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Playground and Garden Physical Activity Levels in Young Children

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To the Graduate Council:

I am submitting herewith a thesis written by Ashlyn Nicole Schwartz entitled "Playground and Garden Physical Activity Levels in Young Children." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Kinesiology and Sport Studies.

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Playground and Garden Physical Activity Levels in Young Children

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DEDICATION

To my brother, Kirk Schwartz. Your time here on earth was short, but your impact is never ending. Your love and support will always be felt. I'll never forget you telling me "you're my little sister, but I look up to you." I am now looking up to you in heaven, but I will never stop making you proud. I can never thank you enough for your pride and faith in me. You are the reason I won't ever give up to reach my dreams.

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ABSTRACT

The purpose of this study was to determine the differences in time spent in physical activity (PA), as assessed by the amount of time spent in PA, vector magnitude (counts/15 sec.), MET values, and energy expenditure (kcal/min), between two outdoor environments (natural playground and garden) in preschool children. Participants were twenty-five children (4.4±0.7 years) enrolled in a university laboratory preschool. PA was assessed using an ActiGraph GT3X+ accelerometer that was worn on the right hip. Each child completed four randomly ordered conditions (30 min each), which included two bouts of unstructured PA on the natural playground and two bouts of semi-structured PA in the garden. Accelerometer data were classified as minutes in sedentary behavior and total PA combining varying intensities (light, moderate, and vigorous). Data were averaged to make one 30 min bout for each environment. Paired Samples T-Tests were conducted to look at differences in PA, vector magnitude, corrected metabolic equivalents (METS), and energy expenditure between the two environments. On average, the children spent 17.7 min/half hour in total PA on the playground and 15.0 min/half hour in total PA in the garden with no significant differences in PA (p=0.053), or sedentary time (p=0.052). The playground had a higher average vector magnitude compared to the garden (793.4±209.6 vs.635.9±191.5 counts/15 sec.; $p<0.05$), corrected MET level (2.9±0.6 vs. 2.5±0.4 ml/kg/min; $p<0.05$), as well as energy expenditure (1.8±0.5 vs. 1.5±0.3 kcal/min; $p<0.05$). Overall, the children exceeded Institute of Medicine activity guidelines (15 min/hour of PA) in both environments and averaged a light intensity of activity for the outdoor session. These

data suggest that gardens may be as beneficial as the natural playground environment in providing an opportunity for children to meet PA recommendations.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE
INTRODUCTION

Early childhood (3-5 years of age) has been identified as a critical time period where the incidence of childhood obesity exceeds any other age range of children (Cunningham, Kramer, & Narayan, 2014). Obesity has become a major cause of many diseases including hypertension, musculoskeletal disorders (e.g. tendonitis, bursitis, carpal tunnel syndrome), type 2 diabetes, many types of cancer, and psychological disorders (Pigeot, Moreno, Luis, Ahrens, & Wolfgang, 2011). Longitudinal studies have shown that 50% of obese school age children become obese adults; this same tracking is seen in overweight preschoolers who are more than four times as likely to become overweight adults (Freedman, Khan, Serdula, Dietz, Srinivasan,& Berenson, 2005). Approximately 21.2% of U.S. children 2-5 years of age are classified as either overweight or obese per body mass index (BMI) standards (Ogden, Carroll, Kit, & Flegal, 2014). With the current obesity epidemic, physical activity interventions are crucial to advance the health of children and adolescents.

Participation in physical activity has been connected with many health benefits including enhanced motor skill proficiency, favorable cardiovascular profiles, adequate bone mineral density, normal growth and maturation, improved health-related fitness, positive behavior, better cognition, improved psychological health, and decreased prevalence in overweight and obesity (Williams, Pfeiffer, O'Neil, Dowda, McIver, Brown, & Pate, 2008; Metcalf, Voss, Hosking, Jeffery, & Wilkin, 2008; Malina, & Bouchard, 2004; Moore, Gao, Bradlee, CUpples, Sundarajan-Ramamurti, & Proctor, 2003).

Physical activity guidelines recommend that preschool children should engage in at least 15 minutes per hour of any intensity activity with no more than 30 minutes per hour of sitting or standing at one time (Institute of Medicine, 2011). Currently, only 50% of preschool children participate in sufficient activity to meet the physical activity guidelines (Pate, O'Neil, Brown, Pfeiffer, Dowda, & Addy, 2015). It is vital to identify strategies to facilitate physical activity and play opportunities in order to advance the health and development of preschool children.

To quantify physical activity levels in young children, an objective motion sensor called an accelerometer is often used (Pate, O'Neil, & Mitchell, 2010). An accelerometer is a wearable monitor that is non-invasive, small, and generally worn on the hip. Accelerometers measure the magnitude of acceleration and deceleration of the body. These data are collected at a given frequency (e.g. 30 Hz), with the final output being activity counts. These activity counts can be sampled over differing epochs (e.g. 15 secs or 1 min). Cutpoints classify the number of activity counts into an intensity level of physical activity. The most commonly used cutpoints that have been validated in preschool children were developed with the accelerometer worn on the hip (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006).

Accelerometer data can also be used to calculate energy expenditure. Using 15-second epochs, accelerometer data are plugged into a validated equation to predict the volume of oxygen consumption (VO_2) for each child during activity (Pate, 2006). The Schofield equation, which includes height (m), weight (kg), and sex can also be used to calculate a corrected metabolic equivalent (MET) value unique to each child (Schofield, 1985). A MET represents the amount of energy the body expends while at rest. Energy expenditure data can be used to see if physical activity recommendations are being met as well as to quantify the caloric expenditure of physical activity in order to alter energy balance for weight loss or gain.

Play is a means for young children to obtain physical activity and has been defined as "a form of buffered learning through which the child can make step-by-step progress towards adult behavior" (Roberts and Sutton-Smith, 1962). Play is essential to child development by allowing children to use their creativity while developing their cognitive, physical, social, and emotional skills. There are many different forms of play that children engage in including social play (solitary, parallel, and group) (Parten,1932), and cognitive play (functional, constructive, dramatic, and games-with-rules) (Piaget, Gattengo, & Hodgson).

The outdoor environment largely impacts preschool children's intellectual, mental, and physical health (Tremblay, Gray, Babcock, Barnes, Bradstreet, Car, & Brussoni, 2015). The Institute of Medicine's physical activity guidelines recommend outdoor play as an option for accumulating daily physical activity (2011). These guidelines also recommend promoting physical activity by "providing an outdoor environment with a variety of portable play equipment, a secure perimeter, some shade, natural elements, an open grassy area, varying surfaces and terrain, and adequate space per child" (Institute of Medicine, 2011).

Physical activity guidelines developed by National Association for Sport and Physical Education (NASPE) suggest that children engage in one hour of structured physical activity as well as an hour or more of unstructured physical activity daily (NASPE, 2002). Structured physical activity is facilitated by an adult, where a child has a set goal or instructions to follow. Generally in a child care setting, a teacher would lead their students through games or lessons such as “duck, duck, goose”, or setting up races for children. These types of activities introduce children to physical activity in a group setting, teach children how to follow rules, are generally developmentally appropriate and allow for development of large motor skills and coordination (Jones, Okely, HInkley, Batterham, & Burke, 2016). However, structured physical activity does not allow children to use their creativity and forces them to express themselves in a more structured fashion.

Semi-structured physical activity is where children are supervised by an adult who facilitates activity (Larson, Brusseau, Chase, Heinemann, Hannon, 2014). This type of activity can be seen in a garden where the teacher may instruct the child to plant flowers, however, the child decides which color flowers to place next to each other, how deep to dig the hole, etc. This is the middle ground between structured and unstructured physical activity, where the activity is goal-oriented. Unstructured physical activity allows children to have the freedom to engage in whatever physical activity they want to do, generally as a means of playing. This type of physical activity allows children to explore the world around them the way they perceive it. When placed in unstructured environments, children are generally more physically active (Page, Cooper, Griew, Davis & Hillsdon; 2005, & Tremblay et al., 2015). This type of physical activity would be seen on a playground where children are able to play with their peers and in their environment in a way that is engaging, purposeful, and enjoyable for them.

Typical preschool outdoor play includes activity on traditional playgrounds with plastic and metal play structures, swings, and slides. Natural playgrounds incorporate recycled elements allowing children to experience nature-based outdoor play time. According to the Position Stand on Active Outdoor Play (Tremblay et al., 2015), "Children are more curious about, and interested in, natural spaces than pre-fabricated play structures. Children who engage in active outdoor play in natural environments demonstrate resilience, self-regulation, and develop skills for dealing with stress later in life" (Tremblay et al., 2015). Additionally, outdoor play builds healthy development, inter-personal skills, and socialization with peers (Tremblay et al., 2015). Settings that mimic natural elements are more flexible, allowing for a greater variety of play for children by being able to manipulate their surroundings unlike the hard, plastic structures seen on traditional playgrounds (Luchs & Fikus, 2013). Within these settings, the theory of loose parts state that loose parts are essential elements that encourage imagination, creativity, motor skill development, and open-ended learning (Greenman, 1992). Outdoor environments have consistently been shown to promote higher amounts of moderate-to-vigorous physical activity (MVPA) than indoor environments (Tremblay et al., 2015; Coe, Flynn, Wolff, Scott, & Durham, 2014). Several studies have found more complex play, and creative play and imagination on natural outdoor environments (Luchs et al., 2013; Dowdell et al., 2011).

Interventions on the social and physical environment for physical activity are vital for preschool children and can positively influence physical activity during the school day. When the environment is not conducive to physical activity, studies have shown that pre-school children have spent the majority of their time in sedentary activities (McKenzie, Sallis, Nader, Patterson, Elder, Berry, & Nelson, 1997) and only 4.5% of play time in vigorous activity (Hannon & Brown, 2008). When the environment has been supportive of physical activity (e.g., grassy areas, portable play equipment, green spaces, defined border, teacher interaction), an increased amount of time spent in physical activity has been shown (Cardon, Cauwenberghe, Labarque, Haerens, & DeBourdeaudhuji, 2008; Hannon & Brown, 2008; Cardon et al., 2009). Outdoor environments have been shown to positively affect play behaviors in natural playgrounds by increasing the exploratory, dramatic, and constructive play (Coe et al., 2014).

Another trend in outdoor environments is raised garden beds and garden spaces for young children. Gardens are unique because they have the potential to incorporate learning as children are active at school and are potentially influencing their nutritional behaviors (Ozer, 2007; Graham, Beall, Lussier, McLaughlin, & Zidenber-Cherr, 2005). Despite this unique feature, limited studies have examined the impact of gardens on children's health behaviors (Wells, Myers, & Henderson, 2014). Studies have linked gardens to an increase in physical activity in Kindergarten through 8th grade (Wells et al., 2014; Hermann, Parker, Brown, Siewe, Denney, & Walker, 2006). Additionally, gardening interventions have elicited decreases in obesity in children aged 2-15

(Castro, Samuels, & Harman, 2013), as well as lower BMI values in children aged 9-13 (Utter, Denny, & Dyson, 2016). A study quantifying physical activity intensity levels in a garden found gardening activities to be moderate- to high-intensity physical activity for children 11-13 years old (Park, Lee, Lee, Son, & Shoemaker, 2013). Additionally, a randomized control trial comparing indoor after school physical activity to a gardening activity program found an increase in MVPA and moderate physical activity in the garden in elementary school children (Wells et al., 2014). The only study to assess physical activity levels in a garden in preschool children found a significant increase in physical activity compared to the normal school lessons (Lee, Parker, Soltero, Ledoux, Mama, McNeil, 2017). Overall, the literature trends show that gardens may positively enhance physical activity levels; however, only one study has objectively assessed physical activity in the preschool population.

There is a need to understand how physical activity differs in outdoor environments, specifically in the garden, a place that has not been extensively studied in terms of preschool children's activity levels. By studying the activity levels during playground and gardening outdoor time, valuable information can be obtained that may be used to develop effective interventions aimed at increasing outdoor physical activity in preschool children.

Research Question

Are there physical activity differences, as assessed by the amount of time spent in physical activity, vector magnitude (counts/15 sec.), MET values, and energy expenditure (kcal/min), between a natural playground and garden?

Hypothesis

It is hypothesized that higher values for time spent in physical activity, vector magnitude, METs, and energy expenditure will be observed during unstructured play on a natural playground compared to semi-structured play in a garden.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter is divided into subsections which examine relevant literature of playground and garden physical activity levels and behaviors in young children. These sections include: 1) Today's Children, 2) Physical Activity Recommendations, 3) Objective Measures of Physical Activity, 5) Importance of Play, 6) Cognitive Play, 7) Social Play, 8) Benefits of Play, 9) Childcare Settings, and 10) Summary.

Today's Children

Early childhood has been identified as a critical time period where the incidence of childhood obesity exceeds any other age range (Cunningham et al., 2014). Obesity has become a global pandemic, affecting preschoolers, whose demographics vary drastically, including moderate and highly affluent countries, low and high income populations, urban and rural areas, and throughout all racial and ethnic groups (Quelly & Lieberman, 2011). The USA has the greatest incidence of overweight and obesity in the world (McManus & Mellecker, 2012). Recently, there has been a 5.5% decrease in obesity in 2-5 year olds due to the compliance of federal nutritional programs from 13.9% to 8.4%. (Ogden et al., 2014). However, still 27.3% of U.S. children entering kindergarten are classified as either overweight or obese (Cunningham et al., 2014)

Evidence suggests that by five years of age obesity is established; high birth weight, genetics, early life environments, and intrauterine variables significantly impact the development of obesity (Cunningham et al., 2014). Half of children who were overweight during preschool years will develop childhood obesity (Cunningham et al.,2014), and are more than four times as likely to become overweight adults (Freedman et al., 2005). Additionally, longitudinal studies have shown 50% of obese school age children become obese adults (Cunningham et al., 2014). The need to attenuate overweight and obese children in the early years can significantly impact a child's future development and health.

Childhood obesity negatively impacts a child's quality of life through many venues, one being the development of disease and decreased physical health. (Lambourne & Donnelly, 2011). Globally, obesity has become a major cause of many diseases including hypertension, musculoskeletal disorders, type 2 diabetes, many types of cancer, and psychological disorders. Primarily being thought of as only adult diseases, type 2 diabetes and metabolic syndrome are now prevalent in children (Lambourne & Donnelly, 2011). This leads to the realization that this generation may be the first to not be expected to outlive their parents (Olshansky et al., 2005). Developing chronic diseases as a child allows for further disease progression and increases the likelihood of complications from these diseases.

In addition to the negative physical health impacts from obesity, there is an additional association with negative social interactions such as decreased self-esteem and increased social altercations (Lambourne & Donnelly, 2011). Childhood obesity has also been related to decreased cognitive performance including poor academic achievement (Roberts, Freed, & McCarthy, 2010; Datar, Sturm, & Magnabosco, 2004; Shore, Sachs, Lidicker, Brett, Wright, & Libonati, 2008) and executive function (Donnelly et al., 2013; Hillman, Pontifex, Castelli, Khan, Raine, Scudder, & Kamijo, 2014). Executive function is an umbrella term describing multiple facets of cognition including planning, inhibition, working memory, scheduling, and coordinating. The findings reinforce the importance of meeting PA guidelines for all children, including those who are overweight and obese (Khan & Hillman, 2014).

Using various methods of physical activity assessment, data consistently show that overweight and obese children are not as active as their normal weight counterparts (McManus & Mellecker, 2012). There is a strong correlation between physical inactivity and childhood obesity (Steinbeck, 2001). Per the energy balance concept, increasing energy intake with a reduce energy expenditure (physical activity) will lead to weight gain. Physical activity is the greatest amendable component of energy expenditure, representing up to 30% of total daily energy expenditure (Lambourne & Donnelly, 2011). It is estimated that preschool children are only meeting physical activity guidelines 50% of the time (Pate, O'Neil, & Mitchell, 2010; Tucker, 2008). Continually, female preschoolers are found to be less active than their male counterparts with a higher percentage of girls not meeting physical activity guidelines (Tucker, 2008; Metcalf et al., 2008). The low number of children meeting current physical activity guidelines suggest the practices and policies to increase physical activity in children are essential, with particular emphasis on female children.

Physical Activity Recommendations

Currently there are two governing bodies with physical activity recommendations for pre-school children that exist, the Institute of Medicine, and the National Association for Sport and Physical Education (NASPE, 2002). The Institute of Medicine recommends that preschool children should engage in at least 15 minutes per hour of any intensity activity and no more than 30 minutes per hour of sitting or standing at one time, besides sleeping, with the ultimate goal of preventing obesity in early childhood (Institute of Medicine, 2011). NASPE guidelines recommend preschoolers obtain at least 60 minutes of structured physical activity daily. Additionally, preschoolers should accumulate 60 minutes up to several hours of unstructured physical activity daily, and should not be sedentary for longer than 60 minutes at a time, excluding sleeping (NASPE, 2002). The Institute of Medicine guidelines main focus is having young children active every hour to limit sedentary time. The main focus of Active Start guidelines is to get an overall amount of physical activity accumulated throughout the day instead of an hourly quota. Although the recommendations are slightly different, both organizations strive to promote physical activity and limit sedentary time in children with the goal of reducing childhood obesity and diseases in inactive children. The guidelines were developed from evidence based research along with specialists in exercise physiology and motor development (NASPE, 2002). The recommendations serve as guidelines for families and child care facilities to follow in an effort to support the developing child's essential and unique needs (NASPE, 2002; Institute of Medicine, 2011).

Child care settings serve a large percentage of young children and provide a great opportunity to advocate the importance of a physically active lifestyle (Larson, Ward, Neelon, & Story, 2011). However, the physical activity recommendations are not clearly targeted for a child care center environment (McWilliams, Ball, Benjamin, Hales, Vaughn, & Ward, 2009). The Nutrition and Physical Activity Self-Assessment for Child Care (NAPSACC) best-practice guideline was created to promote policies encouraging physical activity specific to child care settings which include the following: children should be provided with a minimum of 90-120 minutes of active playtime, twice a day, per eight hour day at child care centers. Additionally, children should be allotted two to three outdoor play times unless weather becomes a safety risk (Larson et al., 2011; McWilliams et al. 2009; American Academy of Pediatrics, 2010).

Children who are regularly physically active and meet physical activity guidelines experience cognitive, physical, and mental health benefits (Lambourne & Donnelly, 2011). The benefits of physical activity include: enhanced motor skill proficiency, favorable cardiovascular profiles, adequate bone mineral density, normal growth and maturation, improved health-related fitness, positive behavior, better cognition, improved psychological health, and decreased prevalence in overweight and obesity (Williams et al. 2008; Metcalf et al. 2008; Malina, 2004). Currently, only 54% of preschool children participate in sufficient activity to meet the physical activity guidelines (Tucker, 2008). It is vital to identify strategies to facilitate physical activity and play opportunities in order to advance the health of preschool children.

Objective Measures of Physical Activity

Recently, there has been a growing interest to support physical activity in preschool aged children due to the heightened awareness of childhood obesity. The current trends in society solidify the need of an objective measure of physical activity in young children to determine if children are meeting physical activity guidelines and if childcare facilities are conducive environments for physical activity. It is essential that this measurement tool is both valid and reliable, which can be challenging in this age group. Tools to quantify physical activity in older populations do not translate to preschool-aged children, such as self-report surveys of physical activity (Pate et al., 2010). Young children's behavior is sporadic in nature due to immature biological, cognitive, and psychosocial factors that have sparked much discussion and research on the best way to monitor and express physical activity levels in this age group (Welk et al.,2000; Dollman, Okely, Hardy, Timperio, Salmon, & Hills, 2008; Dwyer & Baur, 2008). The measurement tool needs to be sensitive enough to capture the intermittent activity of young children (Welk et al., 2000). Outlined below are the objective measures of physical activity that are deemed valid, reliable, and appropriate for preschool children. These tools measure either physical activity or energy expenditure directly.

Physical activity is any movement from skeletal muscle that requires energy expenditure, whereas, energy expenditure refers to the amount of energy your body needs to maintain physiological functions such as breathing, temperature regulation, and food digestion. A person's physical activity levels (volume and intensity) can be used to estimate how many calories were expended during an event or over the course of a day. Both physical activity and energy expenditure can be used simultaneously to see if physical activity recommendations are being met and to quantify the caloric expenditure of physical activity in order to alter energy balance for weight loss or gain. Below are the methods currently used to monitor physical activity in young children.

Indirect Calorimetery

Indirect calorimetery is considered the gold standard of measuring oxygen consumption and energy expenditure during physical activity. This method consists of measuring the oxygen intake and carbon dioxide production of every breath. Indirect calorimetery is often used in a laboratory setting due to the nature of the testing apparatus. Field based indirect calorimetery is also possible with portable units. Indirect calorimetery has been used in young children, however, this is not the common modality to assess energy expenditure in preschool children (Adolph, Puyau, Vohra, Nicklas, Zakeri,& Butte, 2012; Pfeiffer, McIver, Dowda, Almeida, & Pate,2006; Trost et al., 2012). The information yielded from this testing is the volume of oxygen consumed and carbon dioxide produced (e.g., energy expenditure), giving a direct value of caloric expenditure with physical activity. Accelerometers and the cut-points used with accelerometery are typically validated using indirect calorimetery.

There are many disadvantages to using indirect calorimetery in young children. The units require the participant to wear a mask and vest with cords around their face and back, which is not always well received in preschool children. A trained exercise physiologist is needed to administer the testing. The equipment required for indirect calorimetery is more expensive than other assessments of physical activity. Due to the high costs, expertise required, and subject and researcher burden, this method is not often used in preschool children. All other methods listed below have been validated against indirect calorimetery to test for reliability and validity.

Accelerometery

To quantify physical activity levels in young children, an objective motion sensor called an accelerometer is often used. An accelerometer is a wearable monitor that is non-invasive, small, and generally worn on the hip (Pate et al., 2010, Pfeiffer, et al., 2006). Accelerometers measure the magnitude of acceleration and deceleration of the body. These data are collected at a given frequency (e.g. 30 Hz), with the final output being either activity counts or vector magnitude. An activity count represents the point when the acceleration signal reaches a set threshold of acceleration in the vertical plane. Activity counts are the volume of times the stimulus was great enough to be classified as activity. These activity counts can be sampled over different epochs (e.g. 15 secs, 1 min). Cutpoints classify the number of activity counts into an intensity level of physical activity. The most commonly used cutpoints that have been validated in preschool children were developed with the accelerometer worn on the hip using activity counts summed over 15-second epochs (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006).

Studies have validated cutpoints in this age group against indirect calorimetery (Pate et al., 2006). These studies consist of a child performing an activity hooked up to an indirect calorimetery unit while simultaneously wearing an accelerometer and seeing if the data are nearly equivalent (Pate et al., 2006). After validation, accelerometers are widely accepted as an accurate and valid assessment of physical activity volume and intensity, and energy expenditure. Cutpoints for preschool children have been validated against indirect calorimetery to quantify physical activity intensity in young children

(Pate et al., 2006). Additional cutpoints have been validated against direct observation in this age group; however, researchers should be cautious when using these cutpoints. Indirect calorimetery measures energy expenditure, whereas direct observation estimates energy expenditure from an observer. Differences in predicted versus measured values could largely impact cutpoints and energy expenditure.

Vector magnitude is commonly used to quantify physical activity. Vector magnitude represents the square root of three axes squared. Measuring accelerations in three planes is a feature that was once not available in accelerometery. Using data from the x, y, and z plane allows for a precise measure of ambulation, accurately accounting for movements not limited to the vertical plane. Young children have sporadic movement patterns, which may not be accounted for in the vertical axis alone.

Accelerometer data can also be used to calculate energy expenditure. Using 15-second epochs, activity counts are entered into a validated equation to predict the volume of oxygen consumption (VO_2) for the child during activity (Pate, 2006). Basal metabolic rate can be estimated using the Schofield equation, which provides a resting VO_2 (ml/kg/min). Taking the predicted VO_2 of the child during activity and dividing by the basal metabolic rate provides a corrected MET value unique to each child (Schofield, 1985). Caloric expenditure can be estimated using oxygen consumption data that can be used to calculate the number of calories burned per minute of physical activity.

Accelerometers are used to measure physical activity levels for many reasons. One advantage of the accelerometer is that it allows for the identification of physical activity patterns for hours or days at a time, which can be assessed with minimal burden to the participant (Pate et al., 2010). There is a possibility of reactivity from wearing the accelerometer, where a subject changes their behavior due to wearing the device. The influence of reactivity is thought to be minimal, yet has not been extensively studied (Pate et al., 2010). Accelerometers range in price from $50- $400 and can be advantageous or disadvantageous depending on the budget of the researcher and the model of accelerometer chosen (McClain, 2009). Lastly, the burden on the researcher with accelerometer use is much lower than with direct observation.

Importance of Play

To play is to "engage in an activity for enjoyment and recreation rather than a serious or practical purpose" (Ginsburg, 2007). Ginsburg et al., examined why the time allotted for free play among children has been reduced in school settings; and the findings are presented below (2007). The number of working parents has increased resulting in increased numbers of children being sent to child care facilities or after school programs. Children are being entertained in front of screens by television, tablets, video games, computer games, or cellular telephones, ultimately reducing activity levels. In addition, there is a national focus on the importance of academics, resulting in increased homework demand in children and diminishing recess. There has been an increase in violence and environmental dangers that discourage children from playing freely outside, which is unlike previous generations (Ginsburg, 2007). Lastly, the increase in structured activities in children's lives such as child care, and organized sports has led to decreases in children's emerging and fluid playtimes (Burdette & Whitaker, 2005).

Only 14% of preschool child care facilities provide the recommended two hours of active playtime per an eight hour day (American Academy of Pediatrics, 2010). Active play is where a child is being physically active while engaging in play, this is generally seen in bursts of moderate to vigorous physical activity. Active play is essential to child development by allowing children to use their creativity while developing their cognitive, social, emotional, and physical skills (American Academy of Pediatrics, 2010). Play leads to personal development (Piaget, 1962), thus it is no surprised that it has been noted as a human right of every child (Ginsburg, 2007). Play has been defined as "a form of buffered learning through which the child can make step-by-step progress towards adult behavior" (Roberts et al., 2010). Play serves as a childhood milestone essential for necessary development and maturation.

Cognitive Play

In the history of classifying children's play behaviors, Piaget classified stages of play based on the amount of play that was for sensory and motor skill development or having a cognitive component (Rubin, 2001). In 1968, Smilansky furthered Piaget's ideas labeling play as functional, constructive, dramatic, or games-with-rules (Rubin, 2001). The categories of cognitive play defined by the Play Observation Scale used today are: "1) functional play- simple repetitive muscle movements with or without objects, 2) constructive play-manipulation of objects construct or to "create" something, 3) dramatic play- the substitution of an imaginary situation to satisfy the child's personal wishes and needs, 4) games-with-rules- the acceptance of prearranged rules and the adjustment of those rules, and 5) exploration- the focused examination of an object for the purpose of obtaining visual information about its specific physical properties" (Piaget, 1962;Rubin, 2001). The Play Observation Scale allows trained research assistants to code the cognitive play behaviors to determine how environments influence cognitive play. With the increased importance on academics in today's society, identifying experiences that elicit cognitive play can enhance children's development as well as interventions to their environments.

Play contributes to the cognitive health of preschool children. One of the main purposes of the brain is to store, produce, and utilize information and the development is dependent on the integration of new experiences (Shonkoff, 2000). Knowledge, memories, and learning are acquired throughout life from new experiences that increase brain development (Shonkoff, 2000). If deprived of these experiences in early brain development, life-long behavioral functioning problems can exist (Shonkoff, 2000). When a child plays, they learn how to interact and engage with their environment and the world they create. This allows for exploration, social interaction, and conquering their fears, for example (Ginsburg, 2007). Executive function, an umbrella term encompassing cognitive tasks such as multi-tasking, inhibition, and reaction time, is also developed though problem solving during play (Burdette & Whitaker, 2005). Executive function is often linked to later academic success and is positively associated with physical activity (Lambourne & Donnelly, 2011).

Social Play

The type of social play a child engages in has always been a prominent focus of study by contemporary researchers. In 1932, Mildred Parten discovered that social skills increased incrementally with age. She defined six chronological social participation categories (Rubin, 2001). The types of social play he identified are: " 1) solitary play - the child plays apart from other children at a distance greater than three feet and is centered on his own activity, 2) parallel play - the child plays independently, however, the activity often bring him/her within three feet of other children, 3) group play - the child plays with other children and there is a common goal or purpose to their activity (Parten, 1932). The Play Observation Scale also identifies what type of social play is occurring, allowing to see how social participation influences development.

Not only do new experiences aid in cognitive growth, but they facilitate social development by increasing social skills and self-confidence (Ginsburg, 2007). Play creates an environment of social growth by helping facilitate interactions of children with peers and parents. Children learn how to create and sustain friendships through play, and develop "emotional intelligence," which is essential for the development of close social relationships early on and later in life (Burdette & Whitaker, 2005). Preschool children are more likely to play with another child they are familiar with and are developmentally similar to, suggesting that friendship is important for young children (Shonkoff, 2000). Increasing active play time inherently increases the likelihood of increased social integration and friendships, which complements child development.

Benefits of Play

Play fosters emotional growth concurrently with social and cognitive development. When a child plays and has the opportunities to develop friendships, emotions are also developed in these relationships. Making friendships allows a child to love and nurture, trust, and constructively resolve conflict (Shonkoff , 2000). Playing within group situations fosters the development of learning and communication including reasoning, resiliency, language, and problem solving (Shonkoff, 2000; Ginsburg, 2007). Additionally, play influences self-control and independence though regulating one's emotions, behaviors, and attention in group settings (Shonkoff, 2000). Free play has the possibility to attenuate depression, aggression, anxiety, and sleep problems through similar mechanism of being physically active seen in adults (Ginsburg, 2007). Parents engaging in play with their children may also receive the same benefits in mood while increasing physical activity (Pellegini, 1998;Ginsburg, 2007; Parten, 1932; Piaget1962).

Play is a platform that supports a potential increase in physical activity among preschool children. Physical activity is associated with increased motor skills which are the ABC's for movement in children (Dwyer, 2008; Williams, Pfeiffer, O'Neil, Dowda, McIver, Brown & Pate,2008). Children must increase their gross motor skills to be successful in harder movement patterns and sport specific skills later in life (Williams et al., 2008). A child must first be able to jump before they can jump to catch a ball in a game. Physical activity develops the cardiopulmonary, neurological, musculoskeletal, and sensory systems that are essential for overall health (Dwyer, 2008). Children classically engage in play as means of engaging in physical activity, therefore, to increase activity levels, play should be promoted (Dwyer, 2008).

Indoor vs. Outdoor

The environment will directly impact the type of play and level of physical activity seen in preschool children (Brown, Pfeiffer, et al., 2009). Children are exposed to many environments throughout the day, including their home, school, after-school care, work of parents, and potentially many other settings. These environments have set rules for children that govern their behavior. Structured environments with teachers facilitating activities will lead to structured play. Likewise, open environments with less supervision will lead to unstructured play. Since children spend a large portion of their time in child-care facilities, it is vital to understand how the environment influences their physical activity levels with hopes to positively impact them. The main indoor activities seen in preschoolers include napping, large group activities, snacking, and manipulative behaviors (e.g., fine motor skills) (Brown et al., 2006). These activities are associated with a lower volume of physical activity in preschool children. Lack of space is a contributing factor to the lower quantity of physical activity in indoor environments. (Brown et al., 2006).

Outdoor environments are more conducive to a higher volume and intensity of physical activity than the indoor environment (Brown et al., 2006). The outdoor environment largely impacts preschool children's intellectual, mental, and physical health (Tremblay et al., 2015). Recent studies and investigations have shown that children who spend more time in the outdoors and participating in unstructured physical activity have higher standardized test scores (Louv, 2008; Sumpter, & Hedefalk, 2015). Additionally, children who spend more time in nature exhibit less anxiety and depression, and increased mood (McCurdy, Winterbottom, Mehta, & Roberts, 2010; Tremblay et al., 2015). Outdoor play builds healthy development, inter-personal skills, and socialization with peers. (Tremblay et al., 2015). Children playing in outdoor environments have increased physical fitness, motor competency, and lower weight (Stone, & Faulkner, 2014; McCurdy, 2010). Outdoor environments are more demanding on children due to increased space and opportunities for risky play. Children can interact with the environment testing their boundaries in the outdoor environment. Physical activity guidelines recommend outdoor play as an option for accumulating daily physical activity (Institute of Medicine, 2011).

Outdoor environments have been shown to affect play behaviors in both traditional (Tremblay et al., 2015.; Dowdell, 2011) and natural playgrounds (Coe et al., 2014). Outdoor environments have consistently been shown to promote higher amounts of moderate-to-vigorous physical activity (MVPA) than indoor environments (Tremblay et al., 2015).

Structured vs. Unstructured

Physical activity guidelines recommend both structured physical activity and unstructured physical activity daily, with an emphasis on obtaining more unstructured than structured physical activity (NASPE, 2002). Structured physical activity and play can be facilitated by an adult with directions for the child to follow. Unstructured physical activity or play is supervised by an adult, but gives children the freedom to make their own choices about the activity they would like to do. Unstructured play has decreased over the years, leading to an increase in research looking at the two types of play (Tremblay et al., 2015). The literature has shown that less structured physical activity have shown a consistently higher volume of physical activity across the literature (Page et al, 2015; Tremblay et al., 2015).

Childcare Settings

Indoor Settings

Indoor environments are consistently associated with lower amounts of physical activity than outdoor environments (Brown, 2006). One study analyzing 24 preschools found that children were sedentary in 84% of indoor activities. There is great variability between child-care facilities. However, on average, the indoor environment is not conducive to meet physical activity recommendations due to lack of space and the nature of the activities that are mainly done indoors (e.g. nap time, snack, and reading).

Only 15% of preschool children are primarily cared for by their parents, the remaining 85% of children aged 3-5, are enrolled in child-care centers, head start programs, or family child-care (American Academy of Pediatrics, 2010) . Of an eight hour preschool day, around 80-90% is spent indoors depending on the child care facility (American Academy of Pediatrics, 2010). Most of the child-care facilities are not providing sufficient opportunities to allow children to meet physical activity recommendations (Larson, 2011). Interventions on the environment to increase physical activity are vital in preschool-aged children and can positively influence physical activity during the school day.

There are elements of the indoor environment that can increase physical activity. One is providing the staff with training on leading physical activity sessions for children and incorporating physically active teaching (American Academy of Pediatrics, 2010). Other options to increase physical activity indoors include increasing the space for free play, incorporating music during the day, and using physical activity posters and books to encourage students to participate in various activities.

Playgrounds

Typical preschool outdoor play includes activity on traditional playgrounds with plastic and metal play structures, swings, slides, and open spaces. Additional recommendations to increase physical activity include providing an outdoor environment with open grassy areas, sufficient space per child, adequate shade, differing terrain, and a secure perimeter (Institute of Medicine, 2011). Teachers also can increase physical activity on playgrounds by being active with the children (Institute of Medicine, 2011). Strategies to increase physical activity in playgrounds include providing portable play equipment, as well as increasing the time children spend outdoors (Piercy, Dorn, Fulton, Janz, Lee, McKinnon, & Lavizzo-Mourey, 2015).

A new trend in playgrounds is the incorporation of natural and recycled elements to allow children to experience nature during outdoor play time. According to the Position Stand on Active Outdoor Play, "Children are more curious about, and interested in, natural spaces than pre-fabricated play structures. Children who engage in active outdoor play in natural environments demonstrate resilience, self-regulation, and develop skills for dealing with stress later in life" (Tremblay et al., 2015). Settings that mimic natural elements are more compliant and allow a greater variety of play for children, such as dramatic play, creative play, and imagination in natural outdoor environments (Luchs et al., 2013; Dowdell, 2011).

With the rise of indoor sedentary activities, spending time in outdoor environments has become an important focus in practice and in the literature. A new public health concern has been emerging coined by Richard Louv as "Nature Deficit Disorder." This term refers to the lack of exposure to the natural environment children are receiving and the subsequent increase in obesity, depression, and attention disorders seen in children (Louv, 2008).

With this new health concern, the literature has focused on the impact of outdoor environments on physical activity levels, types of play, social, emotional, and cognitive development. Natural outdoor environments provide opportunities for cognitive functioning through reasoning skills, academic achievements, imagination, and problem solving (Dowdell, 2011; Louv, 2008). These environments are conducive to social relationships through collaboration with other children (Louv, 2008; Dowdell, 2011). Physiologically, children are more active in natural environments as they enhance fine and gross motor skills, and improve bone density, blood pressure, and cholesterol levels (Louv, 2008; Lambourne and Donnelly, 2011; Tremblay et al., 2015). Lastly, time spent outdoors has been shown to reduce depression and stress in children (Louv, 2008; Tremblay et al., 2015).

Gardens

Another trend in outdoor environments is raised garden beds and garden spaces for young children. Gardens are unique because they have the potential to incorporate learning while being active at school (Ozer, 2007; Graham et al., 2005). Despite this unique space, little research has studied the effects of gardens on children's physical activity levels (Wells et al., 2014). The majority of research with school gardens has been in elementary schools, focusing on academic and nutritional outcomes. A review of the literature concludes that there is no negative association with gardening and academic and nutritional outcomes, and most likely has a positive association with both (Berezowitz et al., 2015). All gardening studies have found that children increase their fruit and vegetable consumption, while a couple studies have found improvements in science and math achievement. The literature in this field for both physical activity assessment with gardening, and gardening interventions in preschool children is scarce. There is a great need for further investigation with stronger experimental designs.

The body of literature analyzing the effect of school gardens on physical activity levels has shown a positive association, however, the majority of the studies use subjective measurements to assess physical activity. In a cross-sectional study by Hermann et al., a gardening after school program for Kindergarten through eighth grade children resulted in an increase in their physical activity levels. Physical activity was assessed by the following question: "I am physically active every day" and answers, "yes, sometimes, or no" (Hermann et al., 2006). A pilot study for a randomized control trial had a gardening intervention for families and third grade students and measured physical activity with a survey. After the intervention the children reported an increase in physical activity and a decrease in sedentary time (Spears-Lanoix, McKyer, Evans, McIntosh, Ory, Whittlesey, & Warren, 2015). Phelps et al., found an increase in physical activity from an after school gardening program in third through fifth graders (2010). Physical activity was assessed by administering a survey pre-intervention and post-intervention asking the children if they were "non-moving, moving, or fast moving" (Phelps et al., 2010).

The most conclusive evidence supporting gardens and physical activity comes from a two year randomized control trial and a cross-sectional study quantifying energy expenditure with indirect calorimetery. Wells et al., measured physical activity levels by a self-reported survey, accelerometer data, and direct observation in twelve elementary schools in New York, six of which were randomly assigned to a garden intervention (2014). An indoor session of physical activity level was compared to the garden physical activity level. Data were collected at baseline, 6, 12, and 18 months post intervention. The results from the self-reported data indicated a decrease in sedentary activities in the garden compared to the indoor control trial. The accelerometer data found an increase in moderate-to-vigorous physical activity and moderate physical activity. Direct observation data found a 14% increase in walking in the garden, a reduction of sitting from 84% to 14% in the garden, an increase in standing from 9% to 53% in the garden, and the presence of vigorous physical activity which was not found indoors (Wells et al., 2014). The study isn't generalizable to all children, however, it gives compelling data to suggest that gardens increase physical activity levels. Another study used indirect calorimetery to assess the intensity and energy expenditure of ten gardening tasks in older children of 12 years of age. The results found that gardening activities represented moderate to high physical activity for all children (~4-6 METS) (Park et al., 2013). These are the only two studies to objectively measure physical activity levels in school gardens.

There is a significant gap in the literature with regard to the effect of school gardens on physical activity levels in all ages, and no research to date has been found in preschoolers. Additionally, little if anything is known about the play behaviors that occur in the garden. With greater amounts of physical activity shown in natural outdoor environments, the garden environment should be researched for its potential to improve physical activity levels, nutrition, and educational outcomes simultaneously.

Summary

Childhood obesity is highly prevalent in the preschool age and is associated with chronic diseases. Physical activity recommendations are not typically being met in childcare facilities. Child health behaviors track into adulthood, emphasizing the need to positively influence the behaviors of young children. The outdoor environment is an avenue to increase physical activity and facilitate child development through free play. With the body of literature supporting the benefits of natural environments, special attention should be paid to gardening. School gardens could potentially be avenues for physical activity, nutritional, and educational development. The activity levels and behaviors of children should continue to be studied in outdoor environments to shape the development of outdoor play areas. By studying the activity levels and play behaviors during playground and gardening play, valuable information can be obtained that may be used to develop effective interventions aimed at increasing outdoor physical activity in preschool children.

Research question

Are there physical activity differences, as assessed by the amount of time spent in physical activity, vector magnitude (counts/15 sec.), MET values, and energy expenditure (kcal/min), between a natural playground and garden?

Hypothesis

It is hypothesized that higher values for physical activity, vector magnitude, METs, and energy expenditure will be observed during unstructured play on a natural playground compared to semi-structured play in a garden.

CHAPTER THREE
MANUSCRIPT

Abstract

The purpose of this study was to determine the differences in time spent in physical activity (PA), as assessed by the amount of time spent in PA, vector magnitude (counts/15 sec.), MET values, and energy expenditure (kcal/min), between two outdoor environments (natural playground and garden) in preschool children. Participants were twenty-five children (4.4±0.7 years) enrolled in a university laboratory preschool. PA was assessed using an ActiGraph GT3X+ accelerometer that was worn on the right hip. Each child completed four randomly ordered conditions (30 min each), which included two bouts of unstructured PA on the natural playground and two bouts of semi-structured PA in the garden. Accelerometer data were classified as minutes in sedentary behavior and total PA combining varying intensities (light, moderate, and vigorous). Data were averaged to make one 30 min bout for each environment. Paired Samples T-Tests were conducted to look at differences in PA, vector magnitude, corrected metabolic equivalents (METS), and energy expenditure between the two environments. On average, the children spent 17.7 min/half hour in total PA on the playground and 15.0 min/half hour in total PA in the garden with no significant differences in PA ($p=0.053$), or sedentary time ($p=0.052$). The playground had a higher average vector magnitude compared to the garden (793.4±209.6 vs.635.9±191.5 counts/15 sec.; $p<0.05$), corrected MET level (2.9±0.6 vs. 2.5±0.4 ml/kg/min; $p<0.05$), as well as energy expenditure (1.8±0.5 vs. 1.5±0.3 kcal/min; $p<0.05$). Overall, the

children exceeded Institute of Medicine activity guidelines (15 min/hour of PA) in both environments and averaged a light intensity of activity for the outdoor session. These data suggest that gardens may be as beneficial as the natural playground environment in providing an opportunity for children to meet PA recommendations.

Introduction

Early childhood (3-5 years of age) has been identified as a critical time period where the incidence of childhood obesity exceeds any other age range of children (Cunningham, Kramer, & Narayan, 2014). Obesity has become a major cause of many diseases including hypertension, musculoskeletal disorders (e.g. tendonitis, bursitis, carpal tunnel syndrome), type 2 diabetes, many types of cancer, and psychological disorders (Pigeot, Moreno, Luis, Ahrens, & Wolfgang, 2011). Longitudinal studies have shown that 50% of obese school age children become obese adults; this same tracking is seen in overweight preschoolers who are more than four times as likely to become overweight adults (Freedman, Khan, Serdula, Dietz, Srinivasan,& Berenson, 2005). Approximately 21.2% of U.S. children 2-5 years of age are classified as either overweight or obese per body mass index (BMI) standards (Ogden, Carroll, Kit, & Flegal, 2014). With the current obesity epidemic, physical activity interventions are crucial to advance the health of children and adolescents.

Participation in physical activity has been connected with many health benefits including enhanced motor skill proficiency, favorable cardiovascular profiles, adequate bone mineral density, normal growth and maturation, improved health-related fitness, positive behavior, better cognition, improved psychological health, and decreased prevalence in overweight and obesity (Williams, Pfeiffer, O'Neil, Dowda, McIver, Brown, & Pate, 2008; Metcalf, Voss, Hosking, Jeffery, & Wilkin, 2008; Malina, & Bouchard, 2004; Moore, Gao, Bradlee, CUpples, Sundarajan-Ramamurti, & Proctor, 2003). Physical activity guidelines recommend that preschool children should engage in at least 15 minutes per hour of any intensity activity with no more than 30 minutes per hour of sitting or standing at one time (Institute of Medicine, 2011). Currently, only 50% of preschool children participate in sufficient activity to meet the physical activity guidelines (Pate, O'Neil, Brown, Pfeiffer, Dowda, & Addy, 2015). It is vital to identify strategies to facilitate physical activity and play opportunities in order to advance the health and development of preschool children.

To quantify physical activity levels in young children, an objective motion sensor called an accelerometer is often used (Pate, O'Neil, & Mitchell, 2010). An accelerometer is a wearable monitor that is non-invasive, small, and generally worn on the hip. Accelerometers measure the magnitude of acceleration and deceleration of the body. These data are collected at a given frequency (e.g. 30 Hz), with the final output being activity counts. These activity counts can be sampled over differing epochs (e.g. 15 secs or 1 min). Cutpoints classify the number of activity counts into an intensity level of physical activity. The most commonly used cutpoints that have been validated in preschool children were developed with the accelerometer worn on the hip (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006).

Accelerometer data can also be used to calculate energy expenditure. Using 15-second epochs, accelerometer data are entered into a validated equation to predict the volume of oxygen consumption (VO_2) for each child during activity (Pate, 2006). The Schofield equation, which includes height (m), weight (kg), and sex can also be used to calculate basal metabolic rate, which can be converted into a corrected metabolic equivalent (MET) value unique to each child (Schofield, 1985). A MET represents the amount of energy the body expends while at rest. Energy expenditure data can be used to quantify the caloric expenditure of physical activity in order to alter energy balance for weight loss or gain.

Play is a means for young children to obtain physical activity and has been defined as "a form of buffered learning through which the child can make step-by-step progress towards adult behavior" (Roberts and Sutton-Smith, 1962). Play is essential to child development by allowing children to use their creativity while developing their cognitive, physical, social, and emotional skills. There are many different forms of play that children engage in including social play (solitary, parallel, and group) (Parten,1932), and cognitive play (functional, constructive, dramatic, and games-with-rules) (Piaget, Gattengo, & Hodgson).

The outdoor environment largely impacts preschool children's intellectual, mental, and physical health (Tremblay, Gray, Babcock, Barnes, Bradstreet, Car, & Brussoni, 2015). The Institute of Medicine's physical activity guidelines recommend outdoor play as an option for accumulating daily physical activity (2011). These guidelines also recommend promoting physical activity by "providing an outdoor environment with a variety of portable play equipment, a secure perimeter, some shade, natural elements, an open grassy area, varying surfaces and terrain, and adequate space per child" (Institute of Medicine, 2011).

Physical activity guidelines developed by National Association for Sport and Physical Education (NASPE) suggest that children engage in one hour of structured physical activity as well as an hour or more of unstructured physical activity daily (NASPE, 2002). Structured physical activity is facilitated by an adult, where a child has a set goal or instructions to follow. Generally in a child care setting, a teacher would lead their students through games or lessons such as “duck, duck, goose”, or setting up races for children. These types of activities introduce children to physical activity in a group setting, teach children how to follow rules, are generally developmentally appropriate and allow for development of large motor skills and coordination (Jones, Okely, HInkley, Batterham, & Burke, 2016). However, structured physical activity does not allow children to use their creativity and forces them to express themselves in a more structured fashion.

Semi-structured physical activity is where children are supervised by an adult who facilitates activity (Larson, Brusseau, Chase, Heinemann, Hannon, 2014). This type of activity can be seen in a garden where the teacher may instruct the child to plant flowers, however, the child decides which color flowers to place next to each other, how deep to dig the hole, etc. This is the middle ground between structured and unstructured physical activity, where the activity is goal-oriented. Unstructured physical activity allows children to have the freedom to engage in whatever physical activity they want to do, generally as a means of playing. This type of physical activity allows children to explore the world around them the way they perceive it. When placed in unstructured environments, children are generally more physically active (Page, Cooper, Griew, Davis & Hillsdon; 2005, & Tremblay et al., 2015). This type of physical activity would be seen on a playground where children are able to play with their peers and in their environment in a way that is engaging, purposeful, and enjoyable for them.

Typical preschool outdoor play includes activity on traditional playgrounds with plastic and metal play structures, swings, and slides. Natural playgrounds incorporate recycled elements allowing children to experience nature-based outdoor play time. According to the Position Stand on Active Outdoor Play (Tremblay et al., 2015), "Children are more curious about, and interested in, natural spaces than pre-fabricated play structures. Children who engage in active outdoor play in natural environments demonstrate resilience, self-regulation, and develop skills for dealing with stress later in life" (Tremblay et al., 2015). Additionally, outdoor play builds healthy development, inter-personal skills, and socialization with peers (Tremblay et al., 2015). Settings that mimic natural elements are more flexible, allowing for a greater variety of play for children by being able to manipulate their surroundings unlike the hard, plastic structures seen on traditional playgrounds (Luchs & Fikus, 2013). Within these settings, the theory of loose parts state that loose parts are essential elements that encourage imagination, creativity, motor skill development, and open-ended learning (Greenman, 1992). Outdoor environments have consistently been shown to promote higher amounts of moderate-to-vigorous physical activity (MVPA) than indoor environments (Tremblay et al., 2015; Coe, Flynn, Wolff, Scott, & Durham, 2014). Several studies have found more complex play, and creative play and imagination on natural outdoor environments (Luchs et al., 2013; Dowdell et al., 2011).

Interventions on the social and physical environment for physical activity are vital for preschool children and can positively influence physical activity during the school day. When the environment is not conducive to physical activity, studies have shown that pre-school children have spent the majority of their time in sedentary activities (McKenzie, Sallis, Nader, Patterson, Elder, Berry, & Nelson, 1997) and only 4.5% of play time in vigorous activity (Hannon & Brown, 2008). When the environment has been supportive of physical activity (e.g., grassy areas, portable play equipment, green spaces, defined border, teacher interaction), an increased amount of time spent in physical activity has been shown (Cardon, Cauwenberghe, Labarque, Haerens, & DeBourdeaudhuji, 2008; Hannon & Brown, 2008; Cardon et al., 2009). Outdoor environments have been shown to positively affect play behaviors in natural playgrounds by increasing the exploratory, dramatic, and constructive play (Coe et al., 2014).

Another trend in outdoor environments is raised garden beds and garden spaces for young children. Gardens are unique because they have the potential to incorporate learning as children are active at school and are potentially influencing their nutritional behaviors (Ozer, 2007; Graham, Beall, Lussier, McLaughlin, & Zidenber-Cherr, 2005). Despite this unique feature, limited studies have examined the impact of gardens on children's health behaviors (Wells, Myers, & Henderson, 2014). Studies have linked gardens to an increase in physical activity in Kindergarten through 8th grade (Wells et al., 2014; Hermann, Parker, Brown, Siewe, Denney, & Walker, 2006). Additionally, gardening interventions have elicited decreases in obesity in children aged 2-15 (Castro, Samuels, & Harman, 2013), as well as lower BMI values in children aged 9-13 (Utter, Denny, & Dyson, 2016). A study quantifying physical activity intensity level in a garden found gardening activities to be moderate- to high-intensity physical activity for children 11-13 years old (Park, Lee, Lee, Son, & Shoemaker, 2013). Additionally, a randomized control trial comparing indoor after school physical activity to a gardening activity program found an increase in MVPA and moderate physical activity in the garden in elementary school children (Wells et al., 2014). The only study to assess physical activity levels in a garden in preschool children found a significant increase in physical activity compared to the normal school lessons (Lee, Parker, Soltero, Ledoux, Mama, McNeil, 2017). Overall the literature trends show that gardens may positively enhance physical activity levels, however, only one study has objectively assessed physical activity in the preschool population.

There is a need to understand how physical activity differs in outdoor environments, specifically in the garden, a place that has not been extensively studied in terms of preschool children's activity levels. By studying the activity levels during playground and gardening outdoor time, valuable information can be obtained that may be used to develop effective interventions aimed at increasing outdoor physical activity in preschool children.

Methods

Study Participants

Participants were recruited from a university laboratory preschool located on a college campus. Parents received flyers in their children's mailboxes, as well as reminder emails from the demonstration teachers. Each parent/guardian signed a parental permission form and children provided verbal assent prior to participating in the study. The participation rate was 70% and included 25 preschool children, 13 boys (4.8 ± 0.7 y), and 12 girls (4.0 ± 0.6 y). Institutional Review Board approval was obtained prior to participant recruitment and enrollment.

Research Design

This study is a cross-sectional study designed to examine physical activity levels and energy expenditure during children's outdoor time on a natural playground and in a garden. Data collection occurred at the university laboratory preschool during normal operating hours (8:00am-5:30pm). The total time involved in the study for each child was three hours distributed over four days. Each of the four days involved a thirty-minute free living assessment with one day in between in each assessment. The order that the children participated in these four assessments was randomized. No assessments interrupted the children's normal school schedule.

Instrumentation and Procedures

Anthropometry

Each child's standing height and body weight was assessed using standard procedures, with participants dressed in light clothing and shoes removed (Lohman, Roche, &

Martorell, 1988). Body mass index (BMI; kg/m^2) was calculated from weight and height. The Centers for Disease Control and Prevention BMI-for-age growth charts for girls and boys were used to determine BMI cut-points for underweight, normal weight, overweight, and obese (Kuczmarski et al., 2000; Kuczmarski et al., 2002).

Physical Activity Assessment

Physical activity levels were assessed using an ActiGraph GT3X+ accelerometer (ActiGraph Corp.; Pensacola, FL). The accelerometer was placed above the iliac crest of the right hip using an elastic belt. The children wore the ActiGraph during each of the four outdoor sessions (30 minutes each; two on the natural playground and two in the garden) during school hours. Student research assistants placed the monitor on the children before outdoor time and removed the monitor when the children returned to the classroom.

The ActiGraph accelerometer data for each axis were collected at 30 Hertz and converted to activity counts and vector magnitude. An activity count represents the point when the acceleration signal reaches a set threshold of acceleration in the vertical plane. Activity counts are the volume of times the stimulus was great enough to be classified as activity. For the current study, the activity counts were sampled over 15-second epochs. Pate et al. cutpoints were used to classify the number of activity counts into an intensity level (light, moderate, and vigorous) of physical activity (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006). The data were further classified as minutes in sedentary behavior and combined physical activity of varying intensities (light, moderate, and vigorous).

Vector magnitude is commonly used to quantify physical activity. Vector magnitude represents the square root of three axis squared,($\sqrt{(x^2+y^2+z^2)}$). Measuring acceleration in three planes is a feature that was once not available in accelerometery. Using data from the x, y, and z planes allow for a precise measure of ambulation, accurately accounting for movements not limited to the vertical plane. Young children have sporadic movement patterns, which may not be accounted for in the vertical axis alone.

Data were averaged to make one 30 minute bout for each environment (natural playground and garden) for sedentary and activity time, as well as vector magnitude. Sessions were averaged to give a meaningful representation of children's activity levels (activity time and vector magnitude) on differing days.

Energy expenditure was calculated from the equation: VO_2 = 10.0714 + (0.02366*count/15-sec) (Pate, 2006). The Schofield equation, which includes height (m), weight (kg), and sex was used to calculate a basal metabolic rate value unique to each child (Schofield, 1985). To obtain a corrected MET value, the energy expenditure was divided by the basal metabolic rate. To convert the corrected MET to physical activity energy expenditure, values were converted to kilocalories (VO_2/1000 X weight) *4.86). The corrected MET data and energy expenditure data are expressed relative to body weight (ml/kg/min) and (kcal/min), respectively.

Free Living Measurement

For the four free-living measurements, children were fit with accelerometers as described above. During this 30-minute period, the children were allowed to move around the playground or garden freely and take water or bathroom breaks if necessary. The environment of the natural playground was unstructured, where teachers supervised but did not interact with the children. During the playground sessions, the children were surrounded by many of their peers (up to 35). In the garden, the environment was semi-structured, where activities were facilitated by the teachers. During the garden sessions, children were surrounded by a maximum of five peers due to a smaller overall space.

Statistical Treatment

Statistical analyses were conducted using SPSS version 24.0 for Windows (SPSS Inc., Chicago, IL). An alpha level of 0.05 was used to designate statistical significance. All demographic characteristics are reported as mean ± standard deviation (SD).

Data were averaged to make one 30-minute bout for each environment (playground and garden). Paired Samples T-Tests were run to look for differences in time spent in physical activity, vector magnitude, corrected MET levels, and energy expenditure on the playground and in the garden.

Results

Characteristics of the participants are presented in Table 1 (Appendix E). Table 2 (Appendix F) presents the differences in sedentary time (min), active time (min), vector magnitude (counts/15 sec.), corrected metabolic values (ml/kg/min), and caloric expenditure (kcal/min) between the playground and garden. The children did not differ in time spent in activity $t(24)=2.03$, $p=0.053)$ or sedentary time $t(24)=-2.05$, $p=0.052)$

between the playground and garden. The children had a higher vector magnitude in the playground compared to the garden $t(24)=3.32$, $p<0.05$). The children had a higher corrected MET level in the playground $t(24)=3.66, p<0.05$), as well as caloric expenditure $t(24)=3.64, p<0.05$).

Discussion

This study describes the activity levels and energy expenditure of preschool children in two outdoor environments, a natural playground and garden. The primary findings of this study are as follows: 1) the activity level of the preschool children was higher in the natural playground than the garden, and 2) the energy expenditure, as assessed by corrected MET values and caloric expenditure was higher in the playground than the garden.

In the current study, the preschool children were active at least half of the 30-minute period in both environments. The children were active 17.7 minutes on the playground and 15.0 minutes in the garden, doubling the physical activity recommendation for the outdoor session. The Institute of Medicine recommends that preschool children should engage in one-quarter of outdoor time in activity (e.g., 15 min/hour)(Institute of Medicine, 2011). Additionally, the recommended maximum amount of time spent in sedentary behavior (30 min/hour) was not exceeded in either environment (Institute of Medicine, 2011).

The children participated in 2.7 more minutes of physical activity when playing on the natural playground compared to the garden, suggesting that the practical difference between the environments is minimal. However, the way children accumulated activity (e.g., play or non-play behaviors) is most likely different and important to understand how play drives physical activity. Further research should look at differing play behaviors as means to accumulate physical activity and identify which types of play or goal-oriented activities are associated with activity.

After gardening interventions, children have shown increased physical activity levels when compared to an indoor environment or a typical educational lesson (Wells et al., 2014; Lee et al., 2017). The current study confirms that gardens are a viable avenue to meet physical activity recommendations in young children. Our findings are consistent with the literature suggesting outdoor environments are conducive to meeting physical activity recommendations. (Brown, et al, 2006; Louv, 2008; Mygind, 2007).

When assessing activity levels in young children, vector magnitude should also be considered. Assessing acceleration in three planes gives a more precise measurement of ambulation in young children with sporadic movement patterns. The vertical axis alone, may not accurately capture all movement patterns. New cutpoints incorporating the three axes should be developed to further classify activity intensity due to the nature of physical activity in young children.

The overall activity intensity was light in both environments, but approaching average moderate on the natural playground. The energy expenditure was higher on the playground than in the garden. This is the first study to quantify intensity level of gardening in the preschool age group. Park and colleagues found specific gardening activities to be around 4-7 METs (moderate to high intensity) in 12 year old children (2013). The increase in METs observed in the Park et al. study is most likely due to measuring a specific activity in an environment, instead of the average metabolic cost of the environment. Further studies are needed to quantify the energy expenditure of structured gardening activities in young children.

This study compared activity levels of a semi-structured (garden) environment to an unstructured environment (natural playground). In the garden, the teachers facilitated activities; this instruction could have led to less time spent in physical activity. Additionally, the structure and inherent tasks of the garden are goal-oriented, whereas play is not. This could have affected the children’s physical activity. The garden was a smaller area than the playground, the smaller space may have contributed to lower activity levels. The current study's findings were concurrent with other studies, showing that unstructured environments elicit higher intensity of physical activity levels (Page et al., 2005; Tremblay et al., 2015; Larson et al., 2014). Future studies should continue to investigate the relationship between activity levels in structured, semi-structured, and unstructured environments.

In order to effectively raise physical activity levels in young children, their environment needs to be conducive to physical activity. The current data collection took place throughout both summer and winter months (June-December). This variation in season (e.g. temperature changes, crop changes) gives a meaningful representation of activity level in the outdoor environments studied across various seasons. The social environment could have potentially influenced the children's activity level as well (e.g., the number of children around the focal child, the amount of friends with the child). However, neither the number of children outdoors during assessments, nor were the children's friends noted in this study. Future research should take into account the size of the space, number of peers, and the volume of interaction and direction from the teacher.

The current study has strengths and weaknesses. The strengths of this study are as follows: 1) Physical activity was measured objectively through accelerometery; 2) The subjects included a wide range of ethnic variation and equal distribution of males and females; and 3) The study took place over many seasons (summer, fall, and winter).

Limitations of the current study are as follows: 1) This study had a small sample size and took place on a single playground and garden in the Southeast region of the United States, so these results are not generalizable to all playground and garden environments; 2) The BMI of the children was not nationally representative of obesity rates; 3) Different teachers went to the garden with the children, and each teacher had a different dynamic role with the children; and 4) Environmental factors could have influenced the children's behavior, such as the presence of various student workers and teacher observers. The university laboratory preschool is a research-based childcare facility where the children are often being observed. As such, the current author is confident that subjects of this study were not affected by observation during the study. Lastly, construction did occur during one portion of the study. Construction workers added various new elements on the playground (e.g., stage, boulders) which could have changed activity levels in children. Data were analyzed to determine whether a difference occurred after the construction took place, and no differences were found.

In conclusion, outdoor environments, such as natural playgrounds and gardens are conducive to meeting physical activity recommendations. Preschools should consider incorporating natural playgrounds and gardens into their play areas to obtain increases in physical activity levels. Additionally, gardens should be considered when creating preschool curriculums to encourage the improvement of nutritional outcomes, general education, and physical activity levels.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to assess the activity level and energy expenditure of preschool children on a playground and in a garden. Overall, the children spent significantly more time in activity in the playground (unstructured environment) than the garden (structured environment). The children exceeded Institute of Medicine physical activity guidelines in both environments during their outdoor playtime, suggesting that these outdoor environments are supportive of meeting PA guidelines. Gardens may be a conducive environment to provide an opportunity for children to meet PA recommendations. Future investigations that explore the impact of nature-based environments on activity levels in preschool children are warranted. These studies should also include measures of cognition, to analyze the possible educational component of natural environments.

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APPENDIX

Appendix A
Information Letter for Parents

THE UNIVERSITY *of* TENNESSEE UT
KNOXVILLE
COLLEGE *of* EDUCATION, HEALTH,
& HUMAN SCIENCES

March 8, 2016

Dear Parent,

The purpose of this letter is to invite you to permit your child to participate in a research study entitled: *Playground and Garden Physical Activity Levels and Behaviors in Young Children.* This study will be open to all children enrolled in the preschool classrooms at the ELC. The specific details of the study are provided in the attached consent form. This study is being conducted by Dr. Dawn Coe, Ph.D., a pediatric exercise physiologist from the Department of Kinesiology, Recreation, and Sport Studies, Ashlyn Schwartz, a Master's student from the Department of Kinesiology, Recreation, and Sport Studies, Mary Jane Moran, Interim Head of the Child and Family Studies department, and Robyn Brookshire, Director of the ELC. Please contact Dr. Coe with any questions concerning this study (phone: 865-974-0294, email: dcoe@utk.edu).
Thank you for your consideration.

Regards,

Dawn Coe, Ph.D.

Appendix B
Parental Permission

Permission for Child to Take Part in a Research Study

Title: Playground and Garden Physical Activity Levels and Behaviors in Young Children

Principal Investigator: Dawn P. Coe, Ph.D.
Collaborators: Ashlyn Schwartz, B.S.
Mary Jane Moran, Ph.D.
Robyn Brookshire, Ph.D.

Your permission is required for your child to take part in a research study. This consent form explains the purpose and requirements, of the study. Please read this form carefully. You will be given a chance to ask questions. If you decide to permit your child to be in the study, you will be given a copy of this form.
If you do not permit your child to take part in the study, it will not affect your child's rights to care or services. If you do permit you child to take part, you are also free to remove your child from this study at any time without penalty.

Why is this study being done?
We are conducting this study in order to determine how children's play and activity behaviors are influenced by the outdoor environment. The study activities will take place on the current ELC playground and garden to determine what role the playgrounds, gardens, and associated characteristics contribute to the manner in which children play and are active.

How long will the study last?
Your child's participation will last six (6) days during normal school hours when the children are engaged in regularly scheduled outdoor time. The total time of involvement in the study is five (5) hours.

How many people will be in the study?
About 50 children enrolled in the preschool classrooms at the ELC will be participating in this study.

What will my child do during the study?
During the study, your child's height and weight will be assessed and s/he will be fitted with a physical activity monitor. The physical activity monitor is a small box, the size of a small pager that is worn on a belt around the waist and on both wrists. The monitor will be worn during the outdoor time for four (4) days during the study for approximately thirty minutes each day. The monitors will be put on your child prior to the outdoor period and will be taken off of your child when s/he returns to the classroom. The monitors will not be taken home. Your child will not keep the monitor once the study is completed. During outside play the researchers will observe and record your child's play patterns. Additionally, your child will wear a mask covering his/her mouth and nose for two (2) days during the study for 50 minutes each day to assess how much oxygen your child's body is using to make energy. Although your child's mouth and nose are covered with the

mask, your child will still be able to breathe normally and talk during the test. Your child has the option to remove the mask between each activity for five minute breaks, yielding a total of 35 minutes wearing the mask each time. During this time, your child will also wear the activity monitors on the hip and both wrists. The researchers will be observing the children's play and directing children to partake in specific activities on the playground one day (running, climbing on logs and boulders, playing in the sandbox, playing on the play structure, and playing in the dirt/mud pit) and in the garden on a different day (digging, raking, weeding, watering, and mulching).

________ (parent initial)

What are the risks to my child as a participant in the study?
Risks associated with this study are minimal. Every effort will be made to minimize any discomforts or risks. Risks include falling down, which may result in a scrape or bruise while playing on the playground. These risks are similar to what your child would experience during a typical school day. There is a possibility that your child may experience a warmer face than normal or mild skin irritation from the Oxycon mask. If this is the case, the mask will be adjusted between trials or removed. Additionally, your child may experience mild skin irritation from the belt that contains the activity monitor rubbing on the skin. If that happens, the teacher will adjust the belt or, if necessary, remove it.

Are there benefits to my child for taking part in the study?
There are no direct benefits to your child from this study. However, the results will help us understand how the outdoor environment affects a child's play and activity behaviors. There is no direct benefit to the children in this study. These findings can potentially be used to help shape interventions designed to increase physical activity levels in young children.

What happens if my child gets hurt?
In the event that your child becomes injured as a result of participating in this study, immediate treatment will be available (First Aid and/or CPR). However, you must assume responsibility for all medically necessary treatment. It is important that you tell the researcher, Dawn Coe, Ph.D. if you feel that your child has been injured in this study. You can tell the researcher in person or call her at 865-974-0294.

Who do I call if I have questions about the study?
Questions about the study should be directed to Dawn Coe, Ph.D: 865-974-0294 (Phone #), dcoe@utk.edu (E-mail) and if needed, a meeting can be set up. Questions about your child's rights as a research participant should be directed to the University of Tennessee, Knoxville, Office of Research Compliance Officer at 865-974-3466.

Will anyone know my child is in the study and how is my child's identity being protected?
A record of your child's participation in the study will be kept private and all data will be kept in a confidential file in a locked cabinet in a locked University of Tennessee faculty office for 3 years following completion of the study. After that, your child's data will be destroyed. Only the co-investigators will have access to your child's data. Study results may be prepared for presentation at professional meetings and for publication in journals. However, none of your child's personal information will be revealed. Therefore, your child's identity will be protected.

What if my child does not want to be in the study?
If your child does not wish to participate or becomes upset on one of the testing days, we will attempt to console and comfort your child and allow your child to return to the classroom. We will try to collect data on an additional day. If your child does not wish to participate or becomes upset again on the additional day, your child will be removed from the study. If your child decides that s/he no longer wants to participate in the study, we will return your child to the classroom and will remove your child from the study.

________ (parent initial)

PERMISSION OF PARENT OR GUARDIAN:
I have read or have had read to me the description of the research study. The investigator or her representative has explained the study to me and has answered all of the questions I have at this time. I have been told of the potential risks, discomforts and side effects as well as the possible benefits (if any) of the study. I freely permit my child to take part in this study.

____
Child's Printed Name

______________________________ ______________________________ __________
Printed Name of Parent/Guardian Signature of Parent/Guardian Date

______________________________ ______________________________ __________
Printed name of Investigator Signature of Investigator Date

Appendix C
Assent Script

Verbal Assent Script

- ☐ Hello, my name is (insert name of researcher). I am a teacher (or student) and I study kids and the things they do. Your mom, dad, guardian, etc. said it would be ok for you to help us out with some of these things. On the days that I'm here you will meet with me for about the same amount of time it takes for you to eat lunch. I will explain what you will be doing on each of these days. I will also explain these things again each time I come to see you. Any time you have a question about what I am talking about, please ask.

- ☐ I will see how tall you are and how much you weigh. I will also measure around your belly. I will ask you to wear this belt with a small box on it (show Actigraph). This little box will tell us how much you move. It will not hurt you and you only have to wear it when you are at school. You will wear it for two days for thirty minutes and I will come in and put it on you before you go outside and take it off after outdoor time. Your teacher can fix it if it does not feel right. I would like for you to wear it during these times, but if it still bothers you, you may take it off.

- ☐ I will also ask you to complete five types of activities on the playground (running, climbing on logs and boulders, playing in the sandbox, playing on the play structure, and playing in the dirt/mud pit) and in the garden (digging, raking, weeding, watering, and mulching). I will watch what you do during these activities and write down what I see. I will put a mask on you to see how much air you breathe in and out while you are playing. If you become uncomfortable with this mask, please let me know and I will fix it.

- ☐ I have told you about all of the things you will do. Do you have any questions? Would you like to be a part of my project?

- ☐ You have the choice to stop being a part of this study at any time. You just need to tell us that you no longer want to do the stuff we are having you do.

Appendix D
Confidentiality Agreement

Confidentiality Agreement
Adapted from the Template on the UTK IRB Webpage

Research Team Member's Pledge of Confidentiality

Playground and Garden Physical Activity Levels and Behaviors in Young Children

As a member of this project's research team, I understand that I will be involved in the collection of sensitive data from very young children. The information obtained during data collection was provided by research participants who participated in this project on good faith that their data would remain strictly confidential. I understand that I have a responsibility to honor this confidentially agreement. I hereby agree not to share any information with anyone except the primary researcher of this project or other members of this research team. Any violation of this agreement would constitute a serious breach of ethical standards, and I pledge not to do so.

______________________________ ________________

Research Team Member (Printed Name) Date

____

Research Team Member (Signature)

Appendix E
Tables

Table 1. Descriptive characteristics of the participants.

	Males (n=13)	Females (n=12)	All Participants (n=25)
Age, mean ± SD (range) (yr)	4.8 ± 0.7	4.0 ± 0.6	4.4 ± 0.7
Height, mean ± SD (range) (m)	1.0 ± 0.1	1.0 ± 0.0	1.1 ± 0.1
Weight, mean ± SD (range) (kg)	19.3 ± 3.0	16.6 ± 2.0	18.0 ± 2.8
BMI classification (%)			
Underweight (0-5 percentile)	0.0	4.0	4.0
Normal weight (5-85 percentile)	44.0	40.0	84.0
Overweight (85-95 percentile)	4.0	4.0	8.0
Obese (95-100 percentile)	4.0	0.0	4.0
Race/ethnicity (%)			
White	54.0	58.0	56.0
Other (Asian, African American, Hispanic, Mixed Race)	46.0	42.0	44.0

All data are in means and standard deviations

Table 2. Differences in physical activity and energy expenditure between the playground and garden.

	Playground	Garden	P Value
Vector Magnitude(counts/15sec)	798.4±209.6	635.9±191.5	0.003 *
Sedentary Time (min)	12.4±4.6	15.0±4.9	0.052
Active Time (min)	17.6±4.6	15.0±4.9	0.053
Corrected MET (ml/kg/min)	2.9±0.6	2.5±0.5	0.01*
Energy Expenditure (kcal/min)	1.8±0.5	1.5±0.3	0.01*

*Significantly different from playground ($p<.05$).
All data are in means and standard deviations.

VITA

Ashlyn Nicole Schwartz was born on July 14, 1993 to Jay and Deborah Schwartz. Starting at the age of three, Ashlyn played soccer and continued on to play for her high school, club, the state of Georgia, and Southeast Region. In May 2011, she graduated from Harrison High School in Powder Springs, Georgia. During her last year of high school, she was dual enrolled at Kennesaw State University where she remained at until graduating with her bachelor's degree in Exercise Science in May 2015. During her bachelor's degree, Ashlyn became heavily involved in community service to the pediatric community, international travel, leadership positions, and research in a physiology laboratory. This research involvement and love of pediatrics led her to pursue a Master's degree at the University of Tennessee, Knoxville working under Dr. Dawn Coe, a pediatric exercise physiologist.

During her Master's degree at the University of Tennessee, she has worked as a teaching associate in the Department of Kinesiology Recreation and Sport Studies teaching undergraduate laboratory classes, and has worked for the Center of Physical Activity and Health administering fitness testing and developing Exercise Is Medicine on Campus® initiative. Her research agenda has included physical activity assessment in youth, nature based behaviors and physical activity, and the impact of physical activity on executive function in children and adolescents. In the last two years, she has conducted research, presented her work at professional conferences, and organized a pediatric conference. Additionally, she has been heavily involved in service to the pediatric community in Knoxville, including volunteering with all ages of children. This has included conducting fitness testing for overweight children, working with adapted children internationally and domestically, and assisting physical therapists.

August 29, 2016, Ashlyn's brother passed away unexpectedly. This gutting loss made her reflect on life's purpose and the short time we have on Earth. She realized she had fallen in love with the nature movement occurring for young children. She strongly felt the need to make a difference in the lives of young children and felt that using nature and exercise as medicine could be the outlet for her goal. Ashlyn's career goal is to obtain a PhD in Child and Family Studies at the University of Tennessee, specifically working with the Early Learning Center (ELC) and focusing her research on the development of a forest school. Her lifelong goal is to open an "ocean school" near her family in Florida, dedicated to her brother.