the Early Learning Center on White Avenue. For each session, dietary measures will be collected from the parents. All sessions will begin by escorting children to an empty classroom in the ELC, where verbal assent will be obtained and documented by the researcher. Participants will then be asked to report how they are physically feeling. Measures of height and weight will also be taken at the first visit. Your child will be asked to remove his/her shoes and to stand tall to measure height using a stadiometer. Your child will also be asked to step onto a portable electronic scale to measure weight. All measures will be taken individually by trained research staff members. It will take about 10 minutes per child to take measurements. If your child is above or below the healthy weight criteria (body mass index (BMI)-for-age percentile below the 5th percentile or above the 85th percentile), your child will be ineligible and not participate in the second session of the study.

Eligible children will then participate in 2 complete sessions in which they will engage in unstructured, outdoor play and play the Xbox 360 Kinect ® Kinect Adventures! (River Rush) video game. The procedures for that session will be reviewed with the child and all questions

will be answered. Participants will be made aware that water is available to them during the session.

The first session will include a familiarization with the accelerometers—a small, square, light weight device that measures activity levels and intensity. Your child will also be introduced to a questionnaire that will be used to measure their liking and enjoyment of the activity.

In all session, each child will wear four accelerometers. Two will be placed on an adjustable elastic strap, to be worn around the waist to detect lower body movement. The other two, accelerometers will be placed on both wrists of the participants using soft adjustable straps, which will be used to detect upper body movement. Following the placements of the accelerometers, participants will be given a 5 minute "warm-up" period in their activity session to allow the child to become familiar with the game, as well as allow them to get involved with an activity outside. Following the "warm-up," your child will then engage in 15 minutes of activity that will be measured. During the measurement period, at least one trained research observer will be watching your child while simultaneously, coding your child's activity. Following the 15 minute measurement period, the accelerometers will be removed and your child will then be asked to rate their liking and enjoyment of the activity. After each session, your child will be allowed to pick a book or a puzzle as a prize helping me.

Total participation time for each session is estimated to be 50 minutes. All sessions will take place in the mornings between 7:30-9:30am. All sessions will be scheduled within three weeks of the child's initial session. These sessions will take place during the month of June, July, August, and September 2011.

Each child will participate in the 2 sessions, but will be randomly assigned to the order by which they participate in the sessions.

Please contact Britt MacArthur at (865)-974-0754 or email smacarht@utk.edu, if you and/or your child have any questions about the procedures of the study.

RISKS

Participants are at minimal risk as there are no risks beyond that encountered in normal play behaviors. A child with any known medical conditions that would limit their ability to participate in the study (i.e., cardiopulmonary, metabolic, or orthopedic disease condition or aliment; grass allergy or sensitivity to sunlight) will not be eligible to participate in the study.

BENEFITS

Anticipated benefits to the participant are that the children will get to play the new Xbox 306 Kinect ® Kinect Adventures! (River Rapids) video game. Anticipated benefits for the researcher include a controlled environment to collect valuable information for the advancement of pediatric physical activity behaviors.

CONFIDENTIALITY

All information collected in the study will be kept confidential. A unique code will be used to identify each participant with no reference to individual names, addresses, or phone numbers. No reference will be made in oral or written reports which could link participants to the study. All information will be stored in locked filing cabinets in locked rooms in the Healthy Eating and Activity Laboratory, Room 102 in the Jessie Harris Building. Only the project researchers will have access to participant information. . Once the study has closed all participant information will be properly destroyed. Procedures to protect confidentiality will be approved by the University of Tennessee's Institutional Review Board to ensure they meet standards for the protection of human subjects.

COMPENSATION

As compensation, each child will have the choice to choose from a variety of age-appropriate books or puzzles after the completion of each session.

EMERGENCY MEDICAL TREATMENT

The University of Tennessee does not "automatically" reimburse subjects for medical claims or other compensation. If physical injury is suffered in the course of research, or for more information, please notify the investigator in charge, Britt MacArthur at (865)-974-0754.

CONTACT INFORMATION

If you have questions at any time about the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact the researcher, Britt MacArthur, at Healthy Eating and Activity Laboratory, 102 Jessie Harris Building, 1215 W Cumberland Avenue and (865) 974-0754. If you have questions about your rights as a participant, contact the Office of Research Compliance Officer, Brenda Lawson, at (865) 974-3466.

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at anytime without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed you data will be returned to you or destroyed.

CONSENT

I have read the above information. I have received a copy of this form. I agree to allow my child to participate in this study.

Legal guardian signature _____ Date _____

Investigator's signature _____ Date _____

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Contact Information

Child's Name:	
Primary Caretaker's Name:	
Phone:	**Home:**
	Cell:
	Work:
Address:	
Email Address:	

1. Is this your child's first experience at the Early Learning Center on White Avenue?

☐ Yes ☐ No

2. Please mark the week(s) your child will be attending camp:

___ Our Independence (July 5-8)

___ The Amazing Race 3 (July 11-15)

___ The Incredible World Around Us (July 18-22)

___ Mission Possible (July 25-29)

___ Me, Myself, and I (August 1-5)

3. Will your child be attending the Early Learning Center on White Avenue in the fall of 2011?

☐ Yes ☐ No

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Eligibility Questionnaire-Caretaker

If you have provided consent for your daughter/son to participate in the research study please answer the following questions to ensure you child is eligible for the study.

1. Child's age: ☐☐

2. Does your child have any medical conditions that would limit their ability to participate in the study (i.e., cardiopulmonary, metabolic, or orthopedic disease condition or ailment; grass allergy or sensitivity to sunlight)?

_____
_____
_____
_____

3. Please report your child's height and weight

Child's height: _____ft._____in. weight: _____lbs

(Example: _4_ft._3__in. weight: __74__lbs)

Office Use Only
BMI:_____

Packet 2: Checklist

Please complete the following forms and return on your child's first scheduled session-_____:

___ Caretaker Demographic Questionnaire/Child Demographic Questionnaire

___ Physical Activity and TV Questionnaire

___ Experience with Active Video Games

___ Dietary Form (2)
To be turned on morning of scheduled sessions

Office Use Only
Reference #:
Assessment #:

DATE □□/□□/□□
M M D D Y Y

Caretaker Demographic Information

Please fill out this questionnaire if you are the caretaker primarily in charge of the child that will be involved in this study.

1. AGE □□

2. SEX: ☐ MALE (1) ☐ FEMALE (2)

3. RELATIONSHIP TO CHILD

☐ (1) Mother (biological, adopted, step-parent)
☐ (2) Father (biological, adopted, step-parent)
☐ (3) Grandmother
☐ (4) Grandfather
☐ (5) Aunt
☐ (6) Uncle
☐ (7) Sister
☐ (8) Brother
☐ (9) Cousin
☐ (10) Legal guardian
☐ (11) Other (specify):_____

4. EDUCATION: Check years of school completed. (CHECK ONLY ONE ANSWER)

☐ (1) Grade School (6 yrs or less)
☐ (2) Junior High School (7-9 yrs)
☐ (3) High School (10-12 yrs)
☐ (4) Vocational Training (beyond High School)
☐ (5) Some College (less than 4 yrs)
☐ (6) College/University degree
☐ (7) Graduate or Professional Education

Office Use Only
Reference #:
Assessment #:

5. MARITAL STATUS:

☐ (1) Married
☐ (2) Separated
☐ (3) Divorced
☐ (4) Widowed
☐ (5) Never Married
☐ (6) Not Married (living with significant other)
☐ (7) Other (specify): _____

6. Which of the following best describes your racial heritage? (you may choose more than one)

☐ (1) American Indian or Alaskan Native
☐ (2) Asian
☐ (3) Black or African American
☐ (4) Native Hawaiian or other Pacific islander
☐ (5) White
☐ (6) Other _____

7. Which of the following best describes your ethnic heritage?

☐ (1) Hispanic or Latino
☐ (2) Not Hispanic or Latino

Office Use Only
Reference #:
Assessment #:

Child Demographic Information

1. CHILD'S BIRTHDATE ☐☐/☐☐/☐☐☐☐
   M M D D Y Y Y Y

2. SEX: ☐ MALE (1) ☐ FEMALE (2)

3. Which of the following best describes this child's racial heritage? (you may choose more than one)

   ☐ (1) American Indian or Alaskan Native
   ☐ (2) Asian
   ☐ (3) Black or African American
   ☐ (4) Native Hawaiian or other Pacific islander
   ☐ (5) White
   ☐ (6) Other _____

6. Which of the following best describes your child's ethnic heritage?

   ☐ (1) Hispanic or Latino
   ☐ (2) Not Hispanic or Latino

Office Use Only
Reference #:
Assessment #:

DATE

☐☐/☐☐/☐☐

M M D D Y Y

Physical Activity and TV Questionnaire

Please circle the answer for each question that best describes your child's TV watching habits.

1. On a typical **weekday**, on average, how many hours per day does your child watch TV, video, DVD, or use the computer (not for school)?

1 hour or less	2 hours	3 hours	4 hours	5 hours or more
(1)	(2)	(3)	(4)	(5)

2. On a typical **weekend** day, on average, how many hours per day does your child watch TV, video, DVD, or use the computer (not for school)?

1 hour or less	2 hours	3 hours	4 hours	5 hours or more
(1)	(2)	(3)	(4)	(5)

3. How often does your child eat while watching TV/DVD/video or playing with the computer?

Never	Almost never	Sometimes	Frequently	Always
(1)	(2)	(3)	(4)	(5)

4. Does your child have a TV in his or her bedroom?

Yes	No
(1)	(2)

Please circle the answer for each question that best describes your child's activity habits.

5. How active is your child compared to other children his or her age?

Much less active	A little less active	Just as active	A little more active
(1)	(2)	(3)	(4)

Office Use Only
Reference #:
Assessment #:

6. How many times, in a typical week, including weekdays and weekends, does your child play or exercise enough to sweat and breath hard?

More than once a day	Daily	5-6 days/week	3-4 days/week	1-2 days/week
(1)	(2)	(3)	(4)	(5)

< 1day/week	Never
(6)	(7)

7. My child would rather watch TV or play in the house rather than play outside.

1	2	3	4
Completely True			Completely False

8. How much time would you say your child spends playing outdoors on a typical **weekday**?

_____Hours _____Minutes

Office Use Only
_____ mins.

9. How much time would you say your child spends playing outdoors on a typical **weekend day**?

_____Hours _____Minutes

Office Use Only
_____ mins.

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Experience with Active Video Games

Please fill out this questionnaire if you are the caretaker primarily in charge of the child that will be involved in this study.

1. My child has experience playing the Xbox 360 Kinect.

☐ Yes (1) ☐ No (2)

1a. → Please list any games your child has previous experience playing. _____

_____

_____

_____

2. My child has experience playing the Xbox 360 Kinect, River Rush (Kinect Adventures!) video game.

☐ Yes (1) ☐ No (2)

3. My child has previous experience playing other active video gaming systems such as, Nintendo® Wii, Sony EyeToy™ or Dance Dance Revolution®.

☐ Yes (1) ☐ No (2)

3a. → Please list any gaming systems your child has experience playing. _____

_____

_____

_____

Office Use Only
Reference #:
Assessment #:

4. If mark "Yes" to question 3, please list the video games your child has experience playing on the related gaming systems (i.e., Nintendo® Wii, Sony EyeToy™ or Dance Dance Revolution).

_____

_____

_____

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Breakfast Record

Session 1

In the table below, please write down a description of what your child ate and drank for breakfast. In the description, include the time that he/she ate, a description of each item he/she ate or drank, and the amount of each item consumed.

Example: At breakfast (7:00 am), Tom ate a bowl of cereal, banana, toast with peanut butter and orange juice.

Time	**Description of Food and Drink**	**Amount Consumed**
7:00	Bowl of cereal	
	Frosted Flakes (Kellogg's)	3/4cup
	Milk 1%	8 oz
	Banana medium (7 inches)	1
	Wheat Bread	1 slice
	Peanut Butter (Jif creamy, regular)	2 Tbsp
	Orange juice (Tropicana)	10 oz

Time	Description of Food and Drink	Amount Consumed

Is this a normal weekday breakfast?

More than Normal	Normal	Less than Normal
(1)	(2)	(3)

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Breakfast Record

Session 2

In the table below, please write down a description of what your child ate and drank for breakfast. In the description, include the time that he/she ate, a description of each item he/she ate or drank, and the amount of each item consumed.

Example: At breakfast (7:00 am), Tom ate a bowl of cereal, banana, toast with peanut butter and orange juice.

Time	**Description of Food and Drink**	**Amount Consumed**
7:00	Bowl of cereal	
	Frosted Flakes (Kellogg's)	3/4cup
	Milk 1%	8 oz
	Banana medium (7 inches)	1
	Wheat Bread	1 slice
	Peanut Butter (Jif creamy, regular)	2 Tbsp
	Orange juice (Tropicana)	10 oz

Time	Description of Food and Drink	Amount Consumed

Is this a normal weekly breakfast?

More than Normal	Normal	Less than Normal
(1)	(2)	(3)

Active Video Games Compared to Unstructured, Outdoor Play: Measurements of Estimated Energy Expenditure and Measured Percent Time in Moderate-to-Vigorous Physical Activity

Assent Form

Please read this assent form to your child if you are the caretaker primarily in charge of the child that will be involved in this study.
This form explains the study.

I. In Tennessee assent is required for children (17 years of age and younger) participating in a research study. Assent must be obtained in addition to parental consent.

Examiner: Hello! Thank you for your interest in my study. I am trying to learn more about how much energy kids use when they are playing. I want to learn about this because it is important that kids, just like you, get enough active play time every day. If you would like, you can be in my study.

If you decide you want to be in my study, you will be placed in one of two groups. Both groups will come visit me two times. If you are placed in group 1 you will play outside the first time you visit with me. As you play outside I will be outside with you, watching. My friend will also be watching. While watching you play, we will be writing down what you do. Then the second time you visit with me you will play the Xbox 360 Kinect, River Rush (Kinect Adventures!) video game. While playing the video game I will be in the room with you watching you and writing down what you do. My research assistant will also be in the room watching and recording what you do. For both activities, playing outside and playing the video game, I am not interested in how well you do, but just what you do. If you are placed in group 2 you will play the video game the first time you come visit me. Then the second time you visit you will play outside.

Do you have any questions for me so far?

Since this is your first visit with me I will measure how tall you are and see how much you weigh. Then I will ask you how you are feeling and if your body hurts or aches too badly to play. If you do not feel good or hurt you do not have to play. If you feel good and do not hurt then you can play. Before playing you will be asked to wear a belt with two devices, called accelerometers. This belt will be placed around your waist. Also, two accelerometers will be placed on your wrists. These devices do not hurt. They measure how much energy you use when you play and how fast you can run. Water will be available to you while you are playing if you need it. When you are done playing, I will ask you to mark how much you enjoyed the activity. When we are all done, you can pick a book or a puzzle as a prize for helping me today.

Water will be available to you while you are playing if you need it. Also, if you get tired while playing, just let me know and you can stop to rest. Participating in this study will help me learn more about the energy kids use when they are playing.
Other people will not know if you are in my study. I will put things I learn about you together with things I learn about the other children, so no one can tell what things came from you. When I tell other people about my research, I will not use your name, so no one can tell who I am talking about. Also, no one other than my friend will see your information. All information I collect on you will be kept in a locked closet. When the study is over I will destroy the information.

Your parents or guardian have to say it's OK for you to be in the study. After they decide, you get to choose if you want to do it too. If you don't want to be in the study, no one will be mad at you. If you want to be in the study now and change your mind later, that's OK. You can stop at any time.

My telephone number is (865)-974-0754. If you have any questions later that you cannot think of now you can call me.

I have two of these forms. If you want to be in my study, please write your name on both forms. You can keep one copy for yourself to take home and I will keep a copy.

Agreement

I have decided to be in the study even though I know that I don't have to do it.

_____ _____
Signature of Participant Date

_____ _____
Signature of Researcher Date

Active Video Gaming Compared to Free-Living Outdoor Play in Children: Measurements of Energy Expenditure and Percent Time in Moderate-to-Vigorous Physical Activity

Assent Form

I. In Tennessee assent is required for children (17 years of age and younger) participating in a research study. Assent must be obtained in addition to parental consent.

Child's Name: _____

Examiner: Hi _____ (insert child's name). This is your last visit with me and today we will play outside. Again I am going to ask you if you are still willing to participate in the study. If you agree, then I will ask you how you are feeling and if your body hurts or aches too badly to play. If you do not feel good or hurt you do not have to play. If you feel good and do not hurt then you can play. Before playing you will need put the belt with two accelerometers around your waist, again. You will also need to wear the other two accelerometers around your wrists. Remember, these devices do not hurt. We are using them to measure how much energy you use when you play and how fast you can run. Also, remember water will be available to you while you are playing if you need it. When you are done playing, you will be asked to mark how much you enjoyed the activity. As you play outside I will be outside with you, watching. My friend (insert Research Assistants name and introduce Research Assistant to child) will also be watching you. While watching you play, we will also be writing down how you play. When we are all done, you can pick a book or a puzzle as a prize for helping me today.

Helping me today is up to you. If you decide you don't want to play, that's okay, nobody will be mad at you.

Are you willing to help with this project?

☐Yes

☐No

Great! I think you will find that these things are easy and fun to do. If you decide that you don't want to do this anymore, all you have to do is tell me. You can just say, "I don't want to play this anymore." Okay?

☐Yes

☐No

Are you ready to take part in the program? Let's begin.

II. The examiner will use the following procedures during the course of test administration:

- Maintain a pleasant facial expression.
- Give general reinforcement by means of these example comments:

"You're really working hard."
"Good work!"
"You are really listening well!" (Child's first name), I'm proud of the hard work you are doing."
"You did turn your eyes and ears on, didn't you?"

III. The examiner will use the following procedures at the end of test administration:

- If the child wishes to stop during the testing, the examiner will maintain a neutral expression, close any material, and say, "All right, thank you for helping me again. Let's go back to the classroom."

When the testing is completed, the examiner will say, "Thank you for helping me again. You have really worked hard today. You can pick a book or a puzzle as a prize for all your good work. You may choose one. Let's go back to the classroom."

IV. These behavioral management guidelines will be followed during test administration:

- Prompts will include phrases such as:
  "Keep listening carefully."
  "Please wait until I am finished with the question before you give your answer."
  "Please keep your eyes and your ears turned on."
- If the child is unable to be conditioned to participate in the study, administration will be discontinued.

Active Video Games Compared to Unstructured, Outdoor Play: Measurements of Estimated Energy Expenditure and Measured Percent Time in Moderate-to-Vigorous Physical Activity

Assent Form

I. In Tennessee assent is required for children (17 years of age and younger) participating in a research study. Assent must be obtained in addition to parental consent.

Child's Name: _____

Examiner: Hi _____ (insert child's name). This is your last visit with me and today we will play the Xbox 360 Kinect, River Rush (Kinect Adventures!) video game. Again I am going to ask you if you are still willing to participate in the study. If you agree, then I will ask you how you are feeling and if your body hurts or aches too badly to play. If you do not feel good or hurt you do not have to play. If you feel good and do not hurt then you can play. Before playing you will need put the belt with two accelerometers around your waist, again. You will also need to wear the other two accelerometers around your wrists. Remember, these devices do not hurt. We are using them to measure how much energy you use when you play and how fast you can run. Also, remember water will be available to you while you are playing if you need it. When you are done playing, you will be asked to mark how much you enjoyed the activity. As you play the video game I will be in the room with you, watching. My friend (insert Research Assistant's name and introduce Research Assistant to child) will also be watching you. While watching you play, we will also be writing down how you play. When we are all done, you can pick a book or a puzzle as a prize for helping me today.

Helping me today is up to you. If you decide you don't want to play, that's okay, nobody will be mad at you.

Are you willing to help with this project?

☐Yes

☐No

Great! I think you will find that these things are easy and fun to do. If you decide that you don't want to do this anymore, all you have to do is tell me. You can just say, "I don't want to play this anymore." Okay?

☐Yes

☐No

Are you ready to take part in the program? Let's begin.

II. The examiner will use the following procedures during the course of test administration:

- Maintain a pleasant facial expression.
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  "Keep listening carefully."
  "Please wait until I am finished with the question before you give your answer."
  "Please keep your eyes and your ears turned on."
- If the child is unable to be conditioned to participate in the study, administration will be discontinued.

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Anthropometrics

BMI =

$\frac{\text{Mass(kg)}}{[\text{Height(m)}]^2}$	$\frac{\text{Mass(lb) x 703}}{[\text{height (in)}]2}$

BMI Categories	Normal: 18.5 -- 22.9	Overweight: 23.0-- 24.9	Obese: 25.0 ≤

Child Height: _____ft._____in. Weight: _____lbs

Child BMI (kg/m^2): _____

Weight Status Category	**Percentile Range**
Underweight	Less than the 5th percentile
Healthy weight	5th percentile to less than the 85th percentile
Overweight	85th to less than the 95th percentile
Obese	Equal to or greater than the 95th percentile

Child BMI %: _____

Child BMI z-score: _____

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Physical Activity Enjoyment Scale (PACES)

PACES item: Please rate how you feel *at the moment* about the physical activity you have been doing

1	2	3	4	5	6	7
*I enjoy it						I hate it
1	**2**	**3**	**4**	**5**	**6**	**7**
I dislike it						I like it
1	**2**	**3**	**4**	**5**	**6**	**7**
It's no fun at all						It's a lot of fun
1	**2**	**3**	**4**	**5**	**6**	**7**
*I feel good physically while doing it						I feel bad physically while doing it
1	**2**	**3**	**4**	**5**	**6**	**7**
I am very frustrated by it						I am not at all all frustrated by it

*Item is reversed scored (i.e., 1=7, 2=6, 3=5, 4=4, 5=3, 6=2, 7=1)

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Pediatric Quality of Life Inventory 4.0 (PedsQL™)

This morning, how much of a problem has it been for you . . . . . .

1. It is hard for me to walk for a long time	Not at all problem (0)	Sometimes a problem (2)	A lot of a problem (4)
2. It is hard for me to run	Not at all problem (0)	Sometimes a problem (2)	A lot of a problem (4)
3. It is hard for me to play sports activities or exercise	Not at all problem (0)	Sometimes a problem (2)	A lot of a problem (4)
4. It is hard for me to life something heavy	Not at all problem (0)	Sometimes a problem (2)	A lot of a problem (4)
5. I hurt or ache	Not at all problem (0)	Sometimes a problem (2)	A lot of a problem (4)
6. I have low energy	Not at all problem (0)	Sometimes a problem (2)	A lot of a problem (4)

Office Use Only
Reference #:
Assessment #:

DATE ☐☐/☐☐/☐☐
M M D D Y Y

Temperature

Inside (S_1, S_2)

Temperature (°C)	Humidity

Outside (S_1, S_2)

Temperature (°C)	Humidity

Office Use Only
Reference #:
Assessment #:

CARS (**0**=two different activities done in < 3 seconds), (1=stationary/motionless), (**2**=stationary/movement of limbs or trunk), (3=slow speed/easy translocation), (**4**= medium speed/moderate translocation), (5=fast/very fast translocation)

Seconds	Code	Seconds	Code	Seconds	Code	Seconds	Code
3		249		295		741	
9		255		501		747	
15		261		507		753	
21		267		513		759	
27		273		519		765	
33		279		525		771	
39		285		531		777	
45		291		537		783	
51		297		543		789	
57		303		549		795	
63		309		555		801	
69		315		561		807	
75		321		567		813	
81		327		573		819	
87		333		579		825	
93		339		585		831	
99		345		591		837	
105		351		597		843	
111		357		603		849	
117		363		609		855	
123		369		615		861	
129		375		621		867	
135		381		627		873	
141		387		633		879	
147		393		639		885	
153		399		645		891	
159		405		651		897	
165		411		657		903	
171		417		663		909	
177		423		669		915	
183		429		675			
189		435		681			
195		441		687			

201		447		693			
207		453		699			
213		459		705			
219		465		711			
225		471		717			
231		477		723			
237		483		729			
243		489		735			

Vita

Britt Macarthur earned her Bachelor of Science degree from the University of Tennessee, Knoxville (UTK) in May 2010. During her undergraduate studies, she had several opportunities working in numerous areas within the field of Nutrition. These opportunities included gaining experience in: the clinical and foodservice settings working as a Nutrition Tech preparing infant and baby formulas at East Tennessee Children's Hospital; learning about nutrition in the sports arena by assisting in meal planning for UTK athletes; and understanding the effects of supplemental nutrition in athletic performance. Britt also had the opportunity to work in Dr. Raynor's laboratory, the Healthy Eating and Activity Lab (HEAL), where she learned the importance of data management and gained experience in behavioral weight loss management,

Upon earning her Bachelor's degree, Britt continued at UTK to pursue her Masters of Science degree in Nutrition with a Public Health Nutrition concentration. While working on her Masters, Britt has served as a Graduate Teaching Assistant under Dr. Hansen-Petrik, for a senior level Clinical Nutrition course; and Lee Murphy, MS-MPH, RD, LDN, for an introductory nutrition course. In addition, Britt also spent time in Dr. Raynor's HEAL lab, where she gained greater knowledge on data management, further developed her skills in working with behavioral weight loss management, and gained knowledge on the organization and facilitation of independent research.

Britt completed her course work for her Masters in the fall of 2011, and entered the dietetic internship in the spring of 2012. Britt's main interests are in child and adolescent nutrition, physical activity, and weight management.