# THE EFFECTS OF OUTDOOR, UNSTRUCTURED PLAY ON PHYSICAL ACTIVITY AND OBESITY RATES IN CHILDREN

By

David J Farbo
Bachelor of Science in Physical Education, 2014
Master of Science in Exercise Psychology, 2017
Texas Christian University
Fort Worth, Texas

Submitted to the Graduate Faculty of
Harris College of Nursing and Health Sciences
Texas Christian University
in partial fulfillment of the requirements
for the degree of

Doctor of Philosophy

May 2022

**THE EFFECTS OF OUTDOOR, UNSTRUCTURED PLAY ON PHYSICAL ACTIVITY AND OBESITY RATES IN CHILDREN**

A Dissertation for the Degree

Doctor of Philosophy

by

David J Farbo

Deborah J Rhea

Deborah Rhea, Ed.D.
Dissertation Chair

Robyn Trocchio

Robyn Trocchio, Ph.D.
Dissertation Committee

Yan Zhang

Yan Zhang, Ph.D.
Dissertation Committee

Emily Lund

Emily Lund, Ph.D.
Associate Dean for Research

**Acknowledgements**

Throughout my four-year journey in obtaining this degree, there were hundreds of individuals who contributed in some way to help me reach the end. While I could not have made it without each and every one of those people, there are a few that I need to especially thank for going above and beyond in making this dream a reality.

I would first like to thank my mentor, Dr. Debbie Rhea. Your wisdom and guidance has always been an inspiration and you have taught me everything that I know today. From the moment we met seven years ago, you have driven me to become the best that I can be. I can honestly say that you may have put just as many hours into writing this dissertation as me, and I truly could not have done it without you. Not only were you a tremendous advisor, but I also consider you a close friend and I am excited to see what the future holds as colleagues.

Second, I would like to thank the members of my dissertation committee, Dr. Yan Zhang and Dr. Robyn Trocchio. Dr. Zhang, you have taught me so much over the last four-years and I aspire to one day reach your level of brilliance and statistical mastery. I looked forward to every conversation that we had because I knew I would learn so much and find all the answers to my questions. Dr. Trocchio, your smile and kindhearted nature always put me in a better mood at the most stressful of time. You always asked questions that I never would have considered because you were able to view my research in a different lens. I've had the privilege to learn from you in so many ways as a professor, committee member, and friend.

Next, I would like to thank all of the members of the LiiNK team, especially Laura Maler, Candice Williams, Elizabeth Moore, Kate Webb, and Daryl Campbell-Pierre. You all were ready to do anything that I asked in an instant and none of this could have been possible without all of your help.

To my fellow doctoral cohort, we can finally say that we all made it and I will never forget the friendships that we created.

Thank you to all my friends and family for all their love and support throughout this journey. I especially want to say thank you to my Mom, who has always been my biggest cheerleader. You have made so many sacrifices to provide the greatest life that I could ask for and I hope that you know they do not go unnoticed. I may not always show it, but I truly appreciate everything that you have ever done for me. Knowing that I made you a proud mom makes is better than actually obtaining this degree.

Finally, I especially want to thank my beautiful and loving wife Collin. I would not have made it to the end without you by my side. Whenever there was any doubt or a bad day, you were there to pick me up and keep going. You always put your needs aside to make sure that I was successful, and I will never stop repaying you for that. This truly was a team effort and there is no one else in this world I would want to share this accomplishment with.

**Table of Contents**

## List of Tables

# Chapter 1: Introduction

## *Current State of Childhood Obesity*

The prevalence of childhood obesity has steadily increased as 340 million children between the ages of 5-19 across the globe are considered overweight or obese (World Health Organization, 2021). In the United States this trend continues as 36% of children are considered either overweight or obese, which is three times higher than three decades ago (Fryar et al., 2018). Males (20.5%) between the ages of 2-19 have higher obesity rates than females (18%), while Hispanic children (25.6%) are more likely to be obese than Black (24.2%) or White (16.1%) children (Fryar et al., 2018). This alarming rise has caused childhood obesity to reach epidemic levels worldwide, making it one of the leading health challenges of this generation of children (Sahoo et al., 2015). An estimated $14 billion dollars per year is spent on childhood obesity related medical costs and the average lifetime medical cost per obese child is $19,000 more than a healthy weight child (Tremmel et al., 2017). This generation of children is experiencing an increasing number of health complications that were once only seen in adults (Sanyaolu et al., 2019).

Obesity leads to these health complications and occurs from excessive body fat accumulation when more calories are consumed than burned on a consistent basis (Romieu et al., 2017; WHO, 2021). High fat levels can lead to the development of diabetes, cardiovascular disease, and osteoarthritis, all of which can lead to shorter life expectancy (Sanyaolu et al., 2019). Obesity can also burden psychosocial factors such as mood, quality of life, self-esteem, and body image (Sarwer & Polonsky, 2016). These daily struggles can eventually lead to chronic mental health complications such as depression, eating disorders, anxiety, and substance abuse (Sarwer & Polonsky, 2016). As obesity rates continue to increase, the number of children diagnosed with a mental disorder has doubled over the past decade and one in six children (17%) today have either ADHD, anxiety, depression, or behavior problems (CDC, 2022). About 60% of obese children will remain obese as an adolescent, with 80% of those adolescents turning into obese adults (Simmonds et al., 2016). Therefore, it is vital to change lifestyle habits that lead to obesity early in development to improve the health of children across the lifespan.

The main behavioral risk factors that lead to obesity include dietary choices, sedentary behavior, and low levels of physical activity (PA) (Sahoo et al., 2015). The eating patterns of most children today consist of excessive sugary beverages, fast food, snacks, over eating, skipping breakfast, and consuming very few fruits and vegetables (Kim & Lim, 2019). Children will also average approximately eight hours daily in sedentary behaviors, which includes a large portion of time using technology (Barnett et al., 2018). Technology addictions are rising exponentially today with only 34-39% of children between on the ages of 5-17 meeting the recommended two hours or less of screen time daily (Aubert et al., 2018). Children are also prone to eat while using technology, which further escalates the chances of developing obesity (Kim & Lim, 2019). The school setting contributes to these behaviors as children can spend up to 63% of a seven hour school day sedentary, with some going almost four consecutive hours without movement (C. Egan et al., 2019). The combination of poor eating and sedentary behaviors leads to more calories consumed and less burned. A lead prevention strategy for burning these excess calories and preventing body fat accumulation is engaging in sufficient PA (CDC, 2021b).

The Center for Disease Control and Prevention (CDC) recommends that children engage in at least 60-minutes of moderate to vigorous physical activity (MVPA) per day to yield positive physical and mental health benefits (Bull et al., 2020; CDC, 2021b). Moderate PA is reaching 60%-76% of an individual's maximum heart rate and vigorous is reaching 77%-96% (CDC, 2021b; MacIntosh et al., 2021). Common moderate to vigorous activities for children include jumping, hopping, skipping, or running (Yang, 2019). According to the CDC, only 24-33% of children aged 5-19 meet daily-recommended levels of MVPA (Aubert et al., 2018; CDC, 2021b). Females are more at risk due to consistently engaging in less MVPA per day than males (McLellan et al., 2020). Differences by race also present complications as non-Hispanic White children are shown to be the least active, followed by Hispanic and Black children (National Physical Activity Plan Alliance, 2018). In general, though, children will gradually decrease PA as they age and inactive children are likely to remain inactive as they mature into adults (Fernandez-Jimenez et al., 2018; Mann et al., 2017). While it may seem that children today are less active than ever before, they are not solely to blame for the development of these lifestyle habits.

The home and school environments can significantly impact the amount of time and opportunities children are able to participate in MVPA. From a social learning theory perspective, behaviors are developed through the interaction of environmental factors, cognitive processes, and the behavior itself (Bandura & Walters, 1977). Bandura states that these factors constantly influence each other through a process known as reciprocal determinism (Bandura & Walters, 1977). For example, the environment can serve as a barrier which can prevent an individual from developing the cognitive processes needed to learn a behavior (Bandura & Walters, 1977). Further, this theory concludes that children learn behaviors from their family members or others who are highly influential through observing, modeling, and imitating (Bandura & Walters, 1977). When children do not see others being active, they will not learn the importance of PA for their well-being and will not adopt PA as a regular behavior.

At home, there is a direct correlation between PA patterns within a family and the effects inactive parents have on children (Mitchell, 2019; Sijtsma et al., 2015). When parents do not model PA as an important behavior, children will not develop the motivation needed to be active. Even if children are motivated to be active, parents can create barriers for engaging in PA such as sports and outdoor play due to lack of importance, time, safety, and supervision (Lee et al., 2021; Tremblay et al., 2015). Since fewer families engage in regular PA and negative behavioral patterns are being formed more consistently in this generation of children, the school setting is a natural daily environment where positive PA patterns can be developed and practiced.

The problem is that schools today have an increased focus on standardized tests and meeting academic benchmarks (Jarrett, 2019). This has led to reduced or eliminated opportunities for MVPA through a significant reduction in recess and physical education scheduled across the country (Jarrett, 2019; Ramstetter & Murray, 2017; Rhea, 2016). Most schools only offer one 20-minute recess period daily in order to have more time to focus on academic performance, although, even then, it is often removed as a punishment for poor behavior or tutoring (Dickey et al., 2016; Jarrett, 2019; Rhea, 2016). Adequate time for recess is a bigger problem following the COVID-19 pandemic as teachers and administrators are focused on making up lost time for learning instead of allowing children to be active and reconnect with their peers (London, 2020). This school mentality creates a barrier for children to be active and teaches them that PA may not be as important as other classroom content stressed regularly. Regardless of the setting, children are rarely given a chance to engage in PA, which prevents them from modeling or practicing PA behaviors necessary to develop positive daily active routines and habits.

Since the home and school environments have a large influence on children's behaviors , researchers have implemented interventions in both settings in hopes of reversing negative behavioral habits (Bleich et al., 2018; Nally et al., 2021). Limited evidence supports home based interventions as an appropriate behavior change strategy since factors such as culture, socio-economic status, and location can hinder their effects on children (Bleich et al., 2018). For example, strategies that work in a rural setting may not translate well to urban areas since children may not have the same access to the resources needed for the intervention (Bleich et al., 2018). Due to these different environmental factors, it is difficult to ascertain effective strategies that will work across diverse households in a State, much less the nation. Since most children will spend up to 40% of their waking hours at school, two facets need to be realized. Developmentally, children need PA throughout the day (Hillman & Biggan, 2017) and the school is a more reliable environment for active lifestyles to be realized than a home setting (Bleich et al., 2018; Brown et al., 2019). Schools are the ideal intervention setting to reach all children, no matter which sex, race, or culture, since most will attend school almost every day.

***School-Based Interventions***

School-based obesity interventions have focused on improving eating habits, reducing sedentary time, and improving PA patterns of children (Nally et al., 2021). These interventions can either be single component, focused on one of these behaviors, or multiple component, focused on two or more of these behaviors (Nally et al., 2021). Due to such wide intervention success variability, it is difficult to detect the most effective strategies to decrease obesity (Liu et al., 2019). However, research shows that single component interventions are typically more consistent than multi-component interventions to reduce obesity rates in children (Liu et al., 2019; Nally et al., 2021). The success of these single component interventions depends on which of the obesity related behaviors is targeted.

The least successful single component interventions are dietary programs focused on eating patterns of children (Nally et al., 2021). These types provide healthier food options at school or family education on proper nutrition and healthier food options (Nally et al., 2021). Often times, these interventions do not result in long-term obesity or nutrition differences (Liu et al., 2019; Nally et al., 2021). This may be due to children having little control of their dietary choices due to parent and school limitations on healthy food options (Liu et al., 2019; Nally et al., 2021; Sahoo et al., 2015). As social learning theory explains, if the surrounding environment does not change, it is impossible for children to adopt these behavioral changes (Bandura & Walters, 1977). Because of this limitation, school-based interventions focused on eating behaviors alone may not be the best solution in reducing obesity prevalence in children.

Sedentary behavior school interventions incorporate standing desks, reducing screen time, and educating students/parents on the risks of being sedentary (Liu et al., 2019; Nally et al., 2021). The effectiveness of these interventions is also conflicting and highly variable (Liu et al., 2019; Nally et al., 2021). The most successful interventions provide standing desks in the classroom and are longer than 6 months (Hegarty et al., 2016; Nally et al., 2021). While these interventions can be effective in reducing sedentary time, it still does not help children burn excess calories they accumulate from poor eating habits. As a result, most of these interventions only report marginal reductions in obesity rates of children, if any (Nally et al., 2021). It is clear that single component interventions focused on eating patterns or sedentary behaviors are not a reliable strategy in reducing obesity rates in children. Interventions focused on increasing PA tend to be more successful since they help children burn excess calories and reduce body fat (Brown et al., 2019).

School-based PA interventions include enhancing physical education, before/after school programs, classroom PA breaks, and recess (Errisuriz et al., 2018; Mears & Jago, 2016; Yuksel et al., 2020). Physical education interventions provide additional classes during the day, fitness focused activities, and increased movement skill development (Errisuriz et al., 2018). Most of these interventions demonstrate an increase in MVPA; however, the magnitude of these changes is negligible and ranges from only 2-10 minutes (Errisuriz et al., 2018; Lonsdale et al., 2013). Before and after school interventions provide sports, planned physical activities, and fitness based education (Demetriou et al., 2017). These interventions demonstrate a 5-10 minute MVPA increase in children aged 5-18 when compared to children who did not have one of these programs (Demetriou et al., 2017; Jones et al., 2020; Mears & Jago, 2016). Classroom based PA interventions implement mainly structured activities during class that give a 2-3 minute brain break such as jumping jacks, running in place, or playing a video such as “Go Noodle” for children to follow the steps in place (Watson et al., 2017; Yuksel et al., 2020). Most of these classroom interventions only report small effects ranging from a 2%-12% increase in MVPA when compared to control students or baseline measurements (Watson et al., 2017; Yuksel et al., 2020)

The MVPA increase in most of these school-based interventions is insignificant, ranging from approximately 2-10 minutes (Errisuriz et al., 2018; Jones et al., 2020; Yuksel et al., 2020). In addition, many report minimal or no longitudinal increases in MVPA post intervention (Errisuriz et al., 2018; Jones et al., 2020; Yuksel et al., 2020). This marginal MVPA increase  leads to slight obesity rate effects as there is an average .4 unit decrease in body mass index (BMI) between intervention and control groups (Nally et al., 2021). This may be due to the structured nature of these interventions as children are not always interested in the teacher selected activities or available equipment (Behrens et al., 2019). When children are not interested in the activity, it is difficult for them to develop motivation to be active in other environments outside of the school environment (Liu et al., 2019). School-based PA interventions are most effective when children's enjoyment is emphasized, so providing activities or spaces that children find fun is key to increasing MVPA and decreasing obesity (Liu et al., 2019).

### ***Recess and Play***

When children are asked what their favorite part of the school day is, they usually respond that it is recess (Bauml et al., 2020; Massey et al., 2020). This is because recess allows children to engage in play, which is an essential part to overall wellbeing and physical, social, and emotional development (Lee et al., 2020). When children play, it improves emotional resilience, self-esteem, self-confidence, self-expression, and self-worth (Dickey et al., 2016; Gray, 2011). They are able to socialize with their peers by playing together or coming up with solutions to problems they may experience (Dankiw et al., 2020). Additionally, play can increase PA and help children meet the recommended 60-minutes of MVPA per day, especially when it is outdoors (Gray et al., 2015). Research has shown children can achieve up to 40% up their daily MVPA through play experienced at recess (Pulido-Sánchez & Iglesias-Gallego, 2021). When given 20-minutes of recess during the school day, they will engage in approximately 10-15 minutes of MVPA, which is much more than other school-based PA interventions report (Brusseau & Kulinna, 2015; Pulido-Sánchez & Iglesias-Gallego, 2021). This daily MVPA increase can decrease the BMI score by .74 by the end of the school year (Gray et al., 2019). Based on these benefits, enhancing play experiences at recess may be the key to school-based PA intervention success. However, not all forms of play are equal and can provide the same health benefits to children.

Play can be either structured or unstructured. In structured play, the rules are predetermined and the only way to play is to abide by these rules (Lee et al., 2020). Organized sports or games like kickball are examples of structured play since children must follow the rules that are set in place to participate. Many recess interventions aim to introduce structured play activities to increase MVPA during recess, but they often do not experience success (Beyler et al., 2014; Huberty et al., 2014). For example, Playworks is a structured recess intervention that provides students with a coach who leads activities to promote MVPA (Beyler et al., 2014). Children in 4$^{th}$ and 5$^{th}$ grade who receive this intervention only demonstrate about a 3 minute increase in vigorous PA, with no increases in moderate PA (Beyler et al., 2014). Ready for Recess is another structured play intervention in which teachers are trained to lead PA opportunities during recess (Huberty et al., 2014). Teacher involvement during recess actually decreases MVPA by 2-minutes in 3$^{rd}$ through 6$^{th}$ grade students (Huberty et al., 2014). Based on these results, structured recess interventions may not be an effective method in consistently increasing children's MVPA. Parish et al

(2020) argue that outdoor, unstructured recess interventions are generally more effective in increasing MVPA than structured recess.

Unstructured play, incorporated as recess in the school setting, is self-directed in which individuals participate for the joy that it brings them, rather trying to accomplish a goal (Nijhof et al., 2018). There are no rules that limit the choices children make and they are free to create their own objectives and limits (Gray, 2011; Rhea, 2016). During unstructured play, children have shown to be active ~40% of the time (Farbo et al., 2020; Gray et al., 2015), while during structured play such as soccer, children are active less than 25% of the time (Gray et al., 2015). This PA increase is greater when play is outdoors as children are free to move in open green spaces and have more opportunities for exploration, creativity, and socialization (Dankiw et al., 2020; Gray et al., 2015). In fact, research suggests that children obtain most of their daily MVPA through outdoor play (Gray et al., 2015; Truelove et al., 2018). In addition, the outdoors improves mental well-being, cognitive development, and emotion regulation (McCormick, 2017). When play is indoors, children more often engage in sedentary and solitary activities since their available space and play choices are limited (Lee et al., 2021).

Unstructured recess interventions add loose equipment, natural playgrounds, less rules, and more opportunities for creative, rough and tumble, and risky play (Lee et al., 2020; Parrish et al., 2020). For example, Raney et al. (2019) and van Dijk-Wesselius et al. (2018) added more green space and natural elements to playgrounds including hills, trees, boulders, and logs. These interventions observed a 5%-19% increase in MVPA in $1^{st}$-$5^{th}$ grade students at post, 4 month, and 1 year follow-up compared to control students with traditional playground equipment (Raney et al., 2019; van Dijk-Wesselius et al., 2018). Additionally, Hyndman and Lester (2015) added loose parts to a grass field in 5-12 year old children that included cardboard boxes, hay bales, milk crates, and tires. Their results revealed intervention students spent a significantly greater portion of their recess in MVPA (~42%) than control school students with no loose parts (Hyndman & Lester, 2015). While these studies reinforce unstructured, outdoor play will increase MVPA during school, there is less evidence to support their effectiveness in reducing obesity rates in children.

Limited research has examined unstructured, outdoor recess interventions and their effect on obesity rates. Of the recess intervention studies published, researchers have focused on 30-minutes or less of recess daily over 9-12 weeks in a school year with BMI as the obesity measure (Casolo et al., 2019; Howe et al., 2012; Parrish et al., 2020). Some of the interventions compare structured and unstructured play while others focus more on adding loose parts and less rules to the recess times (Casolo et al., 2019; Farmer et al., 2017; Howe et al., 2012). No differences are found in any of these studies ranging from 1st through 3rd grade children with 30-minutes or less of recess using BMI, waist circumference, or skinfolds as the assessment tool (Casolo et al., 2019; Farmer et al., 2017; Howe et al., 2012). In studies reporting significance, they provide at least 60-minutes of unstructured, outdoor play and are longer than 6 months in length (Ansari et al., 2015; Nally et al., 2021; Yuksel et al., 2020). In addition, shorter, more frequent play breaks report greater MVPA increases than one continuous session (Razak et al., 2018). Based on the literature, the inconclusive results reported in previous studies are due to implementation length (less than 6 months), available time for play (less than 60-minutes), and play frequency (two or less opportunities per day).

The LiiNK Project® (Let's Inspire Innovation N' Kids) is a whole child development intervention addressing all the gaps identified in other unstructured recess interventions. Students in grades K-5 receive four, 15-minute (60-minutes total) recesses as well as a 15-minute character development lesson daily for each year they attend school beginning in kindergarten (Bauml et al., 2020; Rhea, 2016). The LiiNK project defines recess as unstructured, outdoor play with no balls or adult led structured activities (Bauml et al., 2020; Rhea, 2016). Clark and Rhea (2017) found private school students in grades K-2 who received 60-minutes of recess took 400-1,200 more steps during the school day than students who received 30-minutes. Farbo et al. (2020) also found public school 1st and 2nd grade LiiNK® students averaged 25 more MVPA minutes and 900 more steps during the day than students with 30-minutes of recess do. Both groups in the Farbo et al. (2020) study were achieving more than 100-minutes of MVPA per day, which is significantly more than the CDC recommended 60-minutes of MVPA (CDC, 2021b). However, LiiNK data has shown no differences in BMI between intervention and control school students (Farbo, 2019). This led LiiNK researchers to question whether BMI is the best tool to measure obesity rates in children with higher amounts of daily MVPA.

***Body Composition Measures***

Several methods assess body composition including whole body air displacement, dual energy x-ray absorptiometry (DXA), BMI, waist circumference, skinfolds, or bioelectrical analysis (BIA) (Casolo et al., 2019; Farmer et al., 2017; Howe et al., 2012). Air displacement and DXA are typically known as the gold standard in measuring body composition, but they are not realistic in field research as they are expensive and not easily accessible (Lemos & Gallagher, 2017). Skinfolds are cost efficient, but the accuracy depends on the person collecting the measurement following correct protocols and having sufficient training (Kuriyan, 2018). Waist circumference only gives an estimation of body fat and may not be an accurate obesity indication (Sardinha et al., 2016).

The most popular method used in the literature is BMI, which uses height and weight to calculate a BMI score (CDC, 2021a). The BMI score is then used to categorize individuals as either underweight, normal, overweight, or obese based on CDC normative charts (CDC, 2021a). Many researchers use BMI because of its simplicity and moderate association to estimate body fat in obese individuals (Martin-Calvo et al., 2016). However, a high BMI score may not be a true indication of obesity prevalence as it does not directly measure body fat (Borga et al., 2018; Chooi et al., 2019). For example, some individuals may have more muscle mass than body fat, but their weight will remain high and result in a high BMI score. Based on this high score, they may be classified as overweight or obese when in reality they have healthy body fat levels. BMI may provide researchers with less accurate body fat assessments in children who engage in higher MVPA amounts. While each of these measurements has strengths and weaknesses, none are valid, reliable, and realistic options for many field-based researchers.

Conversely, BIA scales are affordable, durable, efficient, and do not require much maintenance to use consistently in field research (Kyle et al., 2015). BIA produces results that are moderately correlated with DXA when measuring body fat percentage (BF%), fat free mass, and fat mass in children (Kabiri et al., 2015; Kuriyan, 2018). This tool uses unnoticeable electrical signals sent throughout the body via either foot to foot or hand to feet metal plates. Fat has a low water content and higher amounts of fat will cause more impedance in the current. Similar to BMI, this information can be used to classify children as underfat, healthy, overfat, or obese (McCarthy et al., 2006a). The main limitation with BIA is that the accuracy depends on the choice of device and the hydration level of the participant at the measurement time (Kuriyan, 2018). For someone who is dehydrated, the scale may calculate higher fat levels since inadequate water will cause additional resistance in the electrical current. Even with these limitations, BIA presents more valid and reliable results than many of the other available body composition assessments. Using this tool to assess obesity rates may produce clearer results for children who receive 60-minutes of recess daily such as with the LiiNK intervention. These students may develop more muscle mass and burn more body fat because of the daily MVPA increase (Farbo et al., 2020).

**Research Questions and Hypotheses**

Therefore, the purpose of the first study was to determine if there was a difference in how BMI and BIA classified students into the four body composition categories. It was hypothesized that BIA measurements would be positively correlated with BMI considering that BMI is known to have a moderate association with high body fat levels in obese individuals. A second hypothesis was BMI and BIA would classify students into body composition categories differently. Finally, it was hypothesized that the body composition classifications would be different between the two measurements by age and sex. Once a valid and reliable obesity measure could be determined, then the impact of the LiiNK project intervention on obesity could be studied.

The second study examined the effects of 30-60 minutes of recess, defined as unstructured, outdoor play, on obesity body fat category shifts in elementary aged children. Body fat category is defined as underfat, healthy, overfat, or obese based on BF%, age, and sex. Category shift is identified by examining the change in body fat category from the pre-to -post assessments. It was hypothesized that children with 60-minutes of recess daily would shift significantly more from an unhealthy to a healthy body fat category than students with 30-minutes of recess daily. A healthy body fat category is defined as students who are underfat and healthy while unhealthy students are those categorized as overfat or obese. It was also hypothesized body fat category shift differences would be found between the groups by sex, grade, and race. Positive results from this study would help support additional recess time as an effective way to decrease children's obesity prevalence. However, stronger conclusions could be drawn if it was also known that intervention children receiving 60-minutes of recess daily were achieving higher MVPA amounts during the school day than children receiving 30-minutes of recess daily. This would eliminate questions about other factors outside of the LiiNK intervention that could have influenced the results.

The purpose of the third study was to examine PA and body composition in 3rd and 4th grade children who receive 30-60 minutes of recess. Our first research question focused on differences in steps and MVPA between groups by sex and grade in children who receive 30, 45, or 60 minutes of unstructured, outdoor play. It was hypothesized that 3rd and 4th grade intervention males and females would have more MVPA minutes and steps than control children. Our second research question focused on body fat category shift differences between intervention and control children by sex and grade. It was hypothesized more 3rd and 4th grade intervention males and females would shift from the overweight/obese category to a healthy category than the control children. Our third question was exploratory and examined PA as predictive of obesity status among children in both groups. The final research question was also exploratory and examined what kinds of play spaces promote the most MVPA in children during recess.

## Chapter 2: A Pilot Study Examining Body Composition Classification Differences Between Body Mass Index and Bioelectrical Impedance Analysis in Children with High Levels of Physical Activity

**David J Farbo, Deborah J Rhea**

Published in Frontiers of Pediatrics: Farbo, D., & Rhea, D. (2021). A Pilot Study Examining Body Composition Classification Differences Between Body Mass Index and Bioelectrical Impedance Analysis in Children With High Levels of Physical Activity. *Frontiers in Pediatrics*, 9, 1304. https://doi.org/10.3389/fped.2021.724053

**Keywords:** body mass index, bioelectrical impedance analysis, body fat, obesity, children, body composition.

### Abstract

**Background:** Body mass index (BMI) is frequently labeled as "flawed" in assessing obesity since it cannot differentiate between muscle and fat leading to misclassifications of healthy individuals. Bioelectrical impedance analysis (BIA) may be a more accurate indicator of obesity since it can distinguish the difference between muscle and fat in children. This pilot study investigated discrepancies between BMI and BIA body composition classifications in children with high levels of physical activity. **Methods:** Participants were selected from three elementary schools (N=380, K=76, 1st=64, 2nd=62, 3rd=61, 4th=83, 5th=34) receiving 60-minutes of outdoor, unstructured play daily. BIA scales were used to collect each child's body fat percentage and BMI score, then those numbers were categorized by BIA and BMI normative values as either underweight, healthy, overweight, or obese. **Results:** Overall, 26% of the students were classified differently when using the normative classifications for BMI and BIA, with the largest discrepancy found in the overweight category at 38%. Similar inconsistencies were found when students were divided as younger (42%) vs older students (36%), and males (40%) vs females (35%). **Conclusions**: This pilot study demonstrated that

there is a significant difference in how BMI and BIA discriminate between the different body composition categories. BIA consistently shows to be a more accurate tool in assessing obesity rates in children since it directly measures body fat.

**Introduction**

Childhood obesity in the United States has steadily increased over the last 30 years and currently impacts over 13 million children nationwide (Centers for Disease Control and Prevention, 2021a). Research has shown that childhood obesity is an important risk factor for the development of Type 2 diabetes and cardiovascular diseases which can become chronic as body fat (BF) percentages increase (CDC, 2021a). As a result of these types of diseases, approximately 150 billion dollars a year is spent on obesity related medical costs in the United States, with 14 billion dedicated to children (Kim & Basu, 2016).

Sedentary lifestyle choices are a significant contributor to the increased obesity rates and health disease rise seen in the United States today (Dankiw et al., 2020; Truelove et al., 2018). Sedentary behaviors are defined as any task that produces energy expenditure that is no greater than at rest, i.e., playing videogames from the couch (Barnett et al., 2018). To prevent development of obesity, the Centers for Disease Control and Prevention (CDC) recommends that children between the ages of 6-17 engage in at least 60-minutes of moderate to vigorous physical activity (MVPA) daily (CDC, 2021b). However, children today are shown to spend up to eight hours a day in sedentary activity, including the school environment. Consequently, only 24% of U.S. children participate in 60-minutes of physical activity (PA) daily (Barnett et al., 2018; CDC, 2021b)

The loss of unstructured play and especially outdoors in the school setting is devastating for the healthy development of a child (Dankiw et al., 2020; Yogman et al., 2018). Physically, children refine gross and fine motor skills, coordination, muscular strength, and adaptability/balance(Alexander et al., 2014; Truelove et al., 2018), while decreasing sedentary lifestyles, obesity risks, and health related chronic diseases (Barnett et al., 2018; Dankiw et al., 2020; Hales et al., 2017). When children are given the opportunity to engage in unstructured play outside, some research has shown their PA patterns improve significantly more than when adults impose structured (PA) on them (Truelove et al., 2018). Furthermore, other studies have shown that unstructured play will accumulate the recommended number of daily PA minutes through more moderate and vigorous activity than those in a structured environment (Herrington & Brussoni, 2015).

Several research interventions have focused on promoting additional school PA opportunities with the goal of decreasing obesity trends in children (Casolo et al., 2019; Guerra et al., 2013; Vaquero-Solís et al., 2020). Limited obesity rate changes have been found in most elementary school focused interventions due to the short implementation intervals, i.e., 6-12 weeks, to assess the changes (Casolo et al., 2019; Guerra et al., 2013; Vaquero-Solís et al., 2020). A different type of school recess intervention called the LiiNK Project® (Let's Inspire Innovation 'N Kids), focuses on whole child development by implementing 60-minutes of outdoor, unstructured play throughout every day of a school year and a 15 minute character development lesson daily to the school schedule. Prior to year 1 of the intervention, all teachers in grades pre-K through grade 1 from each school are trained to do the procedures associated with unstructured, outdoor play breaks and the character curriculum. In the last half of year 1 implementation, grade 2 teachers are trained to do the procedures, then grade 3 teachers are trained in the last half of year 2. Implementation always begins the fall after spring training. The school can choose to advance the project into grades 4 and 5 during the 3rd year of the project. The project requires all teachers per grade level to take their students outside simultaneously four times daily for 15-minutes each time and they cannot withhold recess for tutoring or punishment.

Previous LiiNK Project studies have shown many whole child benefits that include improved on task classroom behavior (Rhea & Rivchun, 2018), attentional focus (Lund et al., 2017), and positive emotional states (Clark & Rhea, 2017). Accelerometer results have shown LiiNK students take approximately 8700 steps and achieve 140-minutes in MVPA each day while they are in school (Clark & Rhea, 2017; Farbo et al., 2020). Other studies have reported that when children aged 7-11 engage in 55-66 minutes of MVPA and ~10,000 steps per day, it lowers their chances of developing excess BF and obesity related health risks (Katzmarzyk et al., 2015; Oliveira et al., 2017). However, these statistics were not seen using BMI as the assessment tool to classify students who are overweight or obese with LiiNK students. Only 7% of the LiiNK students who were classified as overweight or obese at the start of the intervention shifted to the healthy category after a three year period (Farbo, 2019). One reason for these inconclusive results may be due to the use of BMI to assess overweight/obesity rates in these children with a measure that may not accurately assess BF with higher levels of PA throughout the day.

Much attention has been placed on assessing whether a person is considered healthy or unhealthy with weight or BF. Several terms have been used to guide the public's understanding of what target numbers should be. Body composition has been used as a general term and encompasses whole body weight components consisting of fluid, muscle, bone, organs, skin tissue, and fat (Borga et al., 2018). We can then classify individuals into different categories based on body composition that include underweight, healthy, overweight, or obese. The category related to most health concerns for the general public is obesity which is defined as excessive BF accumulation that presents an increased risk for morbidity and mortality (Borga et al., 2018; WHO, 2021). BMI has been utilized for many years as an estimate of body composition for its simplicity and correlation with fat accumulation and health risks in obese individuals (Martin-Calvo et al., 2016). BMI is a height/weight ratio score that uses CDC provided normative charts to categorize each student by age and gender as either underweight, healthy, overweight, or obese (CDC, 2021a). The use of BMI as a determiner of BF has been scrutinized over the years because it uses an estimation of overall BF to categorize individuals instead of measuring BF directly, which can sometimes result in misclassification of those who are not overweight/obese (Borga et al., 2018; Chooi et al., 2019). For example, children who have BMI scores one or two points above the percentile cut-offs for overweight or obese may not actually have high levels of fat. Rather, they may have a higher weight due to the development of more muscle mass, which means they do not fall into the overweight or obese category as BMI would suggest. This chance of error to misclassify individuals may help explain why prior intervention studies using BMI scores as the indicator of obesity have not produced conclusive results as some of these children may have been categorized as overweight or obese when they were not. For children who may have a higher amount of muscle mass due to higher levels of MVPA, using a more accurate BF assessment is needed to properly assess obesity trends (Chooi et al., 2019).

Many techniques are used to collect body composition such as densitometry, BIA, dual energy x-ray absorptiometry (DXA), waist circumference, and skinfolds (Kuriyan, 2018). Densitometry and DXA are typically known as the gold standard for measuring BF.

However, they are both unrealistic options for most researchers as they are expensive, labor intensive, and immobile for large scale studies out in the field (Lemos & Gallagher, 2017). Waist circumference is similar to BMI in that it only gives an estimate of BF and still has a chance to misclassify children (Sardinha et al., 2016). Skinfolds accuracy depends on whether the individual who is administering the skinfolds has sufficient training and follows the standardized protocols for the measurements (Kuriyan, 2018). Additionally, skinfolds can be time consuming and collecting data on a large number of participants could be daunting (Kuriyan, 2018).

BIA is able to determine an estimate of fat mass, fat free mass, water weight, and bone density that shows a moderate to strong association with results provided by DXA (Kuriyan, 2018). These measurements are determined by use of an unnoticeable electrical current that is sent throughout the body by either hand to foot or foot-to-foot metal plates (Kuriyan, 2018; Kyle et al., 2015). This assessment has been recommended as an alternative BF measure in fitness manuals such as Fitnessgram to collect children's data in a school setting due to reducing human error, convenience of using it in large group settings, and BF percentage accuracy across different populations (Kabiri et al., 2015; Kuriyan, 2018; Lemos & Gallagher, 2017). Additionally, most BIA scales are durable, easily transportable, and only require monthly recalibration so they provide reliable results without many additional resources or costs (Kyle et al., 2015; Lemos & Gallagher, 2017). However, accuracy can depend on the choice of device, hydration level (Kuriyan, 2018), and maturation level of the participant (Kyle et al., 2015). Even with these limitations, BIA still has high sensitivity and specificity in classifying individuals into different body composition categories based on BF, which may make it a more reliable measure of obesity than BMI.

Therefore, the purpose of this pilot study was to determine if there was a difference in how BMI and BIA classified students into the four body composition categories. Since this was the first time, the LiiNK researchers had used the BIA assessment tool and were trying to determine BIA and BMI category accuracy, a convenience sample of participants were assessed from different grade levels and schools participating in the LiiNK Project. It was hypothesized that BIA measurements would be positively correlated with BMI considering that BMI is known to have a moderate association with high levels of BF in obese individuals. A second hypothesis was BMI and BIA would classify students into body composition categories differently. Finally, it was hypothesized that the body composition classifications would be different between the two measurements by age and gender also.

## Methods

### *Participants*

This pilot study used a one-group posttest only design and participants were selected using a convenience sample from three North Texas public elementary schools participating in the LiiNK Project intervention. This intervention was approved through a partnership between the school district and the university research team to implement and measure aspects of whole child development. All participants had been participating in four unstructured recesses daily for the past 3-5 years. All students were included who received parental consent and followed the normal school schedule. Students were excluded if they wore a pacemaker, had an injury that prevented them from participating in recess regularly or from being able to stand on the scale with their shoes off. Since this was a pilot study that utilized a convenience sample of students who received parental consent, power estimations were not calculated before recruitment. Table 1 provides the total number of participants

(N=380) by school, age, and gender. The ethnicity of students at the schools selected represented 40% White, 40% Hispanic, 15% Black, and 5% other. Since this study sought to examine differences between BMI and BIA by age and gender, ethnicity was not considered in recruitment of participants or in data analysis.

**Table 1**

*Participants by School, Grade, and Gender*

| Grade | Gender | N |
|---|---|---|
| K | M | 39 (10%) |
| | F | 37 (10%) |
| 1st | M | 36 (10%) |
| | F | 28 (7%) |
| 2nd | M | 39 (10%) |
| | F | 23 (6%) |
| 3rd | M | 34 (9%) |
| | F | 27 (7%) |
| 4th | M | 46 (12%) |
| | F | 37 (10%) |
| 5th | M | 19 (5%) |
| | F | 15 (4%) |
| **Total** | | 380 (100%) |

***Measures-Body Composition***

Bioelectrical impedance analysis was used to measure body composition among participants. The BIA device used was the Tanita® BF 2000, which is proven to be valid and reliable in measuring BF and fat-free mass among elementary aged children (Kabiri et al., 2015). The scale sends a small, unnoticeable electrical signal throughout the body starting at the feet via metal plates located at the base of the device. Fat is a poor conductor of electricity due to a low water content and will cause resistance on the electrical current. The greater impedance present in the current, the higher percentage of BF the scale will calculate.

The height of the participant is measured and entered into the software program beforehand for more accurate body composition measurements. Once height is entered, participants stand on the metal plates with their shoes off for about 10-15 seconds and the scale will calculate fat mass, fat free mass, BF percentage, and BMI.

Results were kept confidential from participants since the scales do not contain a screen and all data is uploaded to a computer via Bluetooth. This feature is important when working with a young population as researchers do not want to initiate any negative psychological effects as a result of children seeing their results. The software program associated with the BIA scale categorizes each student into underweight, healthy, overweight, or obese based on their BF percentage/BMI score, age, and gender. The BMI reference curve scores used to categorize males and females are provided by the CDC(1). McCarthy et al (32) provide the normative values for BF percentages for each gender. For example, for a 9 year old male, a BMI score below the 5$^{th}$ percentile (~14) would classify him as underweight, a score between the 5$^{th}$ and 85$^{th}$ percentile (~14-~18.6) would be healthy, a score between the 85$^{th}$ and 95$^{th}$ percentile (~18.6-~21) would be overweight, and a score above the 95$^{th}$ percentile (>21) would be obese. For that same 9 year old male, the BF normative values would reflect the underweight category to be less than 14% BF, healthy would be 14%-22% BF, overweight would be 22%-27% BF, and obese would be greater than 27% BF.

***Procedures***

The University Institutional Review Board approved the cross-sectional pilot study design. Three schools from the same district participating in the LiiNK intervention were chosen to be assessed with the BIA scales. Comparison schools were not assessed for this pilot since we wanted to identify differences between two body composition tools first for accuracy prior to engaging a different school setting. Once the researchers selected which schools would be assessed, principals were notified about procedures for the study and approval was given prior to the collection of BIA data. Parents were provided and returned informed consent letters to either approve or deny their child's participation in the BIA study and only students that received parental consent were able to participate. Students were able to decline participation at any time if they did not feel comfortable getting their measurements taken using the BIA scale.

Physical education (PE) teachers were asked to provide class rosters, height, and date of birth one week before data collection on an Excel template that was provided by the lead researcher for all children approved to participate. This data was entered into the BIA software prior to school arrival and each student was given a unique ID number to track their data. On the collection day, the researcher arrived at the school approximately 20-minutes before the start of the PE class to set up the BIA scale station.

When the PE class started, the physical education teacher sent groups of 10 students in alphabetical order to a corner of the gym where the researcher and BIA scale were located. Students were asked if they wanted to participate in this assessment by standing on the scale with their shoes and socks off. If they consented, then they were instructed to remove their socks and shoes and when their names were called, they would stand on the metal plates located at the bottom of the scale. After about 15-20 seconds, the scale flashed a green light signifying that the measurement was complete, and students returned to the class activity. The scale was then disinfected with alcohol wipes, the next student was called to stand on the scale, and the process was repeated. Once that group was measured, the teacher would call over the next group of 10 students to the scale station to repeat the same procedures. Each class took approximately 30-minutes to be assessed.

At the end of collection for the day, all data was downloaded from the computer software program into Excel. Each daily Excel sheet was then added to the master data sheet from other days of data collection. Two schools required two days of data collection while the final school only required one day of collection for a total of five data collection days over two weeks. The difference in collection days was due to two schools alternating days in which students attended their PE class while the other school saw all children from each grade level daily. Ideally, students should be measured in a fasted state and well hydrated when using BIA to produce the most accurate results. However, with such a wide variety of schedules and needs of the students, this was not possible for this study. As a result, data was collected at all schools in the morning and afternoon.

***Data analysis***

All data was analyzed using IBM SPSS statistics version 25. Descriptive statistics were used to distinguish the characteristics of the group as a whole, by grade, and by gender. The first hypothesis was tested using Pearson’s correlation coefficient to test the relationship between BMI and BIA before moving forward with further analyses. To test the second and third hypotheses, students were first categorized using CDC’s BMI normative age and gender values labelled as underweight, healthy, overweight, and obese (CDC, 2021a). The students were then categorized using McCarthy and colleagues (McCarthy et al., 2006b) normative values for BF percentage after using the BIA scale to classify them as underweight, healthy, overweight, and obese. The second and third hypotheses were tested using non parametric chi square tests to examine classification differences between BMI and BIA. For the third hypothesis, younger children were identified as those in Kindergarten, first, and second grades (N=202) and older children were identified as those in third, fourth, and fifth grades (N=178).

## Results

### *BMI/BIA Descriptive Statistics*

Since this was a pilot study and students were only measured at one time point, no attrition was experienced in the current sample (N=380). Table 2 shows BMI/BIA means and standard deviations by grade and gender. Fifth grade numbers are noticeably lower than other grade levels due to only one school having the LiiNK intervention through fifth grade at the time of collection. Overall, older students recorded higher BMI and BF percentages than younger students. In addition, females recorded higher BMI, BF percentages, and fat mass than males while males showed higher fat free mass than females.

**Table 2**

*Descriptive Statistics-Means and Standard Deviations*

| | Weight (Kg) mean (SD) | Height (m) mean (SD) | BMI | Body Fat (%) | Fat Mass (Kg) mean (SD) | Fat Free Mass (Kg) mean (SD) |
|---|---|---|---|---|---|---|
| **Gender** | | | | | | |
| Male | 29.77 (8.99) | 1.31 (.11) | 17.12 (3.33) | 20.03 (7.22) | 6.35 (4.09) | 23.43 (5.89) |
| Female | 29.88 (11.22) | 1.30 (.12) | 17.25 (4.00) | 21.68 (8.67) | 7.23 (5.77) | 22.66 (6.12) |
| **Grade** | | | | | | |
| Kindergarten | 21.47 (4.98) | 1.16 (.06) | 15.85 (2.85) | 20.17 (7.01) | 4.64 (2.87) | 16.84 (2.38) |
| 1st | 24.71 (5.23) | 1.24 (.06) | 16.06 (3.17) | 19.22 (7.64) | 5.08 (3.30) | 19.63 (2.59) |
| 2nd | 28.64 (6.45) | 1.30 (.06) | 16.96 (3.20) | 21.36 (7.70) | 6.53 (4.06) | 22.12 (3.06) |
| 3rd | 30.81 (8.97) | 1.32 (.07) | 17.38 (4.04) | 20.99 (8.32) | 7.10 (5.27) | 23.72 (4.25) |
| 4th | 36.18 (9.03) | 1.40 (.07) | 18.27 (3.52) | 21.29 (7.97) | 8.30 (5.16) | 27.89 (4.49) |
| 5th | 53.86 (11.08) | 1.47 (.05) | 19.63 (4.32) | 22.14 (9.77) | 10.41 (7.42) | 32.52 (4.74) |
| **Total** | 29.82 (10.01) | 1.30 (.12) | 17.18 (3.63) | 20.76 (7.92) | 6.73 (4.92) | 23.09 (6.00) |

### *Hypothesis 1: BMI and BIA Correlation*

The Pearson Product correlation coefficient was used to examine the relationship between the BMI and BIA. The results revealed that there was a strong positive correlation between BMI and BIA, r=.85, p<.001. These results suggest that what is measured with BMI is very similar to what is measured with BIA. This confirmation of measurement allows for further analyses of the differences in accuracy between BMI and BIA.

***Hypothesis 2: BIA vs BMI differences***

The chi-square test results revealed a significant difference between how BMI classified students and how BIA classified those same students, $x^2(9)=470.51$, $p<.001$. Table 3 details where the exact differences between the two measurements occurred. According to BMI, 40 students were underweight, 221 students were healthy, 52 were overweight, and 67 were obese, which is presented in the BMI total column. The BIA columns provide information on how the BMI total in each row were categorized according to BIA. For example, of the 40 students classified as underweight according to BMI, 26 were classified as underweight and 14 were classified as healthy according to BIA. This means that 14 of the 40 students were categorized differently between the two measurements, resulting in a 35% difference for the underweight category. These results support the second hypothesis that a classification difference was found between BMI and BIA. Further support is three of the four categories had a 28-38% discrepancy between the two assessment tools. The only low percentage discrepancy was the obese category (6%).

**Table 3**

*Classification Differences Between BMI and BIA All Students*

| | | BIA | | | | |
|---|---|---|---|---|---|---|
| **BMI Total** | **BMI Classification** | **Underweight** | **Healthy** | **Overweight** | **Obese** | **% Difference** |
| 40 | Underweight | 26 | 14 | 0 | 0 | 35% |
| 221 | Healthy | 37 | 160 | 23 | 1 | 28% |
| 52 | Overweight | 0 | 10 | 32 | 10 | 38% |
| 67 | Obese | 0 | 0 | 4 | 63 | 6% |

***Hypothesis 3: BMI and BIA differences by age and gender***

Four chi-square tests were used to test the third hypothesis which stated there would be classification differences between BMI and BIA based on age and gender. For the age analysis, students were divided into two groups, younger (N=202) and older (N=178). Chi-square analysis revealed there was a significant difference between how BMI classified students and how BIA classified those same students for the younger age group, $x^2(9) = 263.71$, $p<.001$, and the older age group, $x^2(9) = 225.32$, $p<.001$. For gender, chi-square analysis also revealed a significant difference between how BMI classified students and how BIA classified those same students for both males, $x^2(9) = 223.75$, $p<.001$, and females, $x^2(9) = 267.57$, $p<.001$. The assumption for running chi-square states that there should be no cells in the contingency table with an expected value less than five. In these results, males and the younger age group reasonably met this assumption, whereas for females and the older age group they were not satisfactory. Therefore, caution should be taken when interpreting the female and older age group results. Table 4 provides where exact differences between the two measurements occurred for each test. The underweight, healthy, and overweight categories had fairly large discrepancies for the younger children and the older children. The overweight category had the largest discrepancy for males and females, while males had a much larger discrepancy than females in the underweight category. All categories had discrepancies, but the largest discrepancies across the participants was with underweight, healthy, and overweight categories.

**Table 4**

*Classification Differences Between BMI and BIA by Age and Gender*

| BMI | | BIA | | | | |
|---|---|---|---|---|---|---|
| **BMI Total** | Category | Underweight | Healthy | Overweight | Obese | **% Difference** |
| | | ***Younger Children*** | | | | |
| 31 | Underweight | 19 | 12 | 0 | 0 | 39% |
| 115 | Healthy | 11 | 86 | 17 | 1 | 25% |
| 24 | Overweight | 0 | 3 | 14 | 7 | 42% |
| 32 | Obese | 0 | 0 | 0 | 32 | 0% |
| | | ***Older Children*** | | | | |
| 9 | Underweight | 7 | 2 | 0 | 0 | 22% |
| 106 | Healthy | 26 | 74 | 6 | 0 | 30% |
| 28 | Overweight | 0 | 7 | 18 | 3 | 36% |
| 35 | Obese | 0 | 0 | 4 | 31 | 11% |
| | | ***Males*** | | | | |
| 23 | Underweight | 11 | 12 | 0 | 0 | 52% |
| 117 | Healthy | 17 | 79 | 20 | 1 | 32% |
| 35 | Overweight | 0 | 7 | 21 | 7 | 40% |
| 38 | Obese | 0 | 0 | 3 | 35 | 8% |
| | | ***Females*** | | | | |
| 17 | Underweight | 15 | 2 | 0 | 0 | 12% |
| 104 | Healthy | 20 | 81 | 3 | 0 | 22% |
| 17 | Overweight | 0 | 3 | 11 | 3 | 35% |
| 29 | Obese | 0 | 0 | 1 | 28 | 3% |

## Discussion

This pilot study sought to examine body composition classification differences between two measures of body composition in elementary school children with 60-minutes of active play daily. BMI has been used for many years since it is fairly easy to collect and demonstrates a moderate correlation in assessing BF in obese individuals (Martin-Calvo et al., 2016). The problem with BMI is that it only provides an estimate of body composition that does not truly distinguish a difference between BF and muscle mass, which can lead to the misclassification of healthy individuals (Chooi et al., 2019). This is especially true when the population measured has a high amount of MVPA as they may have a high weight due to more muscle mass than an accurate BF percentage. Previous studies suggest that 55-66 minutes of MVPA and ~10,000 steps per day in children aged 7-11 will lower their odds of developing excess BF and obesity related health risks (Katzmarzyk et al., 2015; Oliveira et al., 2017). LiiNK Project children, measured with accelerometers over two weeks for the 7.5 hour school day, exceed these recommendations by taking ~9,000 steps and engaging in ~140-minutes of MVPA per day during the school hours only (Farbo et al., 2020), which should result in lower obesity rates in LiiNK Project schools. However, prior LiiNK data only demonstrates marginal changes in overweight and obesity classifications over a three year period when BMI is used to measure obesity rates (Farbo, 2019). Since these children may be experiencing an increase in muscle mass as a result of higher levels of MVPA, BIA seems to show a more accurate way to determine obesity rates since it is able to distinguish the difference between muscle mass and BF (Kuriyan, 2018).

The results reveal many instances in which there was a significant difference in how each measure classified children. Overall, on average, there was a 26% difference between the two measures. BMI classified 99 of the 380 students differently than BIA in all categories, with the overweight category showing the biggest difference at 38%. Similar differences were also reflected in the overweight category by age. Younger children reflected a 42% discrepancy in the overweight category between BMI and BIA, while there was a 36% discrepancy in the overweight category for the older children between the two measurements. This is consistent with Alves et al. (2019), who found a 45% difference between BMI and BIA in classifying children aged 7-10 years old who were in the overweight category. Freedman and Sherry (2009) also discovered that 26% of their participants aged 6-18 were classified as overweight or obese by BMI when they actually had healthy levels of BF. Similar differences can be seen in the overweight classification for both males (40%) and females (35%). This is similar to Alves et al. (2019), who found a 50% difference in males and 37% difference in females between the two measures in the overweight classification. It is clear from these findings that BMI is inaccurate in classifying individuals who are on the border line of either healthy or overweight. These studies support the hypothesis that past LiiNK students who were one or two points higher than the BMI cutoff for overweight were being misclassified and actually should be classified as healthy.

The smallest difference between the two measures across all students was in the obese classification with only a 6% discrepancy. Other research has shown that BMI is accurate in determining obesity in individuals with high levels of fat, or those that are severely obese, which is consistent with the results of this study (Javed et al., 2015). This relationship seems to be consistent when examining younger children and females as they had the smallest difference in the obese classification than any other sub groups at 0% and 3%. In general, there appears to be much more disagreement in the overweight and obese categories in older children and males when compared to younger children and females. These results are similar to the findings of Vanderwall et al. (2017) who found that BMI is a poor predictor of BF percentage in children 9 years old and younger and a moderate predictor in children between the ages of 9-18. This error in students under 9 years old supports the hypothesis that BMI was not a valid tool to assess overweight or obesity rates of students in the LiiNK project as past data has mainly examined trends of students in grades K-2 (5-8 year olds) (Farbo, 2019). Nwizu et al. (2011) also found that the accuracy of BMI to predict BF percentage varies between male and female adolescents as 46% of their male participants with a healthy BF percentage were classified as overweight or obese by BMI compared to only 26% of females. They propose that these differences are a result of a higher accumulation of muscle mass in male participants, which is what could be happening with the males in the current study as a result of the increased time for PA daily (Nwizu et al., 2011).

Another interesting trend was in the underweight classification, where BMI demonstrated a moderately high discrepancy across all ages and gender. Houska et al. (2018) also found that BMI was inconsistent in classifying underweight collegiate female athletes and the authors concluded that BMI is not a useful tool when the population being measured may have more lean mass than BF. This could support the claim that students actively playing at least 60-minutes daily are being misclassified due to higher muscle mass (Javed et al., 2015). Since most of the students selected in this study were entering their fourth or fifth year of the intervention, they could be experiencing longitudinal increases in muscle mass as they age, leading to misclassifications when using BMI. Although the results presented here show that there is a difference between the two measurements, BMI is still frequently used in research studies that aim to decrease obesity rates in children by increasing PA (Casolo et al., 2019; Guerra et al., 2013; Vaquero-Solís et al., 2020). These studies report little to no changes in obesity rates at the end of a PA intervention, but their results may be questionable since they used BMI and they may discover different finding if they used BIA. Researchers who continue to use BMI as an assessment of body composition in children who have higher amounts of PA are at risk of producing inaccurate results. Some may not use BIA due to lack of awareness that another assessment tool is available or lack of funds to purchase equipment (Kuriyan, 2018; Kyle et al., 2015). However, BIA continues to reflect a more accurate assessment of obesity since these results are consistent with at least four other studies that have compared BMI and BIA classification differences (Alves et al., 2019; Freedman & Sherry, 2009; Nwizu et al., 2011; Vanderwall et al., 2017). BIA also measures BF directly which is a better indicator of overall health than a BMI score. This could be especially important for those children who are one or two points above or below the percentile cutoffs according to BMI. The use of BIA may then lead to more definitive results in future active play intervention studies focused on obesity rate determination in children.

### *Limitations*

The first limitation of this study is the sample size when age and gender are assessed categorically with chi-square tests. The results showed that the assumptions of chi-square were not supported for females and older age children. A larger sample size would provide better insight about the differences in females and older children. The second limitation of this study was the variability in the hydration level and time of day BIA measurements were collected. Ideally, BIA measurements should be measured when the participant is fully hydrated, and before eating or exercise has taken place. However, it was nearly impossible to measure all students at a time in which they were fully hydrated, had not eaten, or engaged in PA before-hand due to the nature of the LiiNK intervention. These factors could have produced inaccurate assessments of BF percentage which would lead to a misclassification, but may be more unlikely since they match so well with other studies examining differences in these measurements (Alves et al., 2019; Freedman & Sherry, 2009; Nwizu et al., 2011; Vanderwall et al., 2017). Another limitation is ethnic differences that may have contributed to the extent and direction of the error seen between the two measures. Different ethnicities may experience higher variability in bone density, limb length, and even maturation rate, all of which could have led to a misclassification when using BF produced by BIA since the scale cannot account for these differences. However, analyses by ethnicity were not possible for the current study due to a smaller number of diverse groups. Finally, a COVID-19 limitation is the inability to compare BIA results to a gold standard body composition measure such as DXA to calculate specificity and sensitivity of the scale used in the current study. Other studies have confirmed the scale to be valid and reliable when compared to DXA, however the population used in the current study experienced higher levels of PA than normal which may alter the sensitivity and specificity of the scales. Confirming these results in future studies would strengthen the accuracy of BIA in assessing obesity rates in children with higher levels of PA.

***Future Directions***

Future studies should consider a larger sample size since this was only a pilot study that utilized a convenience sample of participants. This is especially the case when examining any differences between the measures in females and older children in the current study, which had a limited sample size and were not satisfactory to meet the assumptions of the chi-square analyses. Future research should examine specificity and sensitivity for the BIA scale used in the current study to confirm its accuracy in determining obesity rates in children with high levels of PA. Additionally, future research among this population should examine differences in BF percentage between children in the LiiNK project and a control school with less than 20-minutes of recess daily. It would also be beneficial to examine race and ethnic differences in BF percentage between LiiNK and control school students since each can have an effect on body composition. An examination of the longitudinal effects of the LiiNK project on BF percentage would also be appropriate for future research. LiiNK project students may be experiencing greater increases in muscle mass and decreases in BF than control school students over multiple years in the intervention, which will help combat the development of obesity over time. Examining the PA trends and dietary patterns of these children in future studies would also support the effectiveness of the intervention.

***Conclusion***

The results of this pilot study added evidence to existing research showing a significant difference in how BMI and BIA classify students into different body composition classifications. This seems to be especially evident in populations with a high amount of PA, in which BIA may be a more accurate assessment of obesity than BMI. Future researchers should use caution when using BMI to assess obesity rates among children and should seek alternative methods such as BIA, especially when the data is assessed in a place other than a lab setting. BIA has been found to be a valid and reliable assessment tool that can be used specifically in a field setting. Therefore, as shown in multiple studies, BIA takes us a step closer to a field based assessment that can be used in large children populations with consistency. Further analysis is needed to determine if hydration and time of day creates a larger gap in category identification than this study reported.

## Chapter 3: The Effects of a Yearlong Recess Intervention on Body Fat Shifts in Elementary Aged Children

**David J Farbo, Deborah J Rhea**

Published in The International Journal of Child Health and Nutrition. Farbo, D., & Rhea, D. (2022). The effects of a yearlong recess intervention on body fat shifts in elementary aged children. *The International Journal of Child Health and Nutrition*.

**Keywords:** body fat, recess, unstructured play, school, children, obesity, bio-electrical impedance analysis

### Abstract

**Introduction:** Obesity has continued to rise in recent years due to lack of physical activity. The school environment contributes to this problem as opportunities for physical activity are eliminated for more classroom time. Recess, defined as unstructured, outdoor play, can increase MVPA and improve current obesity trends. The purpose of this study was to examine body fat category shift differences in children who received 40-60 minutes and those who received 30-minutes. A secondary purpose was to examine differences by district, sex, grade, and race across both groups since they received more than the national average for recess. **Methods:** Students in 2nd-5th grade (7-11 years old) (N=393) were selected from schools serving as an intervention (N=190) or control school (N=203) in a larger longitudinal intervention titled Let's Inspire Innovation N' Kids (LiiNK). Bio-electrical impedance analysis was used to categorize students as either underfat, healthy, overfat, or obese. These categories were then used to determine if students shifted a category between pre and post measurements. **Results:** At least 30-minutes of recess was significantly associated with a body fat shift in 2nd graders and females. Additionally, the percentage of obese students did not change over the school year. There was no association between group, sex, or race.

**Conclusion:** Due to this study occurring during COVID-19, it is hard to make definitive conclusions on the effects of increased recess time on obesity. However, there are some positive trends pointing towards recess as a successful method in preventing a rise in childhood obesity.

**Introduction**

Childhood obesity has nearly tripled over the last three decades and currently has reached epidemic levels, making it one of the leading health concerns of this generation of children (Anderson et al., 2019; Sanyaolu et al., 2019). Over 340 million children aged 5-19 worldwide are considered overweight or obese, of which 14.4 million in the United States are obese (CDC, 2021a; WHO, 2021). Obesity can increase a child's chances of developing high cholesterol, asthma, muscle and bone disorders, degeneration of the liver, sleep apnea, and cardiovascular disease (Sanyaolu et al., 2019). Obese children also run the risk of experiencing poor self-esteem, body image, self-confidence, and discrimination from their peers (Sarwer & Polonsky, 2016). These experiences can eventually lead to the development of depression, anxiety, eating disorders, and substance abuse (Sarwer & Polonsky, 2016). Previous studies have highlighted the main behavioral risk factors leading to the development of obesity including low levels of physical activity (PA) and sedentary lifestyles (Kumar & Kelly, 2017).

According to the Centers for Disease Control and Prevention (CDC) (CDC, 2021b), children should be participating in at least 60-minutes of moderate to vigorous physical activity (MVPA) per day to yield optimal physical and psychological benefits and combat obesity. However, only 24% of children today between the ages of 6-19 actually meet those recommendations; whereas in contrast, they spend up to eight hours daily in sedentary activities (Barnett et al., 2018; CDC, 2021b). These sedentary lifestyle habits are a result of increased dependence on technology as 34-39% of children will exceed the recommended two hours or less of screen time daily (Aubert et al., 2018; Barnett et al., 2018). The school setting also contributes significantly to sedentary behaviors as many children spend over 60% of the school day sitting in the classroom and on technology, which equates to almost five hours daily (C. Egan et al., 2019). Since the majority of children in the United States attend school daily, it can be the ideal setting to increase MVPA and possibly reverse the current trends in obesity seen across the country (Nally et al., 2021). Unfortunately, the results of many school-based interventions do not provide concrete evidence of support that increasing PA during the school day can be effective in reducing obesity.

Most of these school-based interventions include structured PA activities that are adult led with an emphasis on increasing MVPA during classroom time, before/after school, physical education, and recess (Nally et al., 2021). Classroom based PA includes teacher directed activities such as jumping jacks, dancing, or running in place for approximately 4-20 minutes twice per day (Watson et al., 2017). Physical education or before/after school sessions focus on fitness activities, sports, or adhering to teacher developed physical education curriculum (Errisuriz et al., 2018; Mears & Jago, 2016). Recess interventions, typically structured, add activities that promote PA through teacher direction of games & sports that have rules and strategies, and usually need equipment or markings on the hardtop or field areas (Nally et al., 2021; Parrish et al., 2013).

All four types of interventions only report a 2-14% daily increase in MVPA, which equates to only about 2-10 minutes and still does not lead to children meeting the recommended amount of MVPA (Demetriou et al., 2017; Errisuriz et al., 2018; Parrish et al., 2013; Watson et al., 2017). Children are not taking advantage of the extra time that they have for PA in these types of interventions. This may be due to the structured design since adult led PA may not increase levels of MVPA as children are not always interested in the activity that is selected (Frank et al., 2018). Liu et al. (2019) discovered that the effectiveness of PA interventions strengthened when the participant's enjoyment was also emphasized. Providing enjoyable PA may increase the effectiveness of school-based interventions to improve MVPA and combat obesity in children.

Unstructured, outdoor play opportunities, especially in school settings through recess, have shown to improve MVPA, while being enjoyable and building intrinsic motivation and whole child health (Gray, 2011; Rhea, 2016). Whole child health development encompasses enhancing motor skills, rebooting their brains, socializing with peers, and regulating emotions like empathy and happiness (Bento & Dias, 2017; Lee at al., 2020). Additionally, unstructured, outdoor play provides more opportunities for PA, exploration, and learning through nature and their peers (Bento & Dias, 2017; Lee at al., 2020). During this type of play, children are active upwards of 40% of the time and increase their chances of reaching higher levels of MVPA (Herrington & Brussoni, 2015). Unfortunately, opportunities for recess continue to be sacrificed in favor of increasing classroom time to meet academic demands for student performance (Jarrett, 2019; Ramstetter & Murray, 2017). Finding a balance between daily play breaks and classroom time is essential to allow children opportunities to engage in a sufficient amount of MVPA and combat the development of obesity.

Brusseau and Kulinna (2015) examined the differences between MVPA when children are given one 20-minute or multiple 15-minute outdoor recesses during the day.

Students averaged about 4-minutes more MVPA when given multiple outdoor, unstructured opportunities for recess, with some even doubling their activity time (Brusseau & Kulinna, 2015). Additionally, Razak et al. (2018), examined differences in MVPA of children aged 3-6 who either received one 60-minute or three 15-minute unstructured, outdoor play breaks during childcare. Their results revealed that children with multiple breaks averaged 6-minutes more MVPA during play and 20-minutes more MVPA throughout the day. In addition, Lee et al. (2020) and Farbo et al. (2020) found that unstructured play was a consistent way to improve MVPA in children in schools. Providing children with outdoor, unstructured free play is a more effective way to increase PA patterns during school than structured recess (Brusseau & Kulinna, 2015; Farbo et al., 2020; Lee et al., 2020). However, there is inconclusive evidence to support the effectiveness of these interventions in decreasing obesity (Liu et al., 2019; Nally et al., 2021).

If the focus shifts to interventions that impact obesity, there are some PA interventions that report significant differences in body mass index (BMI) between groups, however the magnitude of these differences is marginal, .5 $kg/m^2$ or below (Liu et al., 2019; Nally et al., 2021). Even when given at least 20-minutes of outdoor, unstructured play daily, children only experience a .74 unit BMI score decrease by the end of a school year (Fernandes & Sturm, 2011). Similar results are seen when increasing the amount of recess as Casolo et al. (2019) did. They examined BMI in 2nd and 3rd grade students who received daily 15-minute outdoor structured recesses or two 15-minute outdoor unstructured recesses. Their findings revealed no significant differences in BMI between the groups after 12 weeks and BMI actually increased within groups by the end of the intervention (Casolo et al., 2019). Howe et al. (2012) also implemented 30-minutes of either structured or unstructured play in

3rd grade students and BMI was measured pre and post intervention. The researchers found no significant differences in BMI in either group after 9 weeks of implementation. With such wide variability in the success of these interventions at decreasing obesity rates, some researchers are speculating why this may be the case.

Ansari et al. (2015) suggest limitations in the amount of time children are given for unstructured, outdoor play is to blame for these inconsistencies. In an analysis of the relationship between time for outdoor play and BMI, they discovered at least 60-minutes of outdoor play was the point at which BMI begins to decrease in children aged 5-12 (Ansari et al., 2015). Other researchers have identified insufficient intervention lengths as a limitation (Liu et al., 2019; Nally et al., 2021). Most of these intervention types have been implemented for 6 months or less, which may not be long enough to see a decrease in obesity. The third limitation is the use of BMI to assess differences in obesity rates. BMI does not directly measure body fat, which is needed to properly assess if an individual is obese or not (Borga et al., 2018). A high BMI score may be a result of more muscle mass than fat, which may help explain why so many interventions are not seeing any differences and in some cases seeing increases in obesity. Based on these findings, interventions should implement 60-minutes of unstructured, outdoor play for at least 6 months and use a more accurate assessment of body fat to determine their effectiveness on obesity rates in children.

The LiiNK Project (Let's Inspire Innovation N' Kids) is a whole child development recess intervention that addresses all the gaps identified in other school-based PA programs. The intervention introduces teachers and students in grades K-5 to four 15-minute unstructured, outdoor play breaks daily, as well as daily character development lessons each year they are in school beginning in kindergarten (Rhea, 2016). The LiiNK project defines unstructured play as outdoor free play that is child directed and child controlled within a safe environment and no adult influence (Bauml et al., 2020). LiiNK Project first and second grade students have been shown to take 900 more steps and achieve 25-minutes more of MVPA per day than control school students with 30-minutes of recess (Farbo et al., 2020). Similar to other play and PA interventions, it is inconclusive from previous data examining BMI if this increase in MVPA is helping decrease obesity rates in children (Farbo, 2019). However, a recent LiiNK study using bio-electrical impedance analysis (BIA) suggests that BMI is not an accurate way to assess obesity rates in children with consistently higher levels of PA (Farbo & Rhea, 2021). BIA is able to directly measure body fat percentage (BF%) and then classify students as underfat, healthy, overfat, or obese. The results revealed BMI and BIA categorized children differently almost 30% of the time, with the biggest difference in the overfat category at 40% (Farbo & Rhea, 2021). Using a more accurate assessment of body fat such as BIA may generate more conclusive obesity results with longitudinal interventions like LiiNK.

Therefore, the purpose of this study was to examine the effects of 30 to 60 minutes of recess defined as unstructured, outdoor play daily on body fat shifts from beginning of year to end of year in elementary aged children. It was hypothesized that children with up to 60-minutes of recess daily would shift significantly more from an unhealthy to a healthy body fat category than students with 30-minutes of recess daily. A healthy body fat category is defined as students who are underfat and healthy while unhealthy students are those in the overfat or obese body fat categories. Since both groups received more than the national average for recess, the second purpose of this study was to examine the effects recess and body fat category shift had on district, sex, grade, and race. It was also hypothesized there would be body fat category shift differences by district, sex, grade, and race.

## Methods

### *Participants*

Participants were selected from ten schools in north and south central Texas participating in the LiiNK Project as either an intervention school or a matching control school. These particular intervention schools (I) (N=5) received a revised number of minutes of outdoor, unstructured play daily for 4th and 5th graders than the 60-minutes typically required. The daily character lessons were still delivered daily for 15-minutes. The difference in time for recess with this study is due to the administration feeling these two grade levels needed to gradually phase out of that much play time to adjust for middle school, which provides less time for breaks in the day. So, students in 2nd and 3rd grade received 60-minutes (four 15-minute time slots), 4th grade 45-minutes (three 15-minute slots), and 5th grade 40-minutes (two 20-minute slots) of recess daily. The control schools (C) (N=5) only received 30-minutes (two 15–minute time slots) daily. Each intervention school was similarly matched by location and demographics with a control school. Only children in 2nd through 5th grade (7-11 years old) were recruited to participate. Six of the schools (District 1, I=3, C=3) were from the Dallas-Fort Worth metroplex and consisted of approximately 40% White, 40% Hispanic, 15% Black, and 5% other. Four of the schools (District 2, I=2, C=2) were from south central Texas and consisted of 70% Hispanic, 20% White, 5% Black, and 5% other. Other included Asian, Pacific Islander, American Indian, Alaskan Native, or two or more races. Participant distributions (N=393) are provided in Table 5 and pre (beginning of school year) descriptive statistics of height, weight, BMI, BF%, and percentage of students in each

BF% category are provided in Table 6.

**Table 5**

*Participants by School, Grade, and Gender*

| | | District 1 | | District 2 | | |
|---|---|---|---|---|---|---|
| | | Intervention | Control | Intervention | Control | |
| Grade | Gender | N | N | N | N | **Total** |
| 2nd | M | 0 | 0 | 27 | 32 | 59 |
| | F | 0 | 0 | 21 | 37 | 58 |
| 3rd | M | 15 | 8 | 21 | 47 | 91 |
| | F | 21 | 4 | 33 | 34 | 92 |
| 4th | M | 9 | 2 | 0 | 0 | 11 |
| | F | 17 | 13 | 0 | 0 | 30 |
| 5th | M | 8 | 11 | 0 | 0 | 19 |
| | F | 18 | 15 | 0 | 0 | 33 |
| | **Total** | 88 | 53 | 102 | 150 | 393 |

**Table 6**

*Pre-Descriptive Statistics*

| | N | Weight | | Height | | BMI | | BF% | | BF% Categories | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | UF | H | OF | OB |
| **Group** | | | | | | | | | | | | | |
| Intervention | 190 | 73.61 | 21.75 | 52.02 | 3.42 | 18.87 | 3.94 | 23.78 | 8.40 | 6% | 52% | 12% | 30% |
| Control | 203 | 71.26 | 21.75 | 51.64 | 3.42 | 18.52 | 3.87 | 23.60 | 8.31 | 5% | 53% | 18% | 24% |
| **District** | | | | | | | | | | | | | |
| District 1 | 141 | 79.33 | 23.78 | 54.00 | 3.37 | 18.87 | 4.07 | 22.66 | 8.71 | 10% | 57% | 7% | 26% |
| District 2 | 252 | 68.52 | 19.53 | 50.61 | 2.79 | 18.59 | 3.80 | 24.26 | 8.10 | 3% | 50% | 19% | 28% |
| **Gender** | | | | | | | | | | | | | |
| Male | 170 | 70.00 | 21.10 | 51.38 | 3.52 | 18.35 | 3.57 | 24.35 | 7.36 | 6% | 60% | 12% | 22% |
| Female | 223 | 74.22 | 22.11 | 52.17 | 3.31 | 18.96 | 4.12 | 23.18 | 9.01 | 5% | 47% | 17% | 31% |
| **Grade** | | | | | | | | | | | | | |
| 2nd Grade | 127 | 64.23 | 16.12 | 49.40 | 2.52 | 18.35 | 3.50 | 24.31 | 7.46 | 2% | 48% | 20% | 30% |
| 3rd Grade | 173 | 71.91 | 20.49 | 51.83 | 2.56 | 18.62 | 3.93 | 23.57 | 8.54 | 5% | 54% | 15% | 26% |
| 4th Grade | 41 | 82.56 | 25.96 | 54.02 | 3.18 | 19.62 | 4.54 | 23.99 | 9.50 | 7% | 49% | 12% | 32% |
| 5th Grade | 52 | 85.97 | 24.75 | 55.99 | 2.86 | 19.05 | 4.15 | 22.28 | 8.83 | 13% | 60% | 6% | 21% |
| **Race** | | | | | | | | | | | | | |
| White | 139 | 72.02 | 22.56 | 52.47 | 3.65 | 18.12 | 3.84 | 21.69 | 7.80 | 7% | 61% | 13% | 19% |
| Black | 28 | 84.23 | 25.17 | 53.52 | 3.40 | 20.42 | 4.70 | 26.88 | 10.24 | 7% | 40% | 14% | 39% |
| Hispanic | 209 | 71.13 | 20.74 | 51.11 | 3.15 | 18.90 | 3.82 | 24.79 | 8.24 | 3% | 48% | 17% | 32% |
| Other | 17 | 71.54 | 16.49 | 52.59 | 2.65 | 18.04 | 2.98 | 21.15 | 6.86 | 18% | 59% | 0% | 24% |
| **Total** | 393 | 72.40 | 21.75 | 51.83 | 3.42 | 18.69 | 3.90 | 23.69 | 8.35 | 6% | 52% | 15% | 27% |

Note: UF=Underfat, H=Healthy, OF=Overfat, OB=Obese

Originally, 497 students in grades 2-5 received parental consent for their data to be collected during the 2020-21 school year. Students needed to have data at both pre (fall) and post (spring) to be included in the final data analysis. A total of 73 participants (I=37, C=36) did not have data at post, so they were excluded from analysis. Reasons for lack of data would include being absent on collection days, not giving assent, moving to a new school, or their class moving to an online format as a result of COVID-19. In addition, 31 students (I=9, C=22) were eliminated due to errors in their height data. These children either had a smaller height at post than at pre or an unrealistic increase in height as some students appeared to grow 9 to 10 inches between semesters. This most likely was due to an error made when measuring their height or when entering their data into the BIA software. An inaccurate height would cause the BIA scale to inaccurately assess body fat and properly categorize students.

***Measures-Body Composition***

Body composition was measured using BIA. The BIA device used for the current study was the Tanita BF 2000, which is shown to have high specificity in assessing overfat and obese children (Kabiri et al., 2015). In addition, the scale has a moderate to strong correlation when compared to the most accurate assessments of body composition such as dual-energy x-ray absorptiometry (Kabiri et al., 2015). The scales use an unnoticeable electrical current to detect body fat, which has a low water content and will cause impedance in the current. Upon completion of the measurement, the participant’s fat free mass, fat mass, BF% and BMI are calculated. The scale will then use this information to classify students as underfat, healthy, overfat, and obese based on age and sex (McCarthy et al., 2006b).

### *Procedures*

The LiiNK intervention BIA protocol received IRB approval from a North Texas university where the intervention originated. Since this project was approved during the COVID-19 pandemic, special precautions were taken to abide by university COVID-19 guidelines including wearing face shields, masks, and disinfecting the scales in between each participant. Principals were then notified to obtain approval to be on campus and parental consent letters were sent home, signed, and returned by parents. Child assent was also collected by asking children if they were comfortable removing their socks and shoes and then standing on the scale. Any child who did not receive parental consent or did not provide assent was excluded from collection.

Once consent was collected, principals and teachers were notified to coordinate a day researchers could be on campus to begin data collection. In addition, class rosters with sex, grade, date of birth, and height were provided by physical education teachers to be entered in the BIA software program. Physical education teachers collected height earlier in the fall semester as an ongoing measure collected for the LiiNK Project. Height was measured in inches and any student who did not have their height collected beforehand was measured on collection day.

On the data collection day, height and scale stations were set up in a private, centrally located section of the hallway near the classrooms of students participating in data collection. Students who had parent consent were pulled from their classroom in groups of five and were asked if they agreed to participate. If they did, they were requested to remove their socks and shoes and wait for their name to be called. When it was their turn, students stood on the scale for approximately 5-10 seconds as their data was calculated. The scale would flash a green light to signify that a participant's data was being collected and then would disappear once the measurement was complete. Students put their socks and shoes back on and returned to class while the scale was disinfected. The next student was called and the procedures were repeated. If a student was absent on the collection day, a researcher returned on an alternate day to collect their data. The same procedures were followed during the spring semester for post data collection. Ideally, BIA measurements should be taken when participants are in a fasted state and fully hydrated. However, these requirements are hard to implement consistently as students have highly variable schedules and needs throughout the day. Attempting to account for this variability, students were measured at the same time of day in the fall and spring semesters.

At the end of each day, data was saved on the BIA software program on a secure computer. Once all schools were collected, data was downloaded to an Excel file and then combined with a master data sheet. The data downloaded from the BIA software included ID, grade, sex, height, weight, BMI, BF%, and body fat category. Each school only required one day of collection to complete measurements for all students, excluding post days for students who were absent. These measurements were completed over the course of three weeks in the fall and spring semesters.

***Data Analysis***

Data was analyzed using IBM SPSS statistics version 26. The characteristics of the sample by group, district, sex, grade, and race were determined using descriptive statistics. To test the first and second hypothesis, students were first categorized and coded as either (1) underfat, (2) healthy, (3) overfat, or (4) obese according to normative values provided by McCarthy et al (McCarthy et al., 2006b). Then, a new variable was computed to assess body fat category shifts between pre (fall) and post (spring) data points. This new variable was calculated by subtracting the post body fat category from the pre category. For example, if a student was overfat at post and healthy at pre, their new variable would be coded as 1 since 3-2=1. A value of -1 indicated that the participant decreased a body fat category, 0 was no shift, and 1 indicated an increase in a body fat category. Three students received a score of -2, which means they decreased by two body fat categories. However, these students were recoded as -1 since there were only a few who met this classification and would result in violations of the assumptions of chi-square tests. In addition, students who shifted from underfat to healthy or from healthy to underfat were coded as a 0 since they were still considered healthy with either of those shifts. Although these shifts demonstrated either an increase or decrease in BF%, this study was more focused on shifts from the unhealthy categories of overfat and obese to a healthy category.

The first hypothesis was tested using a non-parametric chi square test with an alpha value of $p<.05$ to examine any association between group and body fat category shift. The second hypothesis was also tested using a non-parametric chi square test, however intervention and control groups were combined to have a large enough sample size to examine differences by district, sex, grade, and race. A significant chi-square statistic is an indication that there is a difference between the observed count, what was actually measured, and the expected count if there was no relationship between the independent and dependent variables. Adjusted standardized residuals (AR) are then used to determine which of the observed values are different than the expected values in the chi-square model. An AR greater than 1.96 indicates that the observed values are significantly more or less than expected with $p<.05$, which means there is a significant association between the independent variable and body fat category shift.

## Results

### *Descriptive Statistics*

Descriptive statistics were used to determine the means and standard deviations of height, weight, BMI, BF%, and percentage of students in each BF% category by group, district, sex, grade, and race. Due to lower sample size when dividing group x sex, group x district, etc., descriptives are only provided by main effects. At post, the following differences from fall data were found between groups and by sex, grade, and race. The intervention students had slightly higher BF% (1.75%) and those classified as obese (7%) than control school students. District 1 students had higher BMI (.42) but lower BF% (0.94%) and obesity prevalence (4%) than District 2 students. Males had lower BMI (.56) and obesity prevalence (8%) but higher BF% (1.46%) than females. Across grade levels, BF% was slightly higher in younger students (~24%) until they reached 5$^{th}$ grade where it decreased ~1.2% and reported the lowest percentage of obese students (21%). Black and Hispanic students had the highest BF% (28.11%, 25.38%) and percentage of students who were obese (39%, 31%); white and other had the lowest BF% (22.09%, 19.78%) and obesity prevalence (18%, 18%). However, blacks and other students had lower sample sizes compared to other groups so caution should be used when interpreting their results. Between semesters, weight, height, BMI, BF% increased for all groups except control students and other who demonstrated a slight decrease in BF% (.3%). Table 7 provides descriptives for data collected at the end of the year.

**Table 7**

*Post-Descriptive Statistics*

| | N | Weight | | Height | | BMI | | BF% | | BF% Categories | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | Mean | SD | UF | H | OF | OB |
| **Group** | | | | | | | | | | | | | |
| Intervention | 190 | 78.90 | 23.65 | 52.79 | 3.36 | 19.63 | 4.29 | 25.08 | 8.88 | 4% | 53% | 13% | 30% |
| Control | 203 | 76.33 | 23.02 | 52.99 | 3.35 | 18.85 | 4.06 | 23.33 | 8.77 | 10% | 51% | 16% | 23% |
| **District** | | | | | | | | | | | | | |
| District 1 | 141 | 84.48 | 25.59 | 54.81 | 3.39 | 19.50 | 4.37 | 23.57 | 9.03 | 9% | 56% | 11% | 24% |
| District 2 | 252 | 73.71 | 21.06 | 51.82 | 2.82 | 19.08 | 4.08 | 24.51 | 8.76 | 6% | 49% | 17% | 28% |
| **Gender** | | | | | | | | | | | | | |
| Male | 170 | 75.30 | 22.65 | 52.48 | 3.54 | 18.91 | 3.78 | 25.00 | 7.49 | 6% | 57% | 15% | 22% |
| Female | 223 | 79.31 | 23.75 | 53.20 | 3.18 | 19.47 | 4.46 | 23.54 | 9.74 | 8% | 48% | 14% | 30% |
| **Grade** | | | | | | | | | | | | | |
| 2nd Grade | 127 | 69.15 | 17.89 | 50.78 | 2.66 | 18.68 | 3.71 | 23.97 | 7.97 | 5% | 50% | 17% | 28% |
| 3rd Grade | 173 | 77.22 | 21.89 | 52.75 | 2.58 | 19.32 | 4.24 | 24.72 | 9.16 | 6% | 51% | 15% | 28% |
| 4th Grade | 41 | 88.19 | 28.38 | 55.15 | 3.19 | 20.06 | 4.91 | 24.20 | 10.01 | 7% | 56% | 10% | 27% |
| 5th Grade | 52 | 90.96 | 26.37 | 56.75 | 2.84 | 19.63 | 4.43 | 22.82 | 9.01 | 15% | 52% | 12% | 21% |
| **Ethnicity** | | | | | | | | | | | | | |
| White | 139 | 76.88 | 24.20 | 53.46 | 3.56 | 18.63 | 4.12 | 22.09 | 8.15 | 11% | 59% | 12% | 18% |
| Black | 28 | 90.84 | 28.13 | 54.39 | 3.27 | 21.34 | 5.39 | 28.11 | 11.33 | 3% | 54% | 4% | 39% |
| Hispanic | 209 | 76.41 | 22.08 | 52.20 | 3.12 | 19.45 | 4.04 | 25.39 | 8.67 | 4% | 46% | 19% | 31% |
| Other | 17 | 75.65 | 16.87 | 54.24 | 2.70 | 17.95 | 2.94 | 19.78 | 7.04 | 23% | 59% | 0% | 18% |
| **Total** | 393 | 77.57 | 23.33 | 52.89 | 3.35 | 19.23 | 4.18 | 24.17 | 8.86 | 7% | 52% | 14% | 27% |

Note: UF=Underfat, H=Healthy, OF=Overfat, OB=Obese

***Hypothesis 1: Body fat category shift by group***

Non-parametric chi-square tests were used to determine pre to post body fat category shift differences by group. Chi-square assumptions were met as no values within the contingency table had an expected count of less than five. The chi-square test revealed no significant association between group and body fat category shift, $x^2(2)=1.05$, p=.59. Table 8 provides details reflecting no group differences for increasing (1), decreasing (-1), or maintaining a body fat category (0). The observed column includes the actual number of participants in each group who shifted in body fat category from pre to post. The expected column represents the expected number in the chi square model if the null hypothesis were true and there was no relationship between the independent and dependent variables. Finally, the AR column indicates if the differences between the observed and expected count are significant at $p<.05$. If significant, this means that group (intervention or control) had a significant effect on body fat category shift. For example, in the intervention group, the chi square model expected 15 students to decrease a body fat category (obese to overfat or overfat to healthy). At post, there were actually 13 students who decreased a body fat category, which is two less than expected. According to the AR (-0.7), the difference between the observed (13) is not significantly different from the expected (15). This means that the intervention had no effect in decreasing the body fat category that was significant.

**Table 8**

*Body Fat Category Shift by Group*

| | **-1** | | | **0** | | | **1** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Group** | Observed | Expected | AR | Observed | Expected | AR | Observed | Expected | AR |
| Intervention | 13 | 15 | -0.7 | 161 | 161 | 0 | 16 | 14 | 0.8 |
| Control | 18 | 16 | 0.7 | 172 | 172 | 0 | 13 | 15 | -0.8 |

***Hypothesis 2: Body fat category shift by district, sex, grade, and race***

Non-parametric chi-square tests were also used to determine pre to post body fat category shift differences by district, sex, grade, or race as seen in Table 9. By district, there were no values with an expected value less than five within the contingency table. The chi-square test revealed no association between district and body fat category shift, $x^2(2)=3.08$, $p=.22$.

When analyzing the relationship between sex and body fat category shift, the assumptions of chi square were met as no cells within the contingency table had an expected count less than five. The chi-square results revealed no association between sex and body fat category shift, $x^2(2)=4.33$, $p=.11$. However, females had significantly more (23) than expected (17.6) decrease in body fat category while males had significantly less (8) than expected (13.4) decrease.

By grade level, 4th and 5th graders had multiple contingency table cells with an expected value less than five, so caution should be used when interpreting grade level results. The chi square test revealed a significant association between grade level and body fat category shift, $x^2(2)=12.90$, $p<.05$. Students in 2nd grade had significantly higher (17) than expected (10) decrease or maintain body fat category while students in 3rd grade had significantly lower (8) than expected (13.6) decrease in body fat category.

The results by race also had chi-square assumption violations with Black and other students having cells with an expected count less than five. Chi-square tests revealed no race by body fat category shift association, $x^2(2)=6.85$, $p=.34$. Although race was not associated with a body fat category shift, Hispanics did have significantly more (21) than an expected (15.4) increase in a body fat category.

**Table 9**

*Body Fat Category Shift by District, Gender, Grade, and Race*

| | **-1** | | | **0** | | | **1** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Group** | Observed | Expected | AR | Observed | Expected | AR | Observed | Expected | AR |
| District 1 | 7 | 11.1 | -1.6 | 125 | 119.5 | 1.6 | 9 | 10.4 | -0.6 |
| District 2 | 24 | 20.0 | 1.6 | 208 | 213.5 | -1.6 | 20 | 18.6 | 0.6 |
| Male | **8** | **13.4** | **-2.0*** | 148 | 144.0 | 1.1 | 14 | 12.5 | 0.6 |
| Female | **23** | **17.6** | **2.0*** | 185 | 189.0 | -1.1 | 15 | 16.5 | -0.6 |
| 2nd Grade | **17** | **10.0** | **2.8*** | **101** | **107.6** | **-2.0*** | 9 | 9.4 | -0.2 |
| 3rd Grade | **8** | **13.6** | **-2.1*** | 150 | 146.6 | 1.0 | 15 | 12.8 | 0.9 |
| 4th Grade | 4 | 3.2 | 0.5 | 37 | 34.7 | 1.0 | 0 | 3.0 | -1.9 |
| 5th Grade | 2 | 4.1 | -1.2 | 45 | 44.1 | 0.4 | 5 | 3.8 | 0.7 |
| White | 10 | 11.0 | -0.4 | 121 | 117.8 | 0.9 | 8 | 10.3 | -0.9 |
| Black | 3 | 2.2 | 0.6 | 25 | 23.7 | 0.7 | 0 | 2.1 | -1.5 |
| Hispanic | 17 | 16.5 | 0.2 | 171 | 177.1 | -1.7 | **21** | **15.4** | **2.2*** |
| Other | 1 | 1.3 | -0.3 | 16 | 14.4 | 1.1 | 0 | 1.3 | -1.2 |

Note: *=p<.05

**Discussion**

This study examined body fat category shift differences in grades 2-5 children who received 30-minutes daily (control) versus 40, 45, or 60 minutes daily (intervention) of recess. Although no significant group differences were found between pre and post data using BIA assessments, having 30-60 minutes of recess daily showed some positive results (Jarrett, 2019; Ramstetter & Murray, 2017; Rhea, 2016). In addition, recess is often taken away in other schools due to behavioral issues or to increase instruction time in the classroom (Jarrett, 2019; Ramstetter & Murray, 2017). Neither the intervention nor the control schools in the current study were allowed to withhold recess for any reason, so all students in the control schools received 30-minutes of recess daily and the intervention schools received between 40 and 60 minutes daily depending on grade level.

Positive trends in obesity rates for both groups are worth noting. Providing at least 30-minutes of recess daily seems to aid in preventing obesity rate increases during a full school year. The percentage of obese students in the intervention group remained stable at 30% while the control group decreased from 24% to 23%. This could mean that students in both groups were taking advantage of the time that they had for recess to be active and engage in sufficient MVPA to prevent body fat from increasing. The control schools for this study clearly had a lower percentage of obesity at the pre-test than the intervention schools, so other variables may have played a part in why obese students were obese, i.e., active lifestyles outside of the school setting, food choices at school and at home. Ideally, groups should be equal at baseline to successfully identify if there are any intervention effects at post measurement. However, this study utilized a convenience sample of students who received parental consent instead of using all students in a grade level. This could have resulted in a healthier selection of control school students simply because their parents approved their participation and may not be a true representation of the rest of the population. The healthy (59%), overfat (14%), and obesity (27%) prevalence across both groups is similar to healthy (54%), overweight (17%), and obesity (29%) rates reported across the state of Texas using BMI in the same age group (Texas School Physical Activity and Nutrition Project, 2021). However, until other studies assess body composition with a true body fat measure such as BIA, we won't know the true body fat results of children outside of this intervention. Farbo and Rhea (Farbo & Rhea, 2021) assessed children with both measures and found that BMI can have up to a 30% chance of misclassifying students when compared to BIA, especially those in the overweight category (Farbo & Rhea, 2021). In the current study, BMI had 42% chance of misclassifying overfat and a 14% chance of misclassifying in obese when compared to how BIA categorized students. So further investigation is needed to determine if the overweight/obese statistics reported across states and nationally using BMI have been misleading over the years, especially in children who are active.

One other interesting point is that this data was collected in the midst of the COVID-19 pandemic. Lange and colleagues (Lange et al., 2021) examined obesity rates of 2-19 year olds during the pandemic as well and found obesity prevalence increased from 19.3% to 22.4% and the monthly rate of BMI increase was double during the pandemic than before. This is a result of lifestyle changes including an increase in sedentary time and poorer eating patterns that were heighted during the pandemic (Zemrani et al., 2021). These factors outside of school could have altered the true results of the current study. Further investigation is needed to determine the effects of the intervention during a normal school year when children attend school more consistently and academic pressures facing children decrease.

Due to both groups receiving more time for recess than the national average, we also wanted to analyze body fat shift by sex, grade, and race. By sex, more females than expected in both groups decreased a body fat category, whereas males did not. This is consistent with Podnar and colleagues (Podnar et al., 2021) systematic review that showed many school-based programs demonstrate a strong intervention effect in females and only borderline effects in males. This is interesting as females are commonly shown to engage in less MVPA than males throughout the day (Farbo et al., 2020; McLellan et al., 2020). In addition, body fat has shown to steadily increase across both sexes until about age 11, then males begin to decrease and females continue to increase (Laurson et al., 2011). Females may have been lacking sufficient MVPA at the pre data point, so they were able to take advantage of extra time for recess to increase MVPA and decrease body fat. The males may have engaged in sufficient amounts of MVPA at the pre data point and the additional recesses did not increase MVPA enough to burn body fat. More research is required to determine the parameters needed in school-based interventions to see positive results in male students.

At least 30-minutes of recess is also effective in decreasing obesity rates in 2nd grade students as they had significantly more than expected decrease in body fat category. This contradicts the work of Casolo et al (Casolo et al., 2019), who found no differences in BF% in 2nd grade students who received two 15-minute unstructured recesses throughout the day. The decrease in body fat in 2nd graders suggests that additional time for recess may be an effective way to prevent body fat from increasing in younger children within a school year.

There was no association with body fat category decrease in students in 3rd, 4th, and 5th grade. These students may not have engaged in sufficient MVPA to decrease body fat as MVPA has been shown to gradually decline in children beginning at 7 years old (Farooq et al., 2018). However, obesity prevalence was the lowest in the older grade levels as 4th and 5th grade students had only 27% and 21% of children who were obese. Children in 4th and 5th grade were entering their fifth or sixth year receiving additional recess each day that they were in school, suggesting there may be a larger intervention effect after multiple years of implementation. For children in the older grade levels, additional investigation is needed to examine longitudinal impact of increased time for recess on obesity rates as one year may not be sufficient to see significant differences.

Finally, body fat categories did not shift significantly by race. This may be a result of Hispanic students, who represented over half of the sample, had the highest overweight (19%) and second highest obese (31%) percentages than the other races. In general, Hispanic children typically have higher obesity rates than other races followed by White, Black, and Other (Gállego Suárez et al., 2017). Other researchers have found Hispanic children will consume less fruits and vegetables, more sugary sweetened beverages, and more fast food than children of other races (Chen et al., 2018). Reducing obesity in Hispanic children has shown repeatedly not to be effective with a PA/play school based intervention alone, even when given for a complete school year. Chavez & Nam (Chavez & Nam, 2020) support our findings and state multi-component interventions that include 1) PA/play, 2) reduce calorie intake and improve dietary components, and 3) involve families in changing behaviors at home are more effective in reducing obesity prevalence in Hispanic children. Further research is needed to examine the influence of variables such as sedentary behaviors and dietary patterns outside of the school environment may have on obesity rates by race.

### *Limitations*

The first limitation in this study is it took place in the midst of COVID-19. Evidence shows obesity rates, poor eating habits, and sedentary behaviors were heightened during the pandemic (Zemrani et al., 2021). These changes in lifestyle habits could have minimized the true effects of the intervention. Another limitation is the way in which students were measured using the BIA scale. When using BIA, participants should be in a fasted state and fully hydrated. However, this was not possible with this population as there were many differences in schedules and needs of students throughout the day. If a student was not fully hydrated, it could have resulted in a higher BF% due to a lower water content leading to additional resistance in the electrical current. Another limitation is aging that occurred between the pre and post measurements. A secondary analysis of the data not included here examined body fat category shifts of children who maintained or increased in age between measurements. The data showed more students than expected decreased a body fat category when they increased in age and more than expected increased when they remained the same age. Whether or not a student shifted a body fat category could have been influenced by their age at the time of pre collection. The final limitation is lack of collecting other variables that could affect obesity including sedentary behaviors, socio-economic status, and eating patterns. Collecting and controlling for these variables could provide a clearer picture on the true effects of the intervention on body fat.

### *Future Directions*

Since data collection occurred in the middle of the COVID-19 pandemic, it is hard to make a definitive conclusion on the effects of increased time for recess on obesity rates. Future studies need to examine the effects of increased time for recess on body fat during a non-pandemic school year. A larger sample size would allow for analyses examining interaction effects between the intervention and sex, grade, or race, which were not possible in the current study. Additionally, future research should consider the effect of variables outside of school including sedentary behaviors, eating patterns, and socio-economic status. Adding a true control school with 20-minutes or less for recess would also be valuable to examine in future studies. The additional time for recess in the control group could be minimizing the differences between the two groups. Finally, future studies should examine the effects of aging on body fat classification in children. Age seemed to have an effect on body fat classification in the current study as children who increased in age between measurements were more likely to display a decrease in body fat category. More research is needed to ensure the most accurate assessment of obesity is being used in children.

***Conclusion***

The results of this study revealed no differences in body fat category shift between students who receive either 30 or 60 minutes daily for recess. However, definitive conclusions cannot be made due to this study occurring during the COVID-19 pandemic, which had a significant effect on normal lifestyle habits of children. Despite this limitation, providing at least 30-minutes of recess seems to have a significant association with decreasing body fat categories in 2nd graders and females. In addition, at least 30-minutes of recess is a useful way to deter higher obesity levels as neither the intervention nor the control group had an increase in the number of students who were obese at post measurements or individual students who increased in body fat percentage. From these results, it seems that at least 30-minutes of outdoor, unstructured play is a promising strategy for controlling obesity rates in children. Instead of taking away time for outdoor, unstructured play, it should be incorporated as a regular part of the school day. Further research is needed to examine the effects of 30 vs 60 minutes of recess during a non-pandemic school year with a school schedule that typically has 20-minutes or less of recess daily.

# Chapter 4: The Effects of Outdoor, Unstructured Play on Physical Activity and Obesity Rates in Children

## Introduction

Childhood obesity has reached epidemic levels worldwide as there are currently 340 million children who are categorized as overweight or obese (Kumar & Kelly, 2017; Sanyaolu et al., 2019). In the United States, there is an estimated 14.4 million obese children, with millions more that are overweight (Centers for Disease Control and Prevention, 2021a). Differences by sex and race also present a problem as male (20.5%), Black (24.2%), and Hispanic (25.6%) children have higher obesity rates than female (18%) and non-Hispanic white children (16.1%) (Fryar et al., 2018). The health complications that burden those who are obese can include type two diabetes, cardiovascular disease, sleep apnea, and hypertension (Sahoo et al., 2015). Obese individuals also can develop mental health ailments including low self-esteem, quality of life, poor social relationships, and depression (Sarwer & Polonsky, 2016). Even more concerning, obese children are likely to become obese adults, leading to life-long health complications (Simmonds et al., 2016).

Obesity occurs when more calories are consumed than burned on a consistent basis, leading to excessive body fat accumulation that presents an increased health risk (Romieu et al., 2017; World Health Organization, 2021). In children, this caloric imbalance begins with an increase in sedentary behaviors and poor eating habits (Barnett et al., 2018; Kim & Lim, 2019). Most children will spend up to eight hours a day sedentary and their diet consists of high amounts of snacking, sugary beverages, fast food, and over eating (Barnett et al., 2018; Kim & Lim, 2019). Physical activity (PA) has been shown to be an effective way to burn excess calories and prevent the build-up of body fat (Swift et al., 2014). The CDC recommends that children engage in at least 60-minutes of moderate to vigorous physical activity (MVPA) daily to prevent weight gain and even decrease body fat (CDC, 2021b). However, only 24% of children meet this recommendation, with females achieving 10%-20% less MVPA daily than males (CDC, 2021b; McGovern et al., 2020; Telford et al., 2016). In addition, children who are inactive will continue to be inactive as adolescents and adults (Lounassalo et al., 2019). This life-long risk of inactivity develops as a result of children never learning how to adopt an active and healthy lifestyle.

The social learning theory states that children learn by first observing a behavior, seeing the consequences, then modeling and imitating that behavior (Bandura & Walters, 1977). The theory also explains behaviors are developed through constant interaction between the behavior, cognition, and the environment (Bandura & Walters, 1977). When one or more of these aspects do not align with the others, the targeted behavior will not be learned. Parents and other influential adults such as teachers are highly impactful in the types of behaviors children develop. Furthermore, many children today are not exposed to active lifestyles and do not learn how or why they need to be active (Mitchell, 2019). At home, children will adopt the same PA patterns as their parents and many families across the country are relatively inactive (Mitchell, 2019; Sijtsma et al., 2015). Schools are more focused on core subjects such as math and reading with little emphasis on PA through physical education and recess (Dickey et al., 2016; C. A. Egan et al., 2019; Rhea, 2016). This kind of mindset leads to children believing that PA is not as important as other aspects of everyday life or academics. When given the opportunity, children naturally learn how to be physically active through structured and unstructured play (Gray et al., 2015; Pulido-Sánchez & Iglesias-Gallego, 2021). However, many environments tend to provide more structured play opportunities than unstructured, which may prevent children from enjoying different ways of being physically active  (Herrington & Brussoni, 2015).

Structured play can include sports or games that are planned and adult led with a specific end goal in mind (Kinder et al., 2019). Unstructured play is child-directed and child-controlled with no specific end goal needed (Gray, 2011; Kinder et al., 2019; Rhea, 2016). With structured activities such as soccer, children are actually shown to be active only about 25% of the time as they often are standing and waiting for further direction (Gray et al., 2015). In addition, structured play may not lead to lifelong PA as children may become burned out from adult expectations (Frank et al., 2018). This is an example of how the environment (structured play) can influence the cognitive processes (enjoyment) needed to adopt a behavior (PA), as described by the social learning theory (Bandura & Walters, 1977). During unstructured play, children can be active upwards of 40% of the time, especially when play is outdoors (Herrington & Brussoni, 2015). Most importantly, children enjoy unstructured play and will participate regardless of any adult guidance, which develops the motivation to regularly perform that behavior. Unfortunately, many environmental factors can limit the amount of time children have to engage in sufficient unstructured, outdoor play (Dankiw et al., 2020; Dickey et al., 2016; Rhea, 2016).

Technology has consumed the lives of many children, as up to 60% will spend more than the recommended two hours daily on some kind of electronic device (Barnett et al., 2018). Parents may also limit play due to increasing fear about safe play spaces and concern of trying to occupy children's time with academic activities and sports (Bento & Dias, 2017). In addition, most children only receive 20-minutes or less per day for recess, which is the only opportunity for unstructured, outdoor free play during school (Dickey et al., 2016;

Jarrett, 2019; Rhea, 2016). Even when schools offer recess as unstructured, outdoor play, it is reduced or removed as punishment for bad behavior or to stay in the classroom for additional tutoring (Dickey et al., 2016; Jarrett, 2019; Rhea, 2016). When they are allowed to play outside, it can account for up to 40% of a child's daily MVPA levels (Pulido Sánchez & Iglesias Gallego, 2021). Providing the minimum amount for recess (100-minutes per week) is also associated with a .74 decrease in body mass index (BMI) score compared to children who do not have recess (Gray et al., 2019). Without recess, females have greater odds of becoming overweight or obese than males (Rogers et al., 2022). Evidence suggests recess is vital to increase PA and decrease obesity rates in children.

Researchers have begun to implement various school recess intervention strategies such as adding playground equipment, loose equipment, structured activities, or natural elements, i.e., green spaces and trees (Nally et al., 2021; Naylor et al., 2015; Parrish et al., 2020). Many children's recess interventions focus on introducing structured play activities rather than unstructured play, which has resulted in fewer positive outcomes (Parrish et al., 2020). Beyler et al (2014) examined the effects of Playworks, an intervention that uses coaches to lead children in PA during a 30-minute recess. They found marginally significant differences in vigorous PA (~3-minutes) among 4$^{th}$ and 5$^{th}$ grade children compared to a control group that had 30-minutes of recess (Beyler et al., 2014). Similar results were seen in 3$^{rd}$ and 6$^{th}$ graders in the Ready for Recess intervention which provided staff training, equipment, or a combination of both aspects during a 20-minute recess (Huberty et al., 2014). Only males who received both variables increased MVPA (~13-minutes), while the staff training group decreased MVPA by ~2-minutes (Huberty et al., 2014). Raney et al. (2019) and van Dijk-Wesselius et al. (2018) redesigned playgrounds to incorporate more green spaces and nature based components for $1^{st}$-$5^{th}$ grade children. Children increased MVPA by 5%-20% at both post-test and follow up (4 months-1 year), with greater improvements seen in females (Raney et al., 2019; van Dijk-Wesselius et al., 2018). Parrish et al. (2020) argue that interventions promoting more unstructured activities are most effective in increasing MVPA in children.

While this is promising for the health of children, limited research examines the effects of unstructured, outdoor play on obesity rates in children. Casolo et al. (2019) examined differences in body mass index (BMI) and body fat percentage (BF%) in $2^{nd}$ and $3^{rd}$ grade children who received 15-minutes of structured or 30-minutes of unstructured recess throughout the day. Their results revealed no differences in either measurement after 12 weeks of implementation (Casolo et al., 2019). Similarly, Framer et al (2017) added more unstructured play by adding loose parts, less rules, and opportunities for risky play in 6-9 year old children. No differences were observed in BMI or waist circumference at 1- or 2-year follow ups (Farmer et al., 2017). Howe et al (2012) also examined the effects of 30-minutes of structured or unstructured recess in $3^{rd}$ grade children and no significant differences were found in BMI after nine weeks of implementation (Howe et al., 2012). These insignificant findings across multiple studies makes it hard to support unstructured, outdoor play at recess as an effective way to decrease obesity. However, there are some limitations in prior studies that could explain the observed outcomes.

The first limitation is that many recess interventions only provide up to 30-minutes of recess daily, which may be insufficient to produce significant BMI score decreases (Casolo et al., 2019; Farmer et al., 2017; Howe et al., 2012). Ansari et al. (2015) supports this hypothesis finding that 60-minutes of outdoor play daily was the point at which BMI began to decrease consistently in preschool children. Additionally, Gray et al. (2019) discovered that each additional recess hour provided weekly would reduce the BMI percentile by an additional .30, so more than 30-minutes is needed to see greater differences. However, simply adding extra time for recess may still not result in significant MVPA or body composition improvements. Razak et al. (2018) discovered that 3-6 year old children were more active when they received shorter, more frequent play breaks (two 15-minute, one 30-minutes) than when they received one continuous break (one 60-minute). Providing multiple, unstructured, outdoor recesses throughout the day may lead to more consistent MVPA increases and obesity percentage decline. Another limitation is the use of BMI, waist circumference, and skinfolds to detect changes in obesity rates in children who are more active daily. Waist circumference and BMI use algorithms to estimate body fat while skinfold accuracy depends on the consistency of the researcher (Kuriyan, 2018; Sardinha et al., 2016). With an increase in PA, these children may burn fat and gain muscle mass, which may not be reflected in these measurements. A more valid and reliable assessment could provide a clearer body fat and obesity rate picture in children.

One intervention, the LiiNK Project (Let's inspire innovation 'N Kids), has focused on the whole school, whole community, whole child model (WSCC), providing children in grades K-5 with four, 15-minute unstructured, outdoor play breaks daily (Rhea, 2016). This intervention defines unstructured play as self-directed with no adult guidance in a safe environment (Bauml et al., 2020). This intervention's 1st and 2nd grade children have been shown to take 900 more steps daily and engage in 25 more minutes of MVPA per day than control school children who are provided 30-minutes of recess daily (Farbo et al., 2020). The intervention also utilizes bio-electrical impedance analysis (BIA) to measure obesity rates.

BIA has been shown to be a more accurate assessment for obesity than BMI in children with high amounts of PA (Farbo & Rhea, 2021). A recent study, focused on the LiiNK intervention, found no obesity prevalence or body fat category shift differences between children who received 30-60 minutes of recess daily (Farbo & Rhea, 2022). However, the results showed positive trends in decreasing the prevalence of obesity in 2nd grade children and females (Farbo & Rhea, 2022). A limitation of this study is that it took place during the COVID-19 pandemic, which affected normal children's lifestyle habits as they experienced increases in sedentary behaviors and poor diet (Zemrani et al., 2021). Additionally, due to a limited sample size, interaction effects of group, grade, and sex were not examined. Finally, this study did not measure MVPA, so it is impossible to know if children were actually taking advantage of the extra time they had for recess. Since it is known that 1st and 2nd grade LiiNK children achieve more steps and minutes in MVPA than control, the next step is to examine PA patterns in 3rd and 4th grade children.

Therefore, the purpose of this study was to examine PA and body composition in 3rd and 4th grade children who receive 30-60 minutes for recess. Our first research question examined differences in steps and MVPA between groups by sex and grade in children who receive 30, 45, or 60 minutes of unstructured, outdoor play. PA intensity was measured by minutes spent in sedentary, light, and MVPA throughout the school day. Intervention children participated in 45 or 60 minutes of recess daily while control children had no more than 30-minutes daily. It was hypothesized that intervention males and females in 3rd and 4th grade would have more minutes in MVPA and steps than control children. Our second research question examined body fat category shift differences between intervention and control children by sex and grade. Body fat category is defined as underfat, healthy, overfat, or obese based on BF%, age, and sex. Category shift is identified by examining the change in body fat category from the pre- to -post assessments. It was hypothesized more intervention males and females in 3rd and 4th grade would shift from the overweight/obese category to a healthy category than the control children. Our third question was exploratory and examined whether PA is predictive of obesity status among children in both groups. The final research question was also exploratory and examined what kinds of play spaces will promote the most MVPA in children during recess.

## Methods

### *Study Design*

A control group posttest only design was used to answer the first research question and determine differences in PA between intervention and control groups. Pretest measurements were not possible due children in both groups receiving were already receiving increased minutes for recess when data collection occurred. Accelerometers were used to determine differences between intervention and control groups in the number of steps and MVPA minutes throughout the day. A non-randomized control group pretest-posttest design was to answer the second research question examining differences in body composition between pre and post measurements. Body composition was measured using BIA, which used BF% to categorize students as either underfat, healthy, overfat, or obese.

### *Participants*

Children from three elementary schools across two districts located in either north or south central Texas participated in the study. The first district contained approximately 40% White, 40% Hispanic, 15% Black, and 5% other. The second district contained approximately 70% Hispanic, 20% White, 5% Black, and 5% other. The other category consisted of Asian, Pacific Islander, American Indian, Alaskan Native, or two more races. Only third and fourth grade children were selected to participate and ranged in age from 8-11 years old. All children who received parental consent were included to participate. Students were excluded if they wore a pacemaker or other device that did not allow their body composition data to be collected. They were also excluded if they had a physical disability that limited the activities that they were able to participate in recess (i.e. not being able to climb on playground equipment).

The sample was selected from one LiiNK intervention (I) and two control (C) schools. In order to create a more equal sample size, a second control school was needed due to the low number of consents from the other control school identified. LiiNK intervention schools typically receive, four 15-minute unstructured play breaks daily. The third grade intervention children did receive 60 minutes daily in fall and spring, but divided into three 20-minute recesses. The fourth graders received 45-minutes (3-15 minute) for recess daily in the fall and spring. The reason for the intervention recess minute differences is due to administrators and teachers wanting to spend more time in the classroom to make up for the lack of learning during COVID. Control school children received 30-minutes (2-15 minute) of recess in both 3rd and 4th grades.

***Sample***

A priori power analysis was conducted using G*Power 3.1.9.2 to determine the appropriate sample size to answer the first research question with a medium effect size (Cohens $f^2$=.0625) and an alpha of 0.05. The power analysis determined that a sample size of N=197 was needed to achieve a power of .8 (Faul et al., 2007). As a result, 200 children (I=100, C=100) were recruited to have their PA data collected. However, 38 children (I=15, C=23) did not meet the minimum wear time of at least five school days with 360-minutes of data. In addition, two intervention school children misplaced their accelerometers, therefore, their data was not able to be recovered and six (I=1, C=5) children were removed due to statistical outliers, i.e. minutes in sedentary time were significantly higher than the rest of the participants. Therefore, 154 children (I=82, C=72) were included to determine PA differences between intervention and control groups.

For the body composition collection, 454 children (I=219, C=235) were originally recruited to participate. To get a clearer picture of the recess effects on body composition across the entire grade level, we collected all participants who had parental consent. Children needed both pre and post measurements to be included in the final analysis, which led to 70 children (I=28, C=42) being eliminated. Finally, one intervention child had an error in their profile data as they decreased in height between semesters. The final sample size for body composition data was N=383 (I=190, C=193).

For the third research question, children needed to have body composition data at both time points and PA data. This resulted in 38 children (I=7, C=31) eliminated from the original PA data sample, which was N=154. In addition, six children (I=2, C=4) were eliminated due to statistical outliers. The final number of children used in the analysis was N=110 (I=73, C=37). The participants divided by school, grade, and sex are provided in Table 10. The pre-descriptive statistics for body composition measures are provided in Table 11.

**Table 10**

*Participants by School, Grade, and Sex*

| Grade | Sex | Intervention N | Control N | Total |
|---|---|---|---|---|
| **Physical Activity** | | | | |
| 3rd | M | 21 | 18 | 40 |
| | F | 24 | 15 | 39 |
| 4th | M | 18 | 14 | 35 |
| | F | 19 | 25 | 46 |
| | **Physical Activity Total** | 82 | 72 | 154 |
| **Body Composition** | | | | |
| 3rd | M | 50 | 52 | 102 |
| | F | 40 | 49 | 89 |
| 4th | M | 45 | 37 | 82 |
| | F | 55 | 55 | 110 |
| | **Body Composition Total** | 190 | 193 | 383 |
| **Physical Activity and Body Composition** | | | | |
| 3rd | M | 16 | 9 | 25 |
| | F | 21 | 8 | 29 |
| 4th | M | 18 | 6 | 24 |
| | F | 18 | 14 | 32 |
| | **Combined Total** | 73 | 37 | 110 |

**Table 11**

*Baseline Descriptive Statistics*

| | | Weight | | BMI | | BF% | | BF% Categories | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | UF | H | OF | OB |
| **Intervention** | | | | | | | | | | | |
| 3rd Grade | M | 72.17 | 18.71 | 18.35 | 3.02 | 22.61 | 6.98 | 0% | 48% | 26% | 26% |
| | F | 77.18 | 24.45 | 19.70 | 4.80 | 26.99 | 9.20 | 5% | 43% | 20% | 33% |
| 4th Grade | M | 82.65 | 21.99 | 19.54 | 4.33 | 23.99 | 8.84 | 0% | 49% | 22% | 29% |
| | F | 80.67 | 24.37 | 19.14 | 4.24 | 25.23 | 8.22 | 6% | 64% | 2% | 29% |
| | **Total** | 78.17 | 22.64 | 19.14 | 4.11 | 24.62 | 8.37 | 3% | 52% | 17% | 29% |
| **Control** | | | | | | | | | | | |
| 3rd Grade | M | 82.07 | 25.56 | 20.55 | 5.23 | 28.31 | 10.87 | 2% | 33% | 14% | 52% |
| | F | 72.79 | 26.40 | 18.66 | 5.06 | 25.61 | 8.35 | 6% | 53% | 18% | 22% |
| 4th Grade | M | 83.07 | 26.84 | 19.65 | 4.58 | 23.05 | 10.09 | 8% | 46% | 22% | 24% |
| | F | 83.30 | 23.47 | 19.38 | 4.35 | 25.29 | 8.83 | 11% | 47% | 15% | 27% |
| | **Total** | 80.25 | 25.63 | 19.56 | 4.84 | 25.76 | 9.65 | 7% | 45% | 17% | 32% |
| | **Combined Total** | 79.22 | 24.19 | 19.36 | 4.49 | 25.19 | 09.04 | 5% | 48% | 17% | 31% |

Note: UF=Underfat, H=Healthy, OF=Overfat, OB=Obese

## Measures

### *Measures-Physical Activity*

The first measure, PA, was assessed using the Actigraph wGT3X-BT accelerometer to determine steps and minutes spent in various PA intensities. This device has been shown to be valid and reliable in measuring PA in children (Phillips et al., 2021). The accelerometers calculate PA using tri-axel sensors to detect changes in vertical, horizontal, and perpendicular orientation during different time sampling intervals known as epochs. A 15s epoch value was set for the current study as shorter epoch lengths (1s-15s) are more accurate in assessing MVPA in children than longer epochs (30s-60s) (Aibar & Chanal, 2015). During each of these epochs, the device reports raw data in counts per minute (CPM), which is used to determine wear time validation and the amount of steps and time spent in sedentary, light, moderate, or MVPA.

Children needed at least five days of 360-minutes of wear time to be included in the final analysis. The device has a wear time validation feature that can determine how long a participant wears the device. Consecutive epochs of no movement in which CPM does not change is an indication that the participant was not wearing the device. The Torino (2007) wear time validation parameters were used and 30-minutes or more of consecutive epochs with no movement was considered as non-wear time. In the intervention school, the daily wear time was set to begin at 7:50 am and conclude at 2:20 pm, while the control schools were set to begin at 8:35 and end at 3:15 pm. The range of wear time days among the participants was five to nine days. Regardless of the total number of wear days, an average CPM each day was used in the final analysis.

A scoring system is used to convert CPM into minutes spent in each of the different PA categories. Previous LiiNK intervention studies examining PA used the Puyau Children (2002) scoring system, which classifies sedentary as 0-799 CPM, light as 800-3199, moderate as 3200-8199, and vigorous as 8200 and above. To accurately compare the results of this study with prior LiiNK research, the Puyau children (2002) scoring system was used.

***Measures-Body Composition***

Body fat percentage was measured to examine differences in obesity rates using BIA. BIA can provide measures of body composition that have a moderate to strong correlation with DEXA (Kabiri et al., 2015). The scale used for this study was the TANITA BF-2000, which has high specificity and sensitivity in identifying overweight and obese children (Kabiri et al., 2015). The scale uses small, unnoticeable electrical signals sent throughout the body via foot-to-foot metal plates located at the bottom of the device. Due to body fat having a low water content, it will cause resistance in the current which the scale uses to determine

BF%, fat mass, and fat free mass. Children are then categorized based on their BF% as either underfat (1), healthy (2), overfat (3), or obese (4) based on the normative values provided by McCarthy et al. (2006b). These normative values for children take age and sex into consideration, so the range of BF% in these categories can vary between children.

To examine if children change body fat category between pre and post measurements, a new variable was created to determine shift by subtracting the pre-body fat category from the post-category. A value of -1indicated that a participant decreased a body fat category, 1 increased, and 0 was no difference. For example, if a student shifted from obese to overweight, they would be coded as a -1 since they decreased body fat category. Any student who shifted from underfat to healthy, or healthy to underfat was recoded as 0. While these children demonstrated an increase or decrease in BF%, they were not at risk of developing obesity. No children shifted more than one body fat category between pre and post measurements.

The BIA software program requires height to be entered for each participant prior to the child stepping on the scale to complete BMI and body composition assessments. Participants must also remove their socks and shoes so that their skin makes direct contact with the metal plates. The TANITA BF-2000 does not contain any screens and all data is uploaded to the computer software program via Bluetooth. Participants are blinded from their results, which is an important factor to consider as knowing ones' weight status could have negative psychological effects.

***Measures-Play Preferences***

A playground observation form was developed to determine children's play preferences during recess and can be seen in Appendix A. Intervention children had recess either on a traditional playground, a bus loop, or a blacktop. The traditional playground included playground equipment (slides, swings), a grassy area, and a hill. The bus loop contained a grassy area, blacktop, stones and logs, and a large musical instrument section. The blacktop was in the back parking lot of the school and did not include any equipment. The control school play environment included traditional playground equipment, grassy areas, a climbing net, and a gaga ball pit. Their playgrounds were recently redesigned with the LiiNK intervention and unstructured, outdoor play in mind, so they had the same exact play environments across the campuses. Appendix B provides pictures of the available play areas at intervention and control schools.

This observation assessment was exploratory to aid in better understanding the children's accelerometer tracking patterns. The form was divided into two sections. In the first section, observers would estimate the number of children in different sections of the playground, i.e., blacktop, equipment area, field, swings, and other. The observers were instructed to take a "snapshot" of each of these areas and then record what they saw. After giving an estimate of the number of children in each section, the observer then provided an active versus sedentary percentage of the children. This process was repeated three times beginning at the 1-minute, 7-minute, and 13-minute recess time points. The second part of the form required observers to write down activities children participated in during these snapshots. They were also asked to note the sex of the children who participated in these activities. For example, one observer might record a mix of boys and girls digging in the dirt in the field area of the playground. Similar to the first section, this process was repeated at the 1-minute, 7-minute, and 13-minute recess marks.

## Procedures

The LiinK intervention received IRB approval as a longitudinal research project at a North Texas university. Parental consent letters were sent home, signed, and returned to approve a student's BIA and accelerometer data collections. Any student who did not receive parental consent was excluded from participation. Child assent was also collected and if at any point a student wanted to withdraw from the study, they were allowed to do so. The procedures for each of the three measurements varied in procedures, length, and time of implementation.

### *Procedures-Physical Activity*

For PA collection, a rotation was implemented so 3$^{rd}$ grade children from the three schools wore the devices simultaneously followed by the 4$^{th}$ grade children. The 3$^{rd}$ grade children wore them for the first two weeks of collection followed by the 4$^{th}$ grade children wearing them the next two weeks. Before starting collection, the devices were programmed and assigned an ID number to track the student's data throughout the collection period.

On the first day of collection in each grade, researchers were present to distribute the devices and explain the procedures for the collection days. Children were instructed to wear the device on their non-dominant wrist from the time they entered school in the morning (7:30 in intervention, 8:00 in control) until they left in the afternoon (2:30 in intervention, 3:30 in control). They would repeat these procedures daily for two weeks and did not wear devices home or on the weekend. Once 3$^{rd}$ graders were collected, the devices were charged and reprogrammed for the 4th graders. Data collection concluded and all accelerometer devices were collected on Friday of week 4 from the three schools.

Teachers were asked to track children who were absent on data collection days or provide feedback on any hindrances to their normal school schedule. These changes in schedule included half days, bad weather days, or in one instance a school did not have any power for half of the day so they did not wear the accelerometers. Any days with these problems were excluded from the final analysis.

***Procedures-Body Composition***

Principals at the intervention and control schools were contacted to set up collection times for the BIA measure. To prevent children from missing classroom content, 10-15 children who assented to participate by grade level and again by sex were pulled from their specials classes that included physical education, art, music, and computer/technology. For example, females from class A were pulled, then males from class A, then females from class B, etc. Each group of children was instructed to line up in the hallway, remove their socks and shoes, and wait for their names to be called.

A height and weight scale station was set up in a central location in the hallway near the special classes. The station was set up in a private space so each child felt comfortable and their peers could not see them during the assessment. Once called, children would stand next to a measuring tape located on the wall to record their height in inches into the software program, then step on the BIA scale to have weight and body composition measures recorded. Each child stood with their feet placed on the metal plates of the scale for about 15-20 seconds to complete the assessment (see Appendix B). Once the procedure was completed, the child stepped off of the scale and went back to class while the scale was disinfected and the next child was called to repeat the same procedures. Each class took approximately 30-40 minutes to complete depending on class size and efficiency of the data collection.

All data, including weight, BF%, BMI, and body fat category, was automatically saved to the BIA software on the laptop computer after each measurement. At the end of each day, all data was downloaded and saved to a master data excel file. The intervention school required three days of data collection while the control schools each required one day. These procedures were utilized for the pre and post data collections.

***Procedures-Play Preferences***

This observation form was first developed through multiple meetings and discussions with the research team. Once the final form was created, researchers piloted the tool out in local schools in the month leading up to the accelerometer data dates to determine inter rater reliability between the observers.

The observation data segment occurred during the same time accelerometer data was collected. Observations took place both in the morning and afternoon and depending on the time of day, the recess location and environment changed in each of the schools.

On the day of an observation, the researcher would find a spot on the playground which provided a full view of the play area. A watch or phone was used to identify the time the researchers began each form section. First, they would complete portion A by estimating the number of children in each of the play areas. Then, they would complete the second part of the observation form and record the types of activities they observed in each of the areas. They would continue to record until their timer went off at the 7-minute mark, then repeat part A. At the end of observations, all data was entered in Excel to identify themes of play preferences in the children. Three observations per grade level were completed in both the intervention and control schools for a total of 18 observations.

***Data analysis***

Data was analyzed using IBM SPSS version 27. Descriptive statistics were determined to describe the means and standard deviations for weight, BMI, BF%, steps, and minutes in sedentary, light, and MVPA for groups by sex and grade. To answer the first research question, a multivariate analysis of variance (MANOVA) was used to examine group differences (intervention and control) by sex and grade. If there were any interactions, a two-way ANOVA was used to determine where the significant differences were.

To answer the second research question, a non-parametric chi square test was used to assess any associations between body fat category shift and group, sex, or grade. An alpha value was set at $p<.05$. If there was a significant chi square result, it indicated that there was an association with group, sex, or grade and body fat category shift. Adjusted standardized residuals (AR) were used to determine where significant differences were between the observed and expected values. The expected values is the number of participants who fall in that category if the null hypothesis were true, while the observed is the actual amount that occurred in the study. An AR greater than 1.96 demonstrated a significant difference between the observed and the expected values, with a p value of $p<.05$.

The third research question was answered using a multinomial logistic regression to determine if PA was predictive of body fat category between the groups. Body fat category was used as the dependent variable and minutes spent in sedentary, light, moderate, and vigorous PA were covariates. Finally, play preferences were determined by transcribing observation data into Excel® and running frequencies to identify themes during recess.

**Results-Research Question 1**

***Hypothesis 1***

A 2 x 2 x 2 MANOVA was used to test the first hypothesis and determine differences in steps and average minutes by PA intensities between groups by sex and grade. All assumptions of MANOVA were met, except the assumption of homogeneity of covariance matrices. As a result, Pillai's Trace statistic was used to interpret the results. The MANOVA revealed a significant three-way interaction effect for group by sex by grade, Pillai's Trace=.07, F(4, 143)=2.809, p=.03, $\eta_p^2$=.07, two-way interaction of group by grade, Pillai's Trace=.26, F(4, 143)=12.31, p<.001, $\eta_p^2$=.26, and main effects for group, Pillai's Trace=.28, F(4, 143)=14.11, p<.001, $\eta_p^2$=.28, sex, Pillai's Trace=.28, F(4, 143)=14.06, p<.001, $\eta_p^2$=.28, and grade, Pillai's Trace=.71, F(4, 143)=87.37, p<.001, $\eta_p^2$=.71.

Test of between subjects for the three way interaction of group by sex by grade revealed that there were significant differences in steps F(1, 146)=8.06, p=.005, $\eta_p^2$=.05 and MVPA, F(1, 146)=6.54, p=.01, $\eta_p^2$=.04. In 3$^{rd}$ grade, intervention males took significantly more steps (1,483) than control school males (p<.001, $\eta_p^2$=.44). Additionally, intervention 3$^{rd}$ grade males had significantly more MVPA minutes (25) than control school students (p=<.001, $\eta_p^2$=.27). Among males, these results support the first hypotheses that children with 60 minutes for recess will have higher steps and MVPA minutes than control children with 30 minutes. There were no other significant steps or MVPA differences in the three-way interaction of group, sex and grade.

The significant group by grade interaction differences were in steps, F(1, 146)=29.94, p=<.001, $\eta_p^2$=.17, sedentary PA, F(1, 146)=14.90, p=<.001, $\eta_p^2$=.09, light PA, F(1, 146)=5.02, p=<.03, $\eta_p^2$=.03, and MVPA, F(1, 146)=19.52, p=<.001, $\eta_p^2$=.11. In third grade, intervention children had significantly more steps (843) and MVPA minutes (13) than control school

The significant group by grade interaction differences were in steps, F(1, 146)=29.94, p=<.001, $\eta_p^2$=.17, sedentary PA, F(1, 146)=14.90, p=<.001, $\eta_p^2$=.09, light PA, F(1, 146)=5.02, p=<.03, $\eta_p^2$=.03, and MVPA, F(1, 146)=19.52, p=<.001, $\eta_p^2$=.11. In third grade, intervention children had significantly more steps (843) and MVPA minutes (13) than control school children (p=<.001, $\eta_p^2$=.17; p=.02, $\eta_p^2$=.08). Control third grade children had significantly more sedentary minutes (14) than intervention children (p=.04, $\eta_p^2$=.05). These results support the first hypothesis that children with 60 minutes of recess will take more steps and MVPA minutes than those with 30 minutes. In fourth grade, control children took significantly more steps (524), light PA minutes (11) and MVPA minutes than intervention children (p=.01, $\eta_p^2$=.08; p=<.001, $\eta_p^2$=.16; p=<.001, $\eta_p^2$=.15). Intervention fourth grade children had significantly more sedentary minutes (19) than control children (p=.001, $\eta_p^2$=.13). These results reject the first hypothesis that children with 45 minutes of recess would have more steps and MPVA minutes than children with 30 minutes. Table 12 provides the means and standard deviations for steps, and minutes in sedentary, light, and MVPA.

**Table 12**

*Physical Activity Means and Standard Deviations*

| | | | Steps | | Sedentary | | Light | | MVPA | |
|---|---|---|---|---|---|---|---|---|---|---|
| Grade | Sex | Group | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 3 | Males | I | **8624.74*** ** | **898.73** | 122.13 | 24.21 | 147.28 | 11.33 | **129.44*** ** | **21.32** |
| | | C | 7141.22 | 793.88 | 149.05 | 28.57 | 146.3 | 14.96 | 104.35 | 20.67 |
| | Females | I | 7601.18 | 760.61 | 133.14 | 28.26 | 148.28 | 12.71 | 117.25 | 22.98 |
| | | C | 7347.53 | 957.7 | 131.43 | 26.81 | 151.96 | 10.65 | 116.33 | 24.95 |
| | **3rd Grade Total** | I | **8078.84*** ** | **967.59** | 128 | 26.73 | 147.81 | 11.96 | **122.94*** | **22.81** |
| | | C | 7235 | 864.26 | **141.04*** | **28.77** | 148.87 | 13.29 | 109.8 | 23.15 |
| 4 | Males | I | 6343.1 | 772.13 | 169.66 | 25.05 | 129.91 | 12.38 | 82.71 | 17.15 |
| | | C | 7148.71 | 1195.24 | 148.72 | 28.56 | 138.28 | 14.29 | 105.2 | 25.72 |
| | Females | I | 5817.58 | 622.28 | 176.72 | 22.89 | 125.63 | 9.8 | 82.95 | 13.72 |
| | | C | 6289.52 | 766.28 | 157.35 | 23.13 | 138.26 | 12.81 | 94.72 | 19.19 |
| | **4th Grade Total** | I | 6073.24 | 738.95 | **173.28**** | **23.9** | 127.71 | 11.19 | 82.83 | 15.27 |
| | | C | **6597.95*** | **1016.83** | 154.25 | 25.19 | **138.26*** ** | **13.17** | **98.49*** ** | **22.02** |
| | | **Combined Group Total** | 7041.12 | 118.35 | 148.32 | 31.04 | 140.79 | 14.91 | 104.29 | 25.8 |

Note: ***=p<.001, **=p<.01, *p<.05
I=Intervention, C= Control

## Results-Research Question 2

### *Descriptive Statistics*

The means and standard deviations of weight, BMI, BF%, and percentage of children in each body fat category were determined using descriptive statistics. Between pre and post measurements, 3$^{rd}$ grade males in both groups (I=.17%, C=.82%) decreased BF%, while females (I=.56%, C=.38%) increased BF%. For BF% categories, intervention males (4%) and females (2%) increased in obesity levels, while control males (2%) decreased in obesity levels, while females (0%) did not change. In the overfat category, intervention males (12%), females (7%), and control females (2%) decreased in number of children considered overfat.

Among 4th graders, intervention (M=.43%, F=.19%) children decreased in BF%, while control school children (M=.49%, F=.23%) increased in BF%. Intervention males (2%), control males (6%), and control females (4%) all increased in those who were obese while intervention females (5%) decreased in the obesity category. For the overfat category, intervention females (6%), control males (17%), and females (11%) decreased while intervention males (2%) increased. Both groups (I=1%, C=2%) had marginal increases in those who were obese when combing grade and sex. All participants increased BMI between measurements, even if they decreased BF%. Table 13 provides descriptive statistics for the post BIA measurements.

**Table 13**

*Body Composition Follow-up Descriptive Statistics*

| Group | | Weight | | BMI | | BF% | | BF% Categories | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | Mean | SD | UF | H | OF | OB |
| **Intervention** | | | | | | | | | | | |
| 3rd Grade | M | 75.10 | 19.70 | 18.70 | 3.2 | 22.44 | 7.79 | 0% | 56% | 14% | 30% |
| | F | 81.40 | 25.40 | 20.30 | 5.0 | 27.55 | 9.04 | 5% | 48% | 13% | 35% |
| 4th Grade | M | 86.50 | 24.20 | 20.00 | 4.3 | 23.56 | 8.83 | 4% | 53% | 11% | 31% |
| | F | 84.50 | 24.60 | 19.30 | 3.9 | 25.04 | 7.74 | 6% | 66% | 6% | 24% |
| | **Total** | 81.86 | 23.70 | 19.52 | 4.10 | 24.53 | 8.44 | 4% | 56% | 11% | 30% |
| **Control** | | | | | | | | | | | |
| 3rd Grade | M | 86.11 | 27.16 | 20.72 | 5.28 | 27.49 | 10.92 | 6% | 31% | 14% | 50% |
| | F | 78.19 | 28.35 | 19.13 | 5.04 | 25.99 | 8.12 | 2% | 59% | 16% | 22% |
| 4th Grade | M | 87.73 | 29.57 | 19.99 | 4.87 | 23.54 | 10.30 | 3% | 62% | 5% | 30% |
| | F | 87.89 | 25.64 | 19.62 | 4.40 | 25.52 | 8.59 | 11% | 55% | 4% | 31% |
| | **Total** | 84.92 | 27.60 | 19.86 | 4.90 | 25.79 | 9.52 | 6% | 51% | 10% | 34% |
| | **Combined Total** | 83.22 | 25.73 | 19.67 | 4.51 | 25.10 | 9.01 | 5% | 54% | 10% | 32% |

Note: UF=Underfat, H=Healthy, OF=Overfat, OB=Obese

### *Hypothesis 2*

Three non-parametric chi-square tests were used to answer the second hypothesis and determine if body fat category shifts were different between groups by sex and grade. The chi-square assumptions were met for each test and no values within the contingency tables had an expected value less than 5. By group, the chi square test revealed no significant association between group and body fat category shift, $x^2(2)=.71$, p=.70. There were also no differences among groups by 3rd graders, $x^2(2)=.01$, p=.99, 4th graders, $x^2(2)=1.52$, p=.47, males, $x^2(2)=1.10$, p=.58, or females $x^2(2)=2.04$, p=.36. Table 14 provides the observed, expected, and adjusted standardized residuals for the chi-square tests.

**Table 14**

*Body Fat Category Shift by Group, Group x Sex, and Group x Grade*

| | Shift | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **-1** | | | **0** | | | **1** | | |
| | Observed | Expected | AR | Observed | Expected | AR | Observed | Expected | AR |
| **Group** | | | | | | | | | |
| Intervention | 25 | 23.3 | 0.5 | 152 | 151.8 | 0.1 | 13 | 14.9 | 0.7 |
| Control | 22 | 23.7 | -0.5 | 154 | 154.2 | -0.1 | 17 | 15.1 | 0.7 |
| **Males** | | | | | | | | | |
| Intervention | 15 | 12.9 | 0.9 | 72 | 74.9 | -1.0 | 8 | 7.2 | 0.4 |
| Control | 10 | 12.1 | -0.9 | 73 | 70.1 | 1.0 | 6 | 6.8 | -0.4 |
| **Females** | | | | | | | | | |
| Intervention | 10 | 10.5 | -.2 | 80 | 76.9 | 1.1 | 5 | 7.6 | -1.4 |
| Control | 12 | 11.5 | .2 | 81 | 84.1 | -1.1 | 11 | 8.4 | 1.4 |
| **3rd Grade** | | | | | | | | | |
| Intervention | 12 | 11.8 | .1 | 69 | 69.3 | -0.1 | 9 | 9.0 | 0.0 |
| Control | 13 | 13.2 | -0.1 | 78 | 77.7 | 0.1 | 10 | 10.0 | 0.0 |
| **4th Grade** | | | | | | | | | |
| Intervention | 13 | 11.5 | 0.7 | 83 | 82.8 | 0.1 | 4 | 5.7 | -1.1 |
| Control | 9 | 10.5 | -0.7 | 76 | 76.2 | -0.1 | 7 | 5.1 | 1.1 |

Note: AR=Adjusted Standardized Residual

## Results-Research Question 3

Binary logistic regression was used to answer the third research question: one for intervention and one for control school children. We decided to use two separate models to determine if group membership and PA was predictive of being obese. The assumptions for both analyses were met including no outliers, linearity, independence, and no multicollinearity. However, there was a low number of participants in the overfat and obese control groups so caution should be used when interpreting the results of that analysis.

Among the control group, the model was a significant fit over the null, $x^2$=16.71, p=.03. In the intervention group however, the model was not a significant fit over the null, $x^2$=13.71, p=.09. The McFadden $R^2$ showed that the model explained 31% of the variance in the control group and 11% in the intervention group. The goodness of fit revealed that the model was a good fit for the data in the control ($x^2$=41.95, p=.99) and the intervention ($x^2$=149.78, p=.20) groups. The likelihood ratio tests showed vigorous activity in the intervention was the only significant predictor in the model, $x^2$=10.68, p=.005. The predictive accuracy of the model in the control group was 78.4%, while in the control group it was 69.9%. In the intervention group, children who engaged in higher amounts of vigorous PA were more likely to be healthy or overfat than obese. When interpreting the odds ratio, a multiplier of 10 was used to describe the MVPA data for ease of understanding. For every 10-minute increase in vigorous PA, intervention children are 11.9 times more likely to be healthy than obese and 12.5 times more likely to be overfat than obese. There were no other significant predictors of the model. These results provide some direction on how time for recess and PA can be predictive of obesity status, but extreme caution should be used based on our limited sample size in each group. Table 15 contains regression coefficients, standard errors, Wald statistic, significance values, and odds ratio for the multinomial regression.

**Table 15**

*Binary Logistic Regression Determining Odds of Being Obese*

| Model | Variable | Predictor | B | SE | Wald | df | p | OR |
|---|---|---|---|---|---|---|---|---|
| Control N=37 | Healthy | SED | -0.26 | 0.17 | 2.35 | 1 | 0.13 | 0.77 |
| | | LHT | -0.11 | 0.15 | 0.54 | 1 | 0.46 | 0.90 |
| | | MOD | -0.23 | 0.19 | 1.47 | 1 | 0.23 | 0.80 |
| | | VIG | -0.26 | 0.15 | 3.12 | 1 | 0.08 | 0.77 |
| | Overfat | SED | 0.29 | 0.37 | 0.58 | 1 | 0.45 | 1.33 |
| | | LHT | 0.27 | 0.36 | 0.59 | 1 | 0.44 | 1.31 |
| | | MOD | 0.41 | 0.43 | 0.88 | 1 | 0.35 | 1.50 |
| | | VIG | 0.00 | 0.27 | 0.00 | 1 | 1.00 | 1.00 |
| Intervention N=73 | Healthy | SED | 0.05 | 0.04 | 2.05 | 1 | 0.15 | 1.05 |
| | | LHT | 0.08 | 0.04 | 3.44 | 1 | 0.06 | 1.08 |
| | | MOD | 0.00 | 0.04 | 0.00 | 1 | 0.96 | 1.00 |
| | | **VIG** | **0.17** | **0.06** | **7.35** | **1** | **0.01**** | **1.19** |
| | Overfat | SED | 0.03 | 0.06 | 0.26 | 1 | 0.61 | 1.03 |
| | | LHT | 0.08 | 0.06 | 1.48 | 1 | 0.22 | 1.08 |
| | | MOD | -0.03 | 0.07 | 0.18 | 1 | 0.67 | 0.97 |
| | | **VIG** | **0.22** | **0.09** | **6.44** | **1** | **0.01*** | **1.25** |

Note: Reference=obese
B=regression coefficient, SE=standard error, df=degrees of freedom, p=significance value, OR=odds ratio
**=p<.01, *p<.05

### Results-Play Preferences

Frequencies were used to examine children's recess observation trends during recess activity types. The play preferences of 3rd grade children were similar across both intervention and control groups. Males in 3rd grade engaged in higher intensity activities such as running, tag, climbing playground equipment, or imaginary games that involved lots of movement. Conversely, females preferred less intense activities such as walking, gymnastics, dance, or sitting and socializing. Both groups spent most of their time either on equipment or in the grassy areas next to the playgrounds. During the bus loop intervention recess, intervention children gravitated towards the balancing logs located in the grassy median or verge, as well are running around the concrete bus loop. On the blacktop, intervention males were running and playing tag while girls did more walking and socializing.

In 4th grade, play preferences were slightly different between the groups and based on where recess was located. In the intervention, boys were most active on the playground as about 40% played imaginative games in the grassy area that involved moderate intensity activity. However, they would transition to more walking and socializing when on the bus loop or parking lot. This is very similar to what girls in 4th grade preferred during recess, with many choosing to walk and talk with their friends regardless of the setting. Even when on the equipment in the playground, both sexes did not reach high intensity movements. At the control schools, all children were much more active in the playground area playing tag, climbing, and running around the equipment. In addition, many children gravitated towards the merry go round, which children would hang on and run around in a circle to spin their peers. The control children also played sports such as basketball and football on the blacktop and field areas. While these areas did not have a large percentage of children, it still provided an additional opportunity for MVPA not available in the intervention schools.

**Discussion**

Previous research has shown gaining up to 60-minutes of MVPA daily can prevent excessive body fat build up and decrease a child’s chances of becoming overweight or obese (CDC, 2021b; Swift et al., 2014). Farbo et al. (2020) found that first and second graders produce more steps and MVPA minutes with 60-minutes of recess than those with 30-minutes of recess daily. Farbo & Rhea (2022) then noted some interesting body composition trends among 2nd-5th grade children who received 30-60 minutes of recess, but accelerometer data was needed to support these differences were a result of increased time for recess. To advance results of both of these studies further, this study sought to assess 3rd & 4th grade children focused on three things: 1) Are there differences in steps and MVPA in groups of children who receive 30, 45, or 60 minutes of unstructured, outdoor play?; 2) Will overweight/obese prevalence decrease as a result of increased minutes at play daily?; and 3) What kinds of play spaces will promote the most MVPA in children during play? Sixty minutes of unstructured, outdoor play daily was only provided in the 3rd grade intervention children. The 4th grade intervention group had 45 minutes of recess and both control school grades had 30 minutes.

Unsurprisingly, intervention children in 3rd grade with 60 minutes of recess were the most active group when compared to all other children. Intervention children in 3rd grade took ~900 more steps and ~13 more MVPA minutes than control children. Other interventions that implement up to 30-minutes of structured or unstructured recess only show a 0-5 minute MVPA group difference at post measurements, which often does not result in significant body composition changes (Beyler et al., 2014; Farmer et al., 2017; Huberty et al., 2014). While obesity prevalence did not change, the increase in MVPA resulted in more intervention 3rd graders shifting from overfat to healthy than control 3rd graders. This is significant considering overfat children have a high obese risk if they do not make immediate changes in their lifestyle habits. If they become obese at a young age, they are likely to remain obese as adolescents and adults, leading to lifelong health complications (Simmonds et al., 2016). The PA patterns among 3rd grade intervention children in the current study are similar to LiiNK 1st and 2nd grade children who also received 60 minutes for unstructured, outdoor play (Farbo et al., 2020). The children in both of these studies achieved the highest amounts of steps and MVPA minutes when compared to children who only received 30 or 45 minutes (Farbo et al., 2020). From these collective results, it is clear that 60 minutes of recess is needed for children to achieve the most significant improvements in MVPA which can then lead to positive body composition changes.

As a result of decreasing recess to 45 minutes in the intervention school, children were less active compared to 3rd grade intervention children and consequently had fewer unhealthy body fat shifts to healthy. Although it may be a result of less minutes, it may also be a result of variables that we did not think would impact PA including recess space design and play preference differences across age groups. In addition, other limitations such as time for physical education and school layout may also explain why 4th grade control children had slightly more steps and MVPA minutes than intervention children. Even with less MVPA, intervention children in 4th grade actually decreased BF% while the control children increased BF%. The control school children mirrored what other recess interventions have shown when implementing 15-30 minutes of structured or unstructured recess; whereas the intervention children showed improvements when having access to play for 45 minutes (Casolo et al., 2019; Farmer et al., 2017). Two conclusions can be drawn from these differences. First, there may be outside factors such as eating and PA patterns at home which could have led to this result since intervention children had lower levels of MVPA than control children. The second is that there may be greater longitudinal body composition changes when children receive additional time for recess as this was the 5th year intervention children received 45-60 recess minutes. When children are in 4th grade, it may be the “tipping point” where BF% begins to decrease at a higher rate from the consistent increase in MVPA. The 4th grade intervention group may achieve even greater decreases in BF% if school personnel continue to offer the full 60-minutes of recess as the 3rd grade group received.

Children who were categorized as obese did not change between pre and post measurements regardless of the number of recess minutes received, but it did lower their odds of being obese. For obese children, increased recess minutes may be insufficient to elicit body composition changes and they may need other components such as nutrition education or family involvement (Nally et al., 2021). We did not account for these factors since single component interventions that target MVPA are generally more effective in changing body composition than those focused on other obesity related behaviors (Nally et al., 2021; Podnar et al., 2021). However, we did find that subgroups who achieved higher MVPA (i.e. 3rd grade intervention, 4th grade control) had more children shift from overfat to healthy. Previous research has shown an inverse relationship between more minutes of higher intensity PA and adiposity in children (Miatke et al., 2021). We also found that intervention children had greater odds of being healthy or overfat than obese with every minute increase of vigorous activity. All three time different groups, 30, 45, and 60 minutes, averaged ~66-129 MVPA minutes during school, which is more than other school-based interventions who provide either structured or unstructured activities and report up to ~30-minutes of MVPA daily (Nally et al., 2021; Parrish et al., 2020; Yuksel et al., 2020). This also means that these children were nearly doubling the recommend 60-minutes of MVPA while in school simply with additional time for recess. The 60-minute group averaged 116-129 minutes of MVPA, which means they were less likely to be obese than the 30 or 45-minute group who only averaged 66-116-minutes of MVPA. Since 60-minutes of recess resulted in the highest averages of vigorous PA, this is the minimum amount of time needed to give children their greatest odds of remaining healthy.

It is clear that 60-minutes of recess is needed to provide the most improvements in MVPA and body composition, but in this study, females and older children need more recess to produce healthier results. When comparing our results with prior LiiNK intervention children also with 60-minutes of recess, there is a noticeable decrease in MVPA between 2nd and 3rd grade, with an even larger decrease in 4th graders with 45-minutes of recess (Farbo et al., 2020). In addition, females are consistently less active than males regardless of age or recess minutes provided (Farbo et al., 2020). PA in children is shown to peak at about age eight and then decrease, with males consistently achieving higher MVPA minutes than females (Farooq et al., 2018; McGovern et al., 2020). This is a problem for both of these populations as BF% will steadily increase until about age 11, so lack of sufficient MVPA may lead to excess body fat accumulation and obesity (Laurson et al., 2011). Females and older children especially need additional time for recess to ensure that they engage in enough MVPA to at least prevent the development of obesity. While females and older children still may be less active than males and younger children, 60-minutes of recess gives them more opportunity to be active and achieve healthier body fat levels than 30 or 45 minutes.

The type of play environment also had an effect on children's MVPA during recess regardless of available minutes for recess. Children in both grades were significantly more active when recess was on the playground compared to the bus loop or blacktop (see Appendix A). In these environments, children were more likely to engage in sedentary activities such as socializing, while on the playground they were observed in higher intensity activities such as running and jumping. Other studies have shown that each piece of play equipment available on a playground increases MVPA by 50% (Cohen et al., 2020). There was insufficient available play equipment on the bus loop or blacktop to result in similar

MVPA levels as when children were on the playground. This may explain why 4th grade control children had more steps and MVPA minutes since they were on the same playground for each of their recesses. There may be more significant results in favor of the intervention if both groups had the same play environments for each recess in both grade levels. However, we also need to consider the play needs of different populations of children (i.e. sex, age, race) as activities that were popular among one group of children were not as popular in other groups (i.e. boys running in field area while girls walked and socialized). To ensure children are achieving their highest levels of MVPA during recess, play spaces need to provide appropriate opportunities to cater to the needs of children across all populations. This could include the addition of more playground equipment (i.e. climbing structures, merry-go round), loose parts (i.e. balls, hula hoops), natural elements (i.e. rocks, climbing trees), or green space (Frost et al., 2018). Combining 60-minutes of recess and the proper play environments may lead to even greater MVPA and body composition improvements in children.

***Limitations***

A number of limitations need to be addressed for both the accelerometer and BIA portions of the study. The first limitation is differences in time for physical education as control children attended physical education three times every five days, while intervention children only had two every five days. Due to so many children not meeting the minimum wear time, filtering out days with physical education versus those without was not possible. The layout of each school was also very different as control children had to travel through separate buildings for lunch, specials, and recess while the intervention school was self-contained in one building. This additional physical education class and differences in school layout may have contributed to more steps, light, and moderate PA minutes demonstrated in the 4th grade control children. The second limitation is that children needed to be fasted and fully hydrated before BIA pre and post measurement could be collected most effectively. Due to varying needs of children throughout the day, this aspect could not be completely controlled, but children were measured at the same time of day at both pre and post data collection time points and the children had water bottles in their classrooms so they could drink fluids throughout the day to counter this limitation. Additionally, the accuracy of a participant's height also could have influenced the results of the BIA scale. Researchers ensured the same protocols were used for both groups when measuring height. However, if there was an error in how the measurements were read or how they were entered into the BIA program, it could have resulted in inaccurate measures of BF%. Similar to the Farbo et al. (2022) study, some lingering effects of the COVID-19 pandemic between measurements could have lessened any differences in body composition. Finally, the regression analysis produced a limited sample size in both the overfat and obese categories, so the model used was not the best fit for the data and could have unreliable results.

### *Future Directions*

Future research should consider ways to maintain PA in females and as children age since there was a noticeable difference in MVPA compared to males and younger children. This may include adding even more time for recess or additional play choices that encourage MVPA. Future research should also examine the PA patterns of children at home and on the weekends since they are known to be relatively sedentary in these settings. Combining those results with the current findings will help support the need for more recess during the school day to help children reach healthy levels of MVPA. Future research should also examine the effects of recess on obesity in a normal school year that is not affected by COVID-19. Based on the discrepancies between the BIA and accelerometer data in 4$^{th}$ grade, outside factors could influence obesity rates in this sample of children. Future research should more closely examine how other variables such as diet can be used to elicit greater obesity changes in children. Females in this and previous LiiNK studies seem to have more positive results from the additional time for recess than males. Future research should consider what strategies need to be utilized for males to experience similar obesity prevalence results. Finally, a larger sample size is needed to examine if MVPA is predictive of body fat categories in LiiNK intervention and control children.

***Conclusion***

Sufficient MVPA is needed to help children maintain healthy levels of body fat and prevent the development of obesity. Based on our findings, 60-minutes of unstructured, outdoor play provides children the best opportunity to engage in sufficient MVPA to result in positive changes in body composition. This is the minimum amount of time schools and researchers should provide to see the most significant health improvements in children. If 60-minutes is not possible, 30 or 45 minutes may also help put them on the right track to better health. We also found that available play spaces and equipment can have a significant impact on the amount of MVPA children are able to achieve. Providing both additional time for play and the appropriate environments may be the key to shifting the current obesity and inactivity trends seen in children today.

# Chapter 5: Discussion

## Overview

Childhood obesity is at an all-time high and one of the main contributors to this epidemic is lack of sufficient moderate to vigorous physical activity (MVPA) (Bull et al., 2020). The LiiNK intervention provides children with up to 60 minutes of recess, defined as unstructured, outdoor play each day that they are in school beginning in kindergarten. LiiNK 1$^{st}$ and 2$^{nd}$ grade students are shown to average ~140 minutes of MVPA per day as a result of the increased time for recess (Farbo et al., 2020). Based on this result, we assumed that the LiiNK intervention would lower obesity rates as at least 60 minutes of MVPA per day has been shown to prevent excess body fat accumulation (Bull et al., 2020). However, previous data on obesity rates in LiiNK children revealed inconsistent trends to support this claim (Farbo, 2019). This led to the question of whether the assessment tool used was accurate for this population of children.

Therefore, establishing a valid measure to assess obesity in children who regularly engage in high amounts of MVPA was warranted. With a new tool determined in Study 1 (Chapter 2), the next step was to gain a general understanding of how 30-60 minutes for recess would affect obesity rates in 2$^{nd}$-5$^{th}$ grade children. Using this new measure, we were able to highlight in Study 2 (Chapter 3) some interesting trends, however MVPA data was needed to support our findings were a result of increased recess time. Since it is known that LiiNK 1$^{st}$ and 2$^{nd}$ grade children achieve high levels of MVPA, the next step in Study 3 (Chapter 4), was to examine MVPA levels in 3$^{rd}$ and 4$^{th}$ grade children and use this data to better understand how recess affected obesity rates in this population. We found that 60-

minutes of recess led to the greatest improvements in MVPA and body composition when compared to 30 or 45 minutes. The evidence provided in each study advances what is known about children's PA and obesity levels and provides opportunities to apply our results and further our understanding of this phenomenon.

**Summary of findings**

***Assessments of obesity***

Study 1 sought to determine a valid assessment tool to measure obesity rates in children. While the literature commonly uses body mass index (BMI) in the field to assess children's obesity rates, it does not directly measure body fat and a high BMI score does not always mean that an individual is obese. Through the research established in the previous chapters, bio-electrical impedance (BIA) was chosen over BMI and other body composition measures since it is able to directly assess body fat, has high specificity and sensitivity, and is easy to use in field based research (Kuriyan, 2018). The results revealed that there was ~30% disagreement in how BMI and BIA categorized students, with overweight reflecting the highest category difference at ~40%. In some instances, BMI would categorize students as overweight when in reality they had healthy levels of body fat. These findings are consistent with others who have questioned BMI as a reliable measure in children (Vanderwall et al., 2017).

Studies 2 and 3, focused on 2$^{nd}$ through 5$^{th}$ grades, found similar discrepancies between the two measures with Study 3, focused specifically on grades 3 and 4, found participants who demonstrated an increase in BMI actually decreased in BF%. We found BMI and BIA were similar in categorizing individuals who were obese, which is consistent with the claim that BMI is an accurate assessment for individuals with high fat levels

(Martin-Calvo et al., 2016). However, the large overweight category error supports our prior questions regarding the accuracy of BMI to assess populations with high MVPA levels. These children may be experiencing a body composition change in which they burn fat and build muscle, which would not be detected by BMI.

***Recess and obesity***

With a more accurate obesity assessment determined, Studies 2 and 3 focused on the impact of 30, 45, or 60 recess minutes, defined as unstructured, outdoor play, on obesity prevalence in elementary aged children. To first gain a general understanding of how additional time for recess could affect obesity and the reliability of using BIA in the field, Study 2 collected a random sample of $2^{nd}$-$5^{th}$ grade children. Study 3 incorporated MVPA and BIA assessments in $3^{rd}$ and $4^{th}$ grade children to examine consistencies with previous findings from Farbo et al. (2020) focused on LiiNK $1^{st}$ and $2^{nd}$ grade children. Although one group was labeled as intervention (45-60 minutes) and one was control (30 minutes), it should be noted that each group received more time for recess than most of children across the country (Ramstetter & Murray, 2017). Body fat shifts, whether focused on 30-60 minutes of recess, were similar. In both studies, obesity rates remained stable, as the percentage of obese children were similar between pre and post measurements. These results are consistent with other data that states children will experience greater changes in body composition with each additional hour per week they have for recess (Gray et al., 2019). Additionally, this finding is significant considering that both studies took place during the COVID-19 pandemic, which had a major impact on normal lifestyles of children (Zemrani et al., 2021). During this time, children across the U.S. engaged in higher amounts of sedentary behaviors and poor eating, resulting in ~3% increase in obese students when measured with BMI

(Lange et al., 2021; Zemrani et al., 2021). The obesity rate maintenance in Studies 2 and 3 suggests additional recess time (30-60 minutes) is an effective strategy to prevent obesity increases, even when outside variables are more influential than normal.

In both studies, BF% and obesity prevalence decreased in 4th grade when compared to 3rd and in Study 2, 5th graders in both groups were the healthiest subgroup when compared to other grade levels. At first glance, one might think children who are provided at least 30-minutes of recess each day may see similar long-term changes in body composition as those with 45 or 60. However, in Study 3, 45-minutes of recess in the intervention 4th grade group produced a decrease in BF% between pre and post measurements while the 4th grade control children who received 30-minutes increased in BF%. Although the 4th grade intervention group received 45-recess minutes in Study 3, they had the full 60-minutes each year prior. Other unstructured recess interventions have reported increases in BMI or waist circumference at one or 2-year follow-up (Casolo et al., 2019; Farmer et al., 2017). While multiple systematic reviews on recess and school-based PA interventions suggest that at least 6-months is needed to find the greatest improvements in obesity, our results suggest that even more time may be needed (Nally et al., 2021; Parrish et al., 2020; Yuksel et al., 2020). Children in 4th and 5th grade were entering their fifth and sixth years of receiving 45-60 recess minutes, so the long-term effects may be more significant than what was provided in a year snapshot.

Furthermore, Studies 2 and 3 found positive trends in females. In Study 2, more females than expected decreased body fat category across both groups while in Study 3, the intervention 4th graders had a 5% decrease in obesity. This finding is consistent with a number of school-based PA interventions and may be a result of females experiencing an increase in MVPA in both studies (Brown et al., 2019; Podnar et al., 2021; Yuksel et al., 2020). Females are at a higher risk to develop obesity during childhood since they engage in less MVPA amounts than males (McLellan et al., 2020) and will continue to increase BF% as they age (Laurson et al., 2011). We may be seeing more significant results in females since they are engaging in higher amounts of MVPA from a young age than other populations who have been studied. Since both studies found positive results in females, our findings suggest that additional time for recess may prevent excess body fat accumulation as they age and decrease their chances of becoming obese. In males however, the MVPA increase experienced during recess may still not be enough to result in similar obesity changes. They may need additional strategies that lead to the same outcomes as females from these two studies.

In Study 2, 2nd grade students had more than an expected decrease in body fat category between pre and post measurements. Other structured recess or PA interventions in the same age group have found no changes when measuring with BMI or skinfold measures (Casolo et al., 2019; Nally et al., 2021). However, these interventions were only 9-12 weeks long, which further suggests that children need an intervention implementation length of at least 6 months (Nally et al., 2021; Yuksel et al., 2020). Our findings are especially important as data shows obese adolescents will experience their most rapid body fat increases between the ages of 2-6 and then continue this increase as they age (Geserick et al., 2018). When children develop obesity at a young age, they are likely to remain obese, so it is crucial they experience less excess fat accumulation during childhood (Simmonds et al., 2016). Findings from Farbo et al. (2020) demonstrated that 2nd grade children with 30 minutes or more of recess are very active and achieve ~100 minutes of MVPA during school daily. Therefore, increasing MVPA minutes through unstructured, outdoor recess daily seems to be an effective strategy to prevent children from experiencing excessive weight gain during this stage of physical development.

In Studies 2 and 3, if children were obese in the pre-intervention fall measurements, they were likely to remain obese in the same year post-intervention spring measurements. Obese children, in general, seem to need additional strategies such as nutrition education or family nutrition classes to experience obesity decreases. However in Study 3, there was a noticeable shift of overfat to healthy in all subgroups, with greater subgroup improvements who achieved higher amounts of MVPA. For example, 3rd grade intervention children were more active than control, which led to a greater shift from overfat to healthy. The only subgroup that did not decrease overfat was 4th grade females, but that is because they were the only group to decrease in obesity percentage. Children who are overfat are at a high risk to become obese.  Our results suggest that at least 30 minutes of recess will help them shift to the healthy category and avoid the consequences of obesity. These results also show obese children do not become more obese, they remain stable in BF% from fall to spring. The collective results across both studies is a positive indicator that 30-minutes of recess, minimally, is necessary to produce healthier children. However, greater improvements will occur when they are given at least 60-minutes.

***Recess and MVPA***

Study 3 also examined PA patterns of participants to support any body composition differences observed. We found that 3rd grade intervention children took ~900 more steps and engaged in ~13 more MVPA minutes than control children, with males more active than females. The group differences in our findings is larger than other recess interventions who only report about a 0-5 minute MVPA difference post intervention (Beyler et al., 2014; Huberty et al., 2014). The high MVPA amounts in intervention 3rd grade children explain why they had a larger overfat to healthy shift than control children. A multinomial logistic regression supported these results revealing intervention children were more likely to be healthy or overfat than obese when they achieved higher amounts of vigorous PA. Other studies have also found an inverse relationship with MVPA and body fat accumulation (Miatke et al., 2021). When children are given the proper environment and time to be active, they will engage in high amounts of MVPA on their own, which can lead to positive body composition changes.

In 4th grade, the control school children took ~700 more steps and engaged ~13 more MVPA minutes than intervention children. However, differences in school layout, time for physical education, and time for recess (45 vs 30) could explain these results. Additionally, observational recess data revealed play preferences varied depending on the available play space provided during recess. If the 4th grade intervention children had the same play environments and the full 60-minutes for recess, they might have similar MVPA patterns as the 3rd grade group. Children in both groups averaged ~100 MVPA minutes during school, indicating a 40-minute MVPA increase beyond the CDC 60 minutes needed, which is similar to previous LiiNK MVPA data (Farbo et al., 2020). This is greater than many other intervention studies which show children will only increase MVPA by ~10-20 minutes per day with the addition of the intervention and will still fail to meet movement recommendations (Parrish et al., 2020; Vaquero-Solís et al., 2020). While both groups had up to 100 MVPA minutes, it is worth noting that 3rd grade children who received the full 60-minutes of recess recorded the highest steps and MVPA minutes than 30 or 45 minutes. This is consistent with previous data which shows that 60 minutes leads to larger increases in MVPA than 30 minutes (Farbo et al., 2020). From these results, it is clear that 60 minutes of recess is needed to see the greatest improvements in MVPA and obesity rate decline.

**Contribution to knowledge base**

All three dissertation studies sought to address some of the gaps presented in the literature and provide researchers and professional implementation strategies. In Study 2, a large discrepancy was found between how a child was classified as overweight or healthy based on which assessment tool, BMI or BIA, was used to determine these categories. This was a concern going into the study and was confirmed as a result of examining children who were at varying degrees of PA daily through unstructured, outdoor play. Although obese children were similarly assessed with BMI or BIA, the more reliable and accurate tool to use in field studies to assess all body fat categories of children is BIA. While BMI has been the assessment tool used across the majority of body composition studies over the past few years and has gathered normative data to determine who is heathy, overweight, or obese, the accuracy of state and national childhood obesity data may be misleading (CDC, 2021a; WHO, 2021). This discrepancy is consistent across all three-dissertation studies, further suggesting BMI has misled our health teams in understanding how many children are unhealthy and how necessary it is to use more accurate body fat assessment tools (Farbo & Rhea, 2021; Farbo & Rhea, 2022). These three studies support the use of BIA to determine body fat categories in children whenever possible. Until researchers begin to use a more valid assessment of obesity, it will be hard to draw definitive conclusions on effective strategies that lead to positive improvements in children.

While measurement choice may explain some of the gaps in the literature, the intervention strategies that many researchers choose to implement may also limit findings. Most school-based intervention research focuses on providing no more than 30-minutes of structured recess or PA during the day and report inconsistent improvements in MVPA or obesity (Nally et al., 2021; Parrish et al., 2020; Yuksel et al., 2020). This may be due to children not always being interested in the activities that are chosen, making it impossible to develop the motivation to continue that behavior once independent from an adult or school setting (Bandura & Walters, 1977; Frank et al., 2018). This disinterest in the activity will gradually decrease MVPA, which can ultimately increase their chances of developing obesity. Conversely, when children are given the opportunity to play freely, intrinsic motivation is developed to enjoy what they do and want to repeat it independently of anyone else. This drive to experience happiness during unstructured play has been shown to increase MVPA and decrease obesity (Ansari et al., 2015; Farbo et al., 2020; Lee et al., 2020).

The literature on unstructured play has shown the best way to elicit these improvements is to provide 60-minutes of unstructured, outdoor play split up into shorter, more frequent breaks (Ansari et al., 2015; Razak et al., 2018). To our knowledge, the LiiNK project is the first of its kind to implement both of these strategies into a school setting every single day for a whole year. In Studies 2 and 3, we found our strongest obesity related results in children who had 60-minutes of recess. In Study 3, we found these trends were a result of high MVPA levels every day that children were in school. While we found that 30 or 45 minutes could lead to some benefits, children who had the full 60-minutes for recess engaged more in MVPA and showed lower obesity rates. However, in Study 3, we found that type of play space and available equipment can also have a significant effect on MVPA in older populations of children (i.e. sex, age, race). Not only do children need more time for recess, they also need appropriate play environments and activities which interest and engage them in high MVPA amounts. This supports and adds to the literature that children need 60 minutes of unstructured, outdoor play split into multiple segments throughout the day, every day to be active and remain healthy (Ansari et al., 2015; Farbo et al., 2020; Razak et al., 2018). Structured recess periods daily are not effective to gain MVPA minutes and decrease obesity prevalence in elementary aged children. Unstructured, outdoor play develops all of the necessary whole child experiences needed to be whole and healthy.

**Implications**

This body of evidence has relevant implications for administrators, teachers, and state officials about school recess importance daily. Currently, no national mandate exists for recess, especially outdoors and unstructured, and only a handful of states require it as a regular part of the school day (Jarrett, 2019; Ramstetter & Murray, 2017). In most states, even when recess is provided, it is 20 minutes or less, it can be taken away as punishment, or simply viewed as a reward instead of a key developmental strategy for whole child health (Jarrett, 2019; Ramstetter & Murray, 2017). Many children today receive the majority of their active time in a school setting and it is crucial they are given adequate amounts of recess to accomplish this (Pulido-Sánchez & Iglesias-Gallego, 2021). In fact, children in 1st-4th grade will exceed the recommended 60 minutes of MVPA while they are in school alone if given 30-60 minutes of recess daily (Farbo et al., 2020). If children are able to engage in this amount of MVPA each day that they are in school from a young age, it may prevent them from becoming obese all together. Based on our findings, schools need to increase the amount of recess they offer during the day to improve children's health. If a school is not able to provide the full 60-minutes of recess daily, we suggest that they at least provide 30 minutes each day to result in some positive improvements.

Even after-school programs and other child and adolescent organizations should adopt these evidence-based unstructured, outdoor play practices into their programs. Since the accumulative number of minutes offered yearly seems to effect children's activity levels as they age, endorsing creative play spaces and unstructured, outdoor recess time is essential for older children and females to be active. Developing play spaces that create inquisitive and problem solving activities needs to be a primary focus to aid in continual engagement in MVPA and stabilize healthy body fat levels in children as they age. . Schools present an ideal setting to help reverse negative health trends in this generation of children if focus begins to shift from academics alone to academic improvement through whole child development.

In summary, the findings in this dissertation have a number of contributions to the knowledge base that can be utilized in multiple settings. First, BMI can misclassify students who may be healthy as overweight or obese, so it is not the most accurate tool to utilize in research. BIA seems to be a more consistent and reliable tool to use to determine the true effects of interventions. Second, unstructured, outdoor play seems to be effective in improving obesity rates and MVPA in children. These findings suggest that providing 60 minutes of unstructured, outdoor play during school needs to be both examined more in the literature and implemented in schools to provide the most benefits for children.

**Suggestions for Future Research**

The collective findings throughout this dissertation still present a number of gaps that need to be addressed in future research. When using BIA to measure body fat, participants should be in a fasted state and fully hydrated for the most accurate results. None of the three studies accounted for this due to such a wide variability in collection times and variables outside of the researcher's control. A study examining how hydration and stomach content may influence results could help determine a possible error rate when using these devices in field based research. This information can then be applied to study results to help produce more accurate BIA results. Additionally, the accuracy of these body fat scales when compared to DXA was determined in a normal population of children (Kabiri et al., 2015). A future study could examine if similar results are found when using a population with higher amounts of MVPA than normal. A comparison of DXA, BIA, and BMI could also be examined in future studies to add to the Study 1 findings. Both of these future studies would provide more support for the use of BIA over BMI when determining the effects of a school-based PA interventions.

In Studies 2 and 3, body fat category shift from pre to post was used to determine differences between groups since we felt it provided a clearer picture of obesity than change in BF%. Many of the subgroups included in the analyses contained a high percentage of healthy participants who did not shift categories between measurements. Future studies should include only participants who are overfat or obese, both of which are more likely to experience a body fat category shift as a result of increased MVPA than healthy participants. In Study 3, 4$^{th}$ grade intervention children were less active, yet they decreased BF% while control schools increased BF%. This suggests that outside factors such as diet and sedentary behaviors outside of school could have impacted our results. We chose not to examine these factors as evidence supports that interventions which target PA are generally more effective in decreasing obesity rates than ones focused on eating patterns or sedentary behaviors (Liu et al., 2019; Nally et al., 2021). However, further investigation is needed among LiiNK children to determine how these factors can influence obesity rates. Additionally, Studies 2 and 3 were only measured at the beginning and end of the school year which may not be a long enough period to discover significant changes in obesity rates. The intervention students in both studies receive the additional time for recess each year they are in elementary school, so larger differences may be observed if students are measured over multiple years. Future research should examine trends of obesity in students who receive additional time for recess from the time they enter kindergarten until they reach 5th grade. This longitudinal analysis will lead to more definitive conclusions to support unstructured, outdoor play as an effective method to decrease obesity rates in children

Studies 2 and 3 found greater change in females than males, which is interesting considering that males were more active based on MVPA Study 3 results. This finding provides multiple directions for future researchers to consider. First, males may need even more time for recess than what was available in this intervention. Additionally, both sexes may need additional activities during recess that help reach even higher levels of MVPA. Further examination is needed to determine how much time or the type of play environments is needed by each sex that lead to similar results in obesity and MVPA. Even though children in both groups were more active than what is seen in many other school-based interventions, there was a noticeable decrease in MVPA between 3rd and 4th grade students (Yuksel et al., 2020). An even  larger decrease was observed when compared to LiiNK 1st and 2nd grade children as demonstrated by Farbo et al. (2020). This decrease in MVPA is consistent with what is typically reported in children (Farooq et al., 2018). However, further investigation is needed to determine what strategies can prevent this decrease from occurring. Providing the right opportunities for children to remain active, such as 60 minutes of unstructured outdoor play, shorter more frequent breaks, and proper play environments may help them remain active when they develop into adolescents and adults. Additional time for recess may be the key to children living long and healthy lives and eliminate the risk of developing obesity related consequences.

## References


Aibar, A., & Chanal, J. (2015). Physical Education: The Effect of Epoch Lengths on Children's Physical Activity in a Structured Context. *PLOS ONE*, *10*(4), e0121238. https://doi.org/10.1371/journal.pone.0121238

Alexander, S. A., Frohlich, K. L., & Fusco, C. (2014). Playing for health? Revisiting health promotion to examine the emerging public health position on children's play. *Health Promot Int*, *29*(1), 155-164. https://doi.org/10.1093/heapro/das042

Alves, A., Carola, L., Barros, E., & Pna, C. (2019). Comparison of body mass index, the bioimpedance electric and waist circumference in childhood obesity classification. *Advances in Obesity, Weight Management & Control*, *9*, 144-147. https://doi.org/10.15406/aowmc.2019.09.00289

Anderson, P. M., Butcher, K. F., & Schanzenbach, D. W. (2019). Understanding recent trends in childhood obesity in the United States. *Economics & Human Biology*, *34*, 16-25. https://doi.org/https://doi.org/10.1016/j.ehb.2019.02.002

Ansari, A., Pettit, K., & Gershoff, E. (2015). Combating Obesity in Head Start: Outdoor Play and Change in Children's Body Mass Index. *J Dev Behav Pediatr*, *36*(8), 605-612. https://doi.org/10.1097/dbp.0000000000000215

Aubert, S., Barnes, J. D., Abdeta, C., Nader, P. A., Adeniyi, A. F., Aguilar-Farias, N., . . . Tremblay, M. S. (2018). Global Matrix 3.0 Physical Activity Report Card Grades for Children and Youth: Results and Analysis From 49 Countries. *Journal of Physical Activity and Health*, *15*(s2), S251. https://doi.org/10.1123/jpah.2018-0472 10.1123/jpah.2018-0472 10.1123/jpah.2018-0472 10.1123/jpah.2018-0472

Bandura, A., & Walters, R. H. (1977). *Social learning theory* (Vol. 1). Englewood cliffs Prentice Hall.

Barnett, T. A., Kelly, A. S., Young, D. R., Perry, C. K., Pratt, C. A., Edwards, N. M., . . . Vos, M. B. (2018). Sedentary Behaviors in Today’s Youth: Approaches to the Prevention and Management of Childhood Obesity: A Scientific Statement From the American Heart Association. *Circulation*, *138*(11), e142-e159. https://doi.org/doi:10.1161/CIR.0000000000000591

Bauml, M., Patton, M. M., & Rhea, D. (2020). A Qualitative Study of Teachers' Perceptions of Increased Recess Time on Teaching, Learning, and Behavior. *Journal of Research in Childhood Education*, *34*(4), 506-520. https://doi.org/10.1080/02568543.2020.1718808

Behrens, T. K., Holeva-Eklund, W. M., Luna, C., Carpenter, D., Tucker, E., Field, J., & Kelly, C. (2019). An Evaluation of an Unstructured and Structured Approach to Increasing Recess Physical Activity. *Journal of School Health*, *89*(8), 636-642. https://doi.org/https://doi.org/10.1111/josh.12787

Bento, G., & Dias, G. (2017). The importance of outdoor play for young children's healthy development. *Porto Biomedical Journal*, *2*(5), 157-160. https://doi.org/https://doi.org/10.1016/j.pbj.2017.03.003

Beyler, N., Bleeker, M., James-Burdumy, S., Fortson, J., & Benjamin, M. (2014). The impact of Playworks on students' physical activity during recess: Findings from a randomized controlled trial. *Preventive Medicine*, *69*, S20-S26. https://doi.org/https://doi.org/10.1016/j.ypmed.2014.10.011

Bleich, S. N., Vercammen, K. A., Zatz, L. Y., Frelier, J. M., Ebbeling, C. B., & Peeters, A. (2018). Interventions to prevent global childhood overweight and obesity: a systematic review. *Lancet Diabetes Endocrinol*, *6*(4), 332-346. https://doi.org/10.1016/s2213-8587(17)30358-3

Borga, M., West, J., Bell, J. D., Harvey, N. C., Romu, T., Heymsfield, S. B., & Dahlqvist Leinhard, O. (2018). Advanced body composition assessment: from body mass index to body composition profiling. *J Investig Med*, *66*(5), 1-9. https://doi.org/10.1136/jim-2018-000722

Brown, T., Moore, T. H., Hooper, L., Gao, Y., Zayegh, A., Ijaz, S., . . . Summerbell, C. D. (2019). Interventions for preventing obesity in children. *Cochrane Database Syst Rev*, *7*(7), Cd001871. https://doi.org/10.1002/14651858.CD001871.pub4

Brusseau, T. A., & Kulinna, P. H. (2015). An Examination of Four Traditional School Physical Activity Models on Children's Step Counts and MVPA. *Res Q Exerc Sport*, *86*(1), 88-93. https://doi.org/10.1080/02701367.2014.977431

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., . . . Willumsen, J. F. (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451-1462. https://doi.org/10.1136/bjsports-2020-102955

Casolo, A., Sagelv, E., Bianco, M., Casolo, F., & Galvani, C. (2019). Effects of a structured recess intervention on physical activity levels, cardiorespiratory fitness, and anthropometric characteristics in primary school children. *Journal of Physical Education and Sport*, *19*, 1796-1805. https://doi.org/10.7752/jpes.2019.s5264

Centers for Disease Control and Prevention. (2021a). *Childhood Obesity Facts*. Retrieved December 27, 2021 from https://www.cdc.gov/obesity/data/childhood.html

Centers for Disease Control and Prevention. (2021b). *Physical Activity Facts*. Retrieved December 27 from https://www.cdc.gov/healthyschools/physicalactivity/facts.htm

Centers for Disease Control and Prevention. (2022). *Children's Mental Health*. Retrieved March 14 from https://www.cdc.gov/childrensmentalhealth/data.html

Chavez, R. C., & Nam, E. W. (2020). School-based obesity prevention interventions in Latin America: A systematic review. *Revista de saude publica*, *54*(0), 110. https://doi.org/10.11606/s1518-8787.2020054002038

Chen, X., Cisse-Egbuonye, N., Spears, E. C., Mkuu, R., & McKyer, E. L. J. (2018). Children's healthy eating habits and parents' socio-demographic characteristics in rural Texas, USA. *Health Education Journal*, *77*(4), 444-457. https://doi.org/10.1177/0017896917752014

Chooi, Y. C., Ding, C., & Magkos, F. (2019). The epidemiology of obesity. *Metabolism*, *92*, 6-10. https://doi.org/10.1016/j.metabol.2018.09.005

Clark, L. E., & Rhea, D. J. (2017). The LiiNK Project ® : Comparisons of Recess, Physical Activity, and Positive Emotional States in Grades K-2 Children. *International Journal of Child Health and Nutrition*, *6*, 54-61.

Cohen, D. A., Han, B., Williamson, S., Nagel, C., McKenzie, T. L., Evenson, K. R., & Harnik, P. (2020). Playground features and physical activity in U.S. neighborhood parks. *Preventive Medicine*, *131*, 105945-105945. https://doi.org/10.1016/j.ypmed.2019.105945

Dankiw, K. A., Tsiros, M. D., Baldock, K. L., & Kumar, S. (2020). The impacts of unstructured nature play on health in early childhood development: A systematic review. *PLOS ONE*, *15*(2), e0229006. https://doi.org/10.1371/journal.pone.0229006

Demetriou, Y., Gillison, F., & McKenzie, T. (2017). After-School Physical Activity Interventions on Child and Adolescent Physical Activity and Health: A Review of Reviews. *Advances in Physical Education*, *7*, 191-215. https://doi.org/10.4236/ape.2017.72017

Dickey, K., Castle, K., & Pryor, K. (2016). Reclaiming Play in Schools. *Childhood Education*, *92*(2), 111-117. https://doi.org/10.1080/00094056.2016.1150742

Egan, C., Webster, C., Beets, M., Weaver, R., Russ, L., Michael, R., . . . Orendorff, K. (2019). American Journal of Health Education Sedentary Time and Behavior during School: A Systematic Review and Meta-Analysis Sedentary Time and Behavior during School: A Systematic Review and Meta-Analysis. *American Journal of Health Education*, *50*. https://doi.org/10.1080/19325037.2019.1642814

Egan, C. A., Webster, C. A., Beets, M. W., Weaver, R. G., Russ, L., Michael, D., . . . Orendorff, K. L. (2019). Sedentary Time and Behavior during School: A Systematic Review and Meta-Analysis. *American Journal of Health Education*, *50*(5), 283-290. https://doi.org/10.1080/19325037.2019.1642814

Errisuriz, V., Golaszewski, N., Born, K., & Bartholomew, J. (2018). Systematic Review of Physical Education-Based Physical Activity Interventions Among Elementary School Children. *The Journal of Primary Prevention*, *39*. https://doi.org/10.1007/s10935-018-0507-x

Farbo, D., Maler, L. C., & Rhea, D. J. (2020). The Preliminary Effects of a Multi-Recess School Intervention: Using Accelerometers to Measure Physical Activity Patterns in Elementary Children. *Int J Environ Res Public Health*, *17*(23). https://doi.org/10.3390/ijerph17238919

Farbo, D., & Rhea, D. (2021). A Pilot Study Examining Body Composition Classification Differences Between Body Mass Index and Bioelectrical Impedance Analysis in Children With High Levels of Physical Activity [10.3389/fped.2021.724053]. *Frontiers in Pediatrics*, *9*, 1304. https://www.frontiersin.org/article/10.3389/fped.2021.724053

Farbo, D. C., L. Rhea, D.,. (2019, 2019). The impact of play on overweight/obese children in elementary schools.

Farmer, V. L., Williams, S. M., Mann, J. I., Schofield, G., McPhee, J. C., & Taylor, R. W. (2017). The effect of increasing risk and challenge in the school playground on physical activity and weight in children: a cluster randomised controlled trial (PLAY). *International Journal of Obesity*, *41*(5), 793-800. https://doi.org/10.1038/ijo.2017.41

Farooq, M. A., Parkinson, K. N., Adamson, A. J., Pearce, M. S., Reilly, J. K., Hughes, A. R., . . . Reilly, J. J. (2018). Timing of the decline in physical activity in childhood and adolescence: Gateshead Millennium Cohort Study. *British Journal of Sports Medicine*, *52*(15), 1002-1006. https://doi.org/10.1136/bjsports-2016-096933

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175-191. https://doi.org/10.3758/BF03193146

Fernandes, M. M., & Sturm, R. (2011). The role of school physical activity programs in child body mass trajectory. *Journal of physical activity & health*, *8*(2), 174-181. https://doi.org/10.1123/jpah.8.2.174

Fernandez-Jimenez, R., Al-Kazaz, M., Jaslow, R., Carvajal, I., & Fuster, V. (2018). Children Present a Window of Opportunity for Promoting Health: JACC Review Topic of the Week. *Journal of the American College of Cardiology*, *72*(25), 3310-3319. https://doi.org/https://doi.org/10.1016/j.jacc.2018.10.031

Frank, M. L., Flynn, A., Farnell, G. S., & Barkley, J. E. (2018). The differences in physical activity levels in preschool children during free play recess and structured play recess. *Journal of Exercise Science & Fitness*, *16*(1), 37-42. https://doi.org/https://doi.org/10.1016/j.jesf.2018.03.001

Freedman, D. S., & Sherry, B. (2009). The validity of BMI as an indicator of body fatness and risk among children. *Pediatrics*, *124 Suppl 1*, S23-34. https://doi.org/10.1542/peds.2008-3586E

Frost, M. C., Kuo, E. S., Harner, L. T., Landau, K. R., & Baldassar, K. (2018). Increase in Physical Activity Sustained 1 Year After Playground Intervention. *American Journal of Preventive Medicine*, *54*(5, Supplement 2), S124-S129. https://doi.org/https://doi.org/10.1016/j.amepre.2018.01.006

Fryar, C. D., Carroll, M., & Ogden, C. L. (2018). Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2 19 years: United States, 1963 1965 through 2015 2016.

Gállego Suárez, C., Singer, B. H., Gebremariam, A., Lee, J. M., & Singer, K. (2017). The relationship between adiposity and bone density in U.S. children and adolescents. *PLOS ONE*, *12*(7), e0181587. https://doi.org/10.1371/journal.pone.0181587

Geserick, M., Vogel, M., Gausche, R., Lipek, T., Spielau, U., Keller, E., . . . Körner, A. (2018). Acceleration of BMI in Early Childhood and Risk of Sustained Obesity. *New England Journal of Medicine*, *379*(14), 1303-1312. https://doi.org/10.1056/NEJMoa1803527

Gray, C., Gibbons, R., Larouche, R., Sandseter, E. B., Bienenstock, A., Brussoni, M., . . . Tremblay, M. S. (2015). What Is the Relationship between Outdoor Time and Physical Activity, Sedentary Behaviour, and Physical Fitness in Children? A Systematic Review. *International journal of environmental research and public health*, *12*(6), 6455-6474. https://doi.org/10.3390/ijerph120606455

Gray, H. L., Buro, A. W., Barrera Ikan, J., Wang, W., & Stern, M. (2019). School-level factors associated with obesity: A systematic review of longitudinal studies. *Obesity Reviews*, *20*(7), 1016-1032. https://doi.org/https://doi.org/10.1111/obr.12852

Gray, P. (2011). The decline of play and the rise of psychopathology in children and adolescents. *American Journal of Play*, *3*, 443-463.

Guerra, P. H., Nobre, M. R. C., Silveira, J. A. C. d., & Taddei, J. A. d. A. C. (2013). The effect of school-based physical activity interventions on body mass index: a meta-analysis of randomized trials. *Clinics (Sao Paulo, Brazil)*, *68*(9), 1263-1273. https://doi.org/10.6061/clinics/2013(09)14

Hales, C. M., Carroll, M. D., Fryar, C. D., & Ogden, C. L. (2017). Prevalence of Obesity Among Adults and Youth: United States, 2015-2016. *NCHS Data Brief*(288), 1-8.

Hegarty, L. M., Mair, J. L., Kirby, K., Murtagh, E., & Murphy, M. H. (2016). School-based Interventions to Reduce Sedentary Behaviour in Children: A Systematic Review. *AIMS Public Health*, *3*(3), 520-541. https://doi.org/10.3934/publichealth.2016.3.520

Herrington, S., & Brussoni, M. (2015). Beyond Physical Activity: The Importance of Play and Nature-Based Play Spaces for Children's Health and Development. *Current Obesity Reports*, *4*(4), 477-483. https://doi.org/10.1007/s13679-015-0179-2

Hillman, C. H., & Biggan, J. R. (2017). A Review of Childhood Physical Activity, Brain, and Cognition: Perspectives on the Future. *Pediatric Exercise Science*, *29*(2), 170-176. https://doi.org/10.1123/pes.2016-0125

Houska, C. L., Kemp, J. D., Niles, J. S., Morgan, A. L., Tucker, R. M., & Ludy, M.-J. (2018). Comparison of Body Composition Measurements in Lean Female Athletes. *International journal of exercise science*, *11*(4), 417-424. https://pubmed.ncbi.nlm.nih.gov/29795733

Howe, C. A., Freedson, P. S., Alhassan, S., Feldman, H. A., & Osganian, S. K. (2012). A recess intervention to promote moderate-to-vigorous physical activity. *Pediatr Obes*, *7*(1), 82-88. https://doi.org/10.1111/j.2047-6310.2011.00007.x

Huberty, J. L., Beets, M. W., Beighle, A., Saint-Maurice, P. F., & Welk, G. (2014). Effects of Ready for Recess, An Environmental Intervention, on Physical Activity in Third-Through Sixth-Grade Children. *Journal of Physical Activity & Health*, *11*(2), 384-395. http://lib.tcu.edu/PURL/EZproxy_link.asp?url=https://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,uid&db=s3h&AN=94846627&site=ehost-live

Hyndman, B. P., & Lester, L. (2015). The effect of an emerging school playground strategy to encourage children's physical activity: the Accelerometer Intensities from Movable Playground and Lunchtime Activities in Youth (AIM-PLAY) study. *Children, Youth and Environments*, *25*(3), 109-128.

Jarrett, O. S. (2019). A resarch-based case for recess: Position Paper. *US Play Coalition in collaboration with American Association for the Child's Right to Play (IPA/USA) and the Alliance for Childhood*. https://usplaycoalition.org/wp-content/uploads/2019/08/Need-for-Recess-2019-FINAL-for-web.pdf

Javed, A., Jumean, M., Murad, M. H., Okorodudu, D., Kumar, S., Somers, V. K., . . . Lopez-Jimenez, F. (2015). Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. *Pediatr Obes*, *10*(3), 234-244. https://doi.org/10.1111/ijpo.242

Jones, M., Defever, E., Letsinger, A., Steele, J., & Mackintosh, K. A. (2020). A mixed-studies systematic review and meta-analysis of school-based interventions to promote physical activity and/or reduce sedentary time in children. *Journal of Sport and Health Science*, *9*(1), 3-17. https://doi.org/https://doi.org/10.1016/j.jshs.2019.06.009

Kabiri, L. S., Hernandez, D. C., & Mitchell, K. (2015). Reliability, Validity, and Diagnostic Value of a Pediatric Bioelectrical Impedance Analysis Scale. *Child Obes*, *11*(5), 650-655. https://doi.org/10.1089/chi.2014.0156

Katzmarzyk, P. T., Barreira, T. V., Broyles, S. T., Champagne, C. M., Chaput, J. P., Fogelholm, M., . . . Church, T. S. (2015). Physical Activity, Sedentary Time, and Obesity in an International Sample of Children. *Med Sci Sports Exerc*, *47*(10), 2062-2069. https://doi.org/10.1249/mss.0000000000000649

Kim, D. D., & Basu, A. (2016). Estimating the Medical Care Costs of Obesity in the United States: Systematic Review, Meta-Analysis, and Empirical Analysis. *Value Health*, *19*(5), 602-613. https://doi.org/10.1016/j.jval.2016.02.008

Kim, J., & Lim, H. (2019). Nutritional Management in Childhood Obesity. *Journal of Obesity & Metabolic Syndrome*, *28*(4), 225-235. https://doi.org/10.7570/jomes.2019.28.4.225

Kinder, C. J., Gaudreault, K. L., Jenkins, J. M., Wade, C. E., & Woods, A. M. (2019). At-Risk Youth in an After-School Program: Structured vs. Unstructured Physical Activity [Article]. *Physical Educator*, *76*(5), 1157-1180. https://doi.org/10.18666/TPE-2019-V76-I5-9016

Kumar, S., & Kelly, A. S. (2017). Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment. *Mayo Clinic Proceedings*, *92*(2), 251-265. https://doi.org/10.1016/j.mayocp.2016.09.017

Kuriyan, R. (2018). Body composition techniques. *Indian J Med Res*, *148*(5), 648-658. https://doi.org/10.4103/ijmr.IJMR_1777_18

Kyle, U. G., Earthman, C. P., Pichard, C., & Coss-Bu, J. A. (2015). Body composition during growth in children: limitations and perspectives of bioelectrical impedance analysis. *Eur J Clin Nutr*, *69*(12), 1298-1305. https://doi.org/10.1038/ejcn.2015.86

Lange, S. J., Kompaniyets, L., Freedman, D. S., Kraus, E. M., Porter, R., Dnp, . . . Goodman, A. B. (2021). Longitudinal Trends in Body Mass Index Before and During the COVID-19 Pandemic Among Persons Aged 2-19 Years - United States, 2018-2020. *MMWR. Morbidity and mortality weekly report*, *70*(37), 1278-1283. https://doi.org/10.15585/mmwr.mm7037a3

Laurson, K. R., Eisenmann, J. C., & Welk, G. J. (2011). Body Fat Percentile Curves for U.S. Children and Adolescents. *American Journal of Preventive Medicine*, *41*(4, Supplement 2), S87-S92. https://doi.org/https://doi.org/10.1016/j.amepre.2011.06.044

Lee, E.-Y., Bains, A., Hunter, S., Ament, A., Brazo-Sayavera, J., Carson, V., . . . Tremblay, M. S. (2021). Systematic review of the correlates of outdoor play and time among children aged 3-12 years. *International Journal of Behavioral Nutrition and Physical Activity*, *18*(1), 41. https://doi.org/10.1186/s12966-021-01097-9

Lee, R. L. T., Lane, S., Brown, G., Leung, C., Kwok, S. W. H., & Chan, S. W. C. (2020). Systematic review of the impact of unstructured play interventions to improve young children's physical, social, and emotional wellbeing. *Nursing & Health Sciences*, *22*(2), 184-196. https://doi.org/https://doi.org/10.1111/nhs.12732

Lemos, T., & Gallagher, D. (2017). Current body composition measurement techniques. *Curr Opin Endocrinol Diabetes Obes*, *24*(5), 310-314. https://doi.org/10.1097/med.0000000000000360

Liu, Z., Xu, H. M., Wen, L. M., Peng, Y. Z., Lin, L. Z., Zhou, S., . . . Wang, H. J. (2019). A systematic review and meta-analysis of the overall effects of school-based obesity prevention interventions and effect differences by intervention components. *Int J Behav Nutr Phys Act*, *16*(1), 95. https://doi.org/10.1186/s12966-019-0848-8

London, R. A. (2020). When schools reopen, don’t neglect recess. *Phi Delta Kappan*, *102*(1), 26-27. https://doi.org/10.1177/0031721720956843

Lonsdale, C., Rosenkranz, R. R., Peralta, L. R., Bennie, A., Fahey, P., & Lubans, D. R. (2013). A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons.

*Preventive Medicine*, *56*(2), 152-161. https://doi.org/https://doi.org/10.1016/j.ypmed.2012.12.004

Lounassalo, I., Salin, K., Kankaanpää, A., Hirvensalo, M., Palomäki, S., Tolvanen, A., . . . Tammelin, T. H. (2019). Distinct trajectories of physical activity and related factors during the life course in the general population: a systematic review. *BMC Public Health*, *19*(1), 271. https://doi.org/10.1186/s12889-019-6513-y

Lund, E., Brimo, D., Rhea, D., & Rivchun, A. (2017). The Effect of Multiple Recesses on Listening Effort: A Preliminary Study. *Journal of Educational, Pediatric & (Re) Habilitative Audiology*, *23*.

MacIntosh, B. R., Murias, J. M., Keir, D. A., & Weir, J. M. (2021). What Is Moderate to Vigorous Exercise Intensity? [Perspective]. *Frontiers in Physiology*, *12*. https://doi.org/10.3389/fphys.2021.682233

Mann, K. D., Howe, L. D., Basterfield, L., Parkinson, K. N., Pearce, M. S., Reilly, J. K., . . . Janssen, X. (2017). Longitudinal study of the associations between change in sedentary behavior and change in adiposity during childhood and adolescence: Gateshead Millennium Study. *International Journal of Obesity*, *41*(7), 1042-1047. https://doi.org/10.1038/ijo.2017.69

Martin-Calvo, N., Moreno-Galarraga, L., & Martinez-Gonzalez, M. A. (2016). Association between Body Mass Index, Waist-to-Height Ratio and Adiposity in Children: A Systematic Review and Meta-Analysis. *Nutrients*, *8*(8). https://doi.org/10.3390/nu8080512

Massey, W., Neilson, L., & Salas, J. (2020). A critical examination of school-based recess: what do the children think? *Qualitative Research in Sport, Exercise and Health*, *12*(5), 749-763. https://doi.org/10.1080/2159676X.2019.1683062

McCarthy, H. D., Cole, T. J., Fry, T., Jebb, S. A., & Prentice, A. M. (2006). Body fat reference curves for children. *Int J Obes (Lond), 30*(4), 598-602. https://doi.org/10.1038/sj.ijo.0803232

McCormick, R. (2017). Does Access to Green Space Impact the Mental Well-being of Children: A Systematic Review. *J Pediatr Nurs*, *37*, 3-7. https://doi.org/10.1016/j.pedn.2017.08.027

McGovern, J., Drewson, S. R., Hope, A., & Konopack, J. F. (2020). Gender Differences in a Youth Physical Activity Intervention: Movement Levels and Children's Perceptions. *American Journal of Health Education*, *51*(2), 109-119. https://doi.org/10.1080/19325037.2020.1712667

McLellan, G., Arthur, R., Donnelly, S., & Buchan, D. S. (2020). Segmented sedentary time and physical activity patterns throughout the week from wrist-worn ActiGraph GT3X+ accelerometers among children 7–12 years old. *Journal of Sport and Health Science*, *9*(2), 179-188. https://doi.org/https://doi.org/10.1016/j.jshs.2019.02.005

Mears, R., & Jago, R. (2016). Effectiveness of after-school interventions at increasing moderate-to-vigorous physical activity levels in 5- to 18-year olds: a systematic review and meta-analysis. *British Journal of Sports Medicine*, *50*, 1315 - 1324.

Miatke, A., Maher, C., Fraysse, F., Dumuid, D., & Olds, T. (2021). Are all MVPA minutes equal? Associations between MVPA characteristics, independent of duration, and childhood adiposity. *BMC Public Health*, *21*(1), 1321. https://doi.org/10.1186/s12889-021-11420-5

Mitchell, J. (2019). Physical Inactivity in Childhood from Preschool to Adolescence. *ACSMs Health Fit J*, *23*(5), 21-25. https://doi.org/10.1249/fit.0000000000000507

Nally, S., Carlin, A., Blackburn, N. E., Baird, J. S., Salmon, J., Murphy, M. H., & Gallagher, A. M. (2021). The Effectiveness of School-Based Interventions on Obesity-Related Behaviours in Primary School Children: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *Children (Basel, Switzerland)*, *8*(6), 489. https://doi.org/10.3390/children8060489

National Physical Activity Plan Alliance. (2018). *The 2018 United States Report Card on Physical Activity for Children and Youth*. Retrieved March 6 from https://paamovewithus.org/wp-content/uploads/2020/06/2018_USReportCard_UPDATE_12062018.pdf

Naylor, P.-J., Nettlefold, L., Race, D., Hoy, C., Ashe, M. C., Wharf Higgins, J., & McKay, H. A. (2015). Implementation of school based physical activity interventions: A systematic review. *Preventive Medicine*, *72*, 95-115. https://doi.org/https://doi.org/10.1016/j.ypmed.2014.12.034

Nijhof, S. L., Vinkers, C. H., van Geelen, S. M., Duijff, S. N., Achterberg, E. J. M., van der Net, J., . . . Lesscher, H. M. B. (2018). Healthy play, better coping: The importance of play for the development of children in health and disease. *Neurosci Biobehav Rev*, *95*, 421-429. https://doi.org/10.1016/j.neubiorev.2018.09.024

Nwizu, S. E., Njokanma, O. F., Okoromah, C. A., & David, N. A. (2011). Relationship between bioelectrical impedance analysis and body mass index in adolescent urban Nigerians. *West Afr J Med*, *30*(2), 99-103.

Oliveira, L. C., Ferrari, G. L. d. M., Araújo, T. L., & Matsudo, V. (2017). Overweight, obesity, steps, and moderate to vigorous physical activity in children. *Revista de saude publica*, *51*(0), 38-38. https://doi.org/10.1590/S1518-8787.2017051006771

Parrish, A.-M., Okely, A. D., Stanley, R. M., & Ridgers, N. D. (2013). The Effect of School Recess Interventions on Physical Activity. *Sports Medicine*, *43*(4), 287-299. https://doi.org/10.1007/s40279-013-0024-2

Parrish, A. M., Chong, K. H., Moriarty, A. L., Batterham, M., & Ridgers, N. D. (2020). Interventions to Change School Recess Activity Levels in Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Med*, *50*(12), 2145-2173. https://doi.org/10.1007/s40279-020-01347-z

Phillips, S. M., Summerbell, C., Hobbs, M., Hesketh, K. R., Saxena, S., Muir, C., & Hillier-Brown, F. C. (2021). A systematic review of the validity, reliability, and feasibility of measurement tools used to assess the physical activity and sedentary behaviour of pre-school aged children. *International Journal of Behavioral Nutrition and Physical Activity*, *18*(1), 141. https://doi.org/10.1186/s12966-021-01132-9

Podnar, H., Jurić, P., Karuc, J., Saez, M., Barceló, M. A., Radman, I., . . . Sorić, M. (2021). Comparative effectiveness of school-based interventions targeting physical activity, physical fitness or sedentary behaviour on obesity prevention in 6- to 12-year-old children: A systematic review and meta-analysis. *Obesity Reviews*, *22*(2), e13160. https://doi.org/https://doi.org/10.1111/obr.13160

Pulido-Sánchez, S., & Iglesias-Gallego, D. (2021). Evidence-Based Overview of Accelerometer-Measured Physical Activity during School Recess: An Updated Systematic Review. *International journal of environmental research and public health*, *18*(2). https://doi.org/10.3390/ijerph18020578

Pulido Sánchez, S., & Iglesias Gallego, D. (2021). Evidence-Based Overview of Accelerometer-Measured Physical Activity during School Recess: An Updated Systematic Review. *International journal of environmental research and public health*, *18*(2), 578. https://doi.org/10.3390/ijerph18020578

Ramstetter, C. L., & Murray, R. (2017). Time to Play: Recognizing the Benefits of Recess. *The American Educator*, *41*, 17.

Raney, M. A., Hendry, C. F., & Yee, S. A. (2019). Physical Activity and Social Behaviors of Urban Children in Green Playgrounds. *American Journal of Preventive Medicine*, *56*(4), 522-529. https://doi.org/https://doi.org/10.1016/j.amepre.2018.11.004

Razak, L. A., Yoong, S. L., Wiggers, J., Morgan, P. J., Jones, J., Finch, M., . . . Wolfenden, L. (2018). Impact of scheduling multiple outdoor free-play periods in childcare on child moderate-to-vigorous physical activity: a cluster randomised trial. *Int J Behav Nutr Phys Act*, *15*(1), 34. https://doi.org/10.1186/s12966-018-0665-5

Rhea, D. (2016). Recess: The forgotten classroom. *Instructional Leader Journal*, *29*, 2-6.

Rhea, D. J., & Rivchun, A. P. (2018). The LiiNK Project®: Effects of Multiple Recesses and Character Curriculum on Classroom Behaviors and Listening Skills in Grades K–2 Children [Original Research]. *Frontiers in Education*, *3*. https://doi.org/10.3389/feduc.2018.00009

Rogers, C. D., Richardson, M. R., & Churilla, J. R. (2022). Recess and Overweight and Obesity in Children 5-11 Years of Age: 2013-2016 National Health and Nutrition Examination Survey. *J Sch Health*, *92*(1), 63-70. https://doi.org/10.1111/josh.13105

Romieu, I., Dossus, L., Barquera, S., Blottière, H. M., Franks, P. W., Gunter, M., . . . Willett, W. C. (2017). Energy balance and obesity: what are the main drivers? *Cancer Causes Control*, *28*(3), 247-258. https://doi.org/10.1007/s10552-017-0869-z

Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *J Family Med Prim Care*, *4*(2), 187-192. https://doi.org/10.4103/2249-4863.154628

Sanyaolu, A., Okorie, C., Qi, X., Locke, J., & Rehman, S. (2019). Childhood and Adolescent Obesity in the United States: A Public Health Concern. *Global pediatric health*, *6*, 2333794X19891305-12333794X19891305. https://doi.org/10.1177/2333794X19891305

Sardinha, L. B., Santos, D. A., Silva, A. M., Grøntved, A., Andersen, L. B., & Ekelund, U. (2016). A Comparison between BMI, Waist Circumference, and Waist-To-Height Ratio for Identifying Cardio-Metabolic Risk in Children and Adolescents. *PLOS ONE*, *11*(2), e0149351. https://doi.org/10.1371/journal.pone.0149351

Sarwer, D. B., & Polonsky, H. M. (2016). The Psychosocial Burden of Obesity. *Endocrinology and metabolism clinics of North America*, *45*(3), 677-688. https://doi.org/10.1016/j.ecl.2016.04.016

Sijtsma, A., Sauer, P. J. J., & Corpeleijn, E. (2015). Parental correlations of physical activity and body mass index in young children- the GECKO Drenthe cohort. *International*

*Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 132. https://doi.org/10.1186/s12966-015-0295-0

Simmonds, M., Llewellyn, A., Owen, C. G., & Woolacott, N. (2016). Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. *Obesity Reviews*, *17*(2), 95-107. https://doi.org/https://doi.org/10.1111/obr.12334

Swift, D. L., Johannsen, N. M., Lavie, C. J., Earnest, C. P., & Church, T. S. (2014). The Role of Exercise and Physical Activity in Weight Loss and Maintenance. *Progress in Cardiovascular Diseases*, *56*(4), 441-447. https://doi.org/https://doi.org/10.1016/j.pcad.2013.09.012

Telford, R. M., Telford, R. D., Olive, L. S., Cochrane, T., & Davey, R. (2016). Why Are Girls Less Physically Active than Boys? Findings from the LOOK Longitudinal Study. *PLOS ONE*, *11*(3), e0150041-e0150041. https://doi.org/10.1371/journal.pone.0150041

Texas School Physical Activity and Nutrition Project. (2021). *Child Obesity in Texas*. Retrieved January 29, 2022 from https://sph.uth.edu/research/centers/dell/resources/texas%20span%20overview%206.3.2021.pdf

Tremblay, M. S., Gray, C., Babcock, S., Barnes, J., Bradstreet, C. C., Carr, D., . . . Brussoni, M. (2015). Position Statement on Active Outdoor Play. *International journal of environmental research and public health*, *12*(6), 6475-6505. https://doi.org/10.3390/ijerph120606475

Tremmel, M., Gerdtham, U.-G., Nilsson, P. M., & Saha, S. (2017). Economic Burden of Obesity: A Systematic Literature Review. *International Journal of Environmental Research and Public Health*, *14*(4), 435. https://www.mdpi.com/1660-4601/14/4/435

Truelove, S., Bruijns, B. A., Vanderloo, L. M., O'Brien, K. T., Johnson, A. M., & Tucker, P. (2018). Physical activity and sedentary time during childcare outdoor play sessions: A systematic review and meta-analysis. *Prev Med*, *108*, 74-85. https://doi.org/10.1016/j.ypmed.2017.12.022

van Dijk-Wesselius, J. E., Maas, J., Hovinga, D., van Vugt, M., & van den Berg, A. E. (2018). The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. *Landscape and Urban Planning*, *180*, 15-26. https://doi.org/https://doi.org/10.1016/j.landurbplan.2018.08.003

Vanderwall, C., Randall Clark, R., Eickhoff, J., & Carrel, A. L. (2017). BMI is a poor predictor of adiposity in young overweight and obese children. *BMC Pediatr*, *17*(1), 135. https://doi.org/10.1186/s12887-017-0891-z

Vaquero-Solís, M., Gallego, D. I., Tapia-Serrano, M. Á., Pulido, J. J., & Sánchez-Miguel, P. A. (2020). School-based Physical Activity Interventions in Children and Adolescents: A Systematic Review. *International journal of environmental research and public health*, *17*(3), 999. https://doi.org/10.3390/ijerph17030999

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: a systematic review and meta-analysis. *International Journal of*

*Behavioral Nutrition and Physical Activity*, *14*(1), 114. https://doi.org/10.1186/s12966-017-0569-9

World Health Organization. (2021). *Obesity and Overweight*. Retrieved 7/13 from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Yang, Y. J. (2019). An Overview of Current Physical Activity Recommendations in Primary Care. *Korean journal of family medicine*, *40*(3), 135-142. https://doi.org/10.4082/kjfm.19.0038

Yogman, M., Garner, A., Hutchinson, J., Hirsh-Pasek, K., Golinkoff, R. M., CHILD, C. O. P. A. O., . . . Smith, J. (2018). The Power of Play: A Pediatric Role in Enhancing Development in Young Children. *Pediatrics*, *142*(3). https://doi.org/10.1542/peds.2018-2058

Yuksel, H. S., Şahin, F. N., Maksimovic, N., Drid, P., & Bianco, A. (2020). School-Based Intervention Programs for Preventing Obesity and Promoting Physical Activity and Fitness: A Systematic Review. *Int J Environ Res Public Health*, *17*(1). https://doi.org/10.3390/ijerph17010347

Zemrani, B., Gehri, M., Masserey, E., Knob, C., & Pellaton, R. (2021). A hidden side of the COVID-19 pandemic in children: the double burden of undernutrition and overnutrition. *International Journal for Equity in Health*, *20*(1), 44. https://doi.org/10.1186/s12939-021-01390-w

**Appendices**

## Appendix A

## Recess Observation Form

Observer Name ______________________ Date: ____________ Time: _________

School _______________ Grade ______

Temp ________ Humidity ________ Cloud cover ________

**Size of play area (circle one)** Small Medium Large

**Part A**

- When the majority of children are on the playground, begin a timer on your phone (or note the start time on your watch/phone)
- At minute 1, estimate the number of children in each of the sections listed below. You do not need an exact count, just a rough estimate.
- Repeat the same process beginning at minute 7 and then again at minute 13.
- IF there is a popular area on the playground that is not listed below, please use the OTHER section. Additionally, please describe this area in the space provided
- Additionally, give a rough percentage estimate of the number of kids that are either active or sedentary. Use your best judgement when defining what exactly active and sedentary looks like (i.e. active could be swinging on the swings, running in the field, climbing on the playground, etc. Sedentary could include sitting/standing and socializing, playing in the sandbox, etc.)

**I. Blacktop (i.e. basketball court, parking lot, etc.**

☐ **Not available for this recess**

| **Time** | **# of children** | **% Active** | **% Sedentary** |
|---|---|---|---|
| **Minute 1** | | | |
| **Minute 7** | | | |
| **Minute 13** | | | |

**II. Equipment area (i.e. slides, bridges, monkey bars, etc.)**

- ☐ **Not available for this recess**

| **Time** | **# of children** | **% Active** | **% Sedentary** |
|---|---|---|---|
| **Minute 1** | | | |
| **Minute 7** | | | |
| **Minute 13** | | | |

**III. Field (i.e. open area – may or may not have equipment or moveable parts)**

☐ **Not available for this recess**

| Time | # of children | % Active | % Sedentary |
|---|---|---|---|
| Minute 1 | | | |
| Minute 7 | | | |
| Minute 13 | | | |

**IV. Swings**

☐ **Not available for this recess**

| Time | # of children | % Active | % Sedentary |
|---|---|---|---|
| Minute 1 | | | |
| Minute 7 | | | |
| Minute 13 | | | |

**V. Other 1:**

| Time | # of children | % Active | % Sedentary |
|---|---|---|---|
| Minute 1 | | | |

| | | | |
|---|---|---|---|
| **Minute 7** | | | |
| **Minute 13** | | | |

**VI. Other 2:**

| **Time** | **# of children** | **% Active** | **% Sedentary** |
|---|---|---|---|
| **Minute 1** | | | |
| **Minute 7** | | | |
| **Minute 13** | | | |

**Part B Instructions**

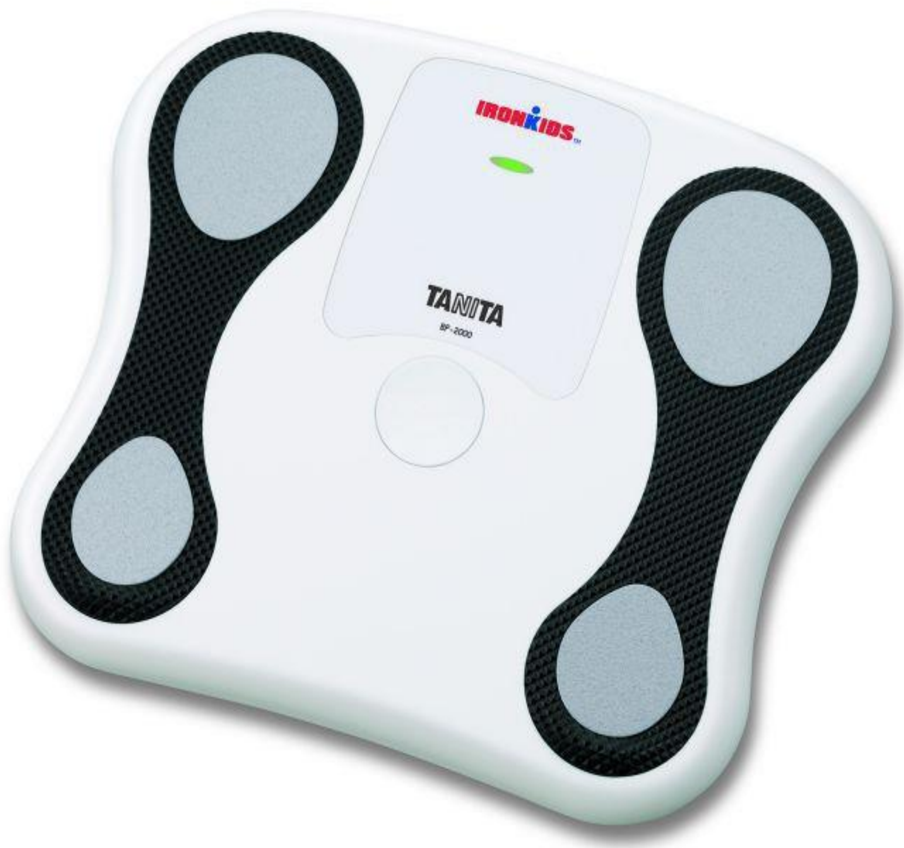
- Record general themes of what is being done within each area. Also note the sex of the children in the activities listed (i.e. on black top, group boys playing a game of tag or; in playground area, group of girls sitting in a circle underneath the slide talking)
- IF there is a popular area on the playground that is not listed below, please use the OTHER section. Additionally, please describe this area in the space provided

| **Location** | **Minute 1** | **Minute 7** | **Minute 13** |
|---|---|---|---|
| Blacktop (i.e. basketball court, parking lot, etc.)<br>☐ **Not available for this recess** | | | |
| Equipment area (i.e. slides, bridges, monkey bars, etc.)<br>☐ **Not available for this recess** | | | |
| Field (i.e. open area – may or may not have equipment or moveable parts)<br>☐ **Not available for this recess** | | | |
| Swings<br>☐ **Not available for this recess** | | | |

| | | | |
|---|---|---|---|
| | | | |
| Other 1: | | | |
| Other 2: | | | |

**Appendix B**

BIA Scale

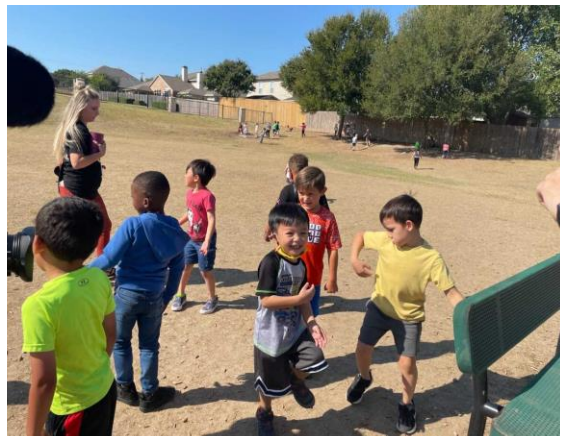


## Appendix C

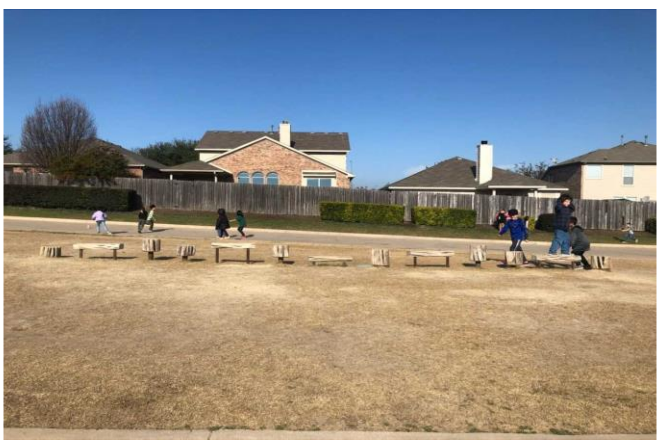
Playground Pictures

**Intervention school**

**Playground**

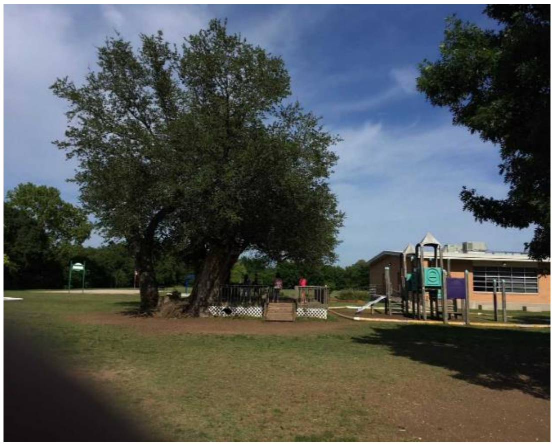


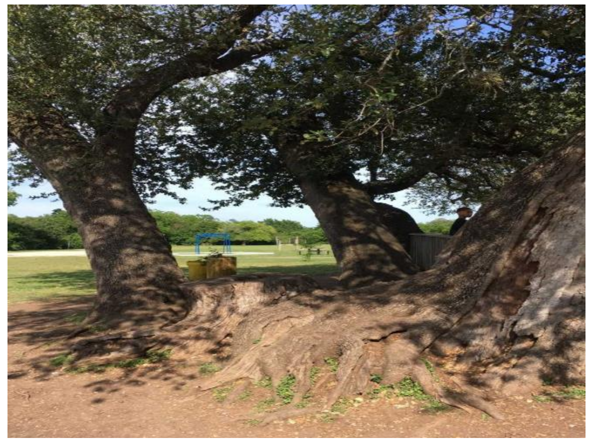
**Bus Loop**

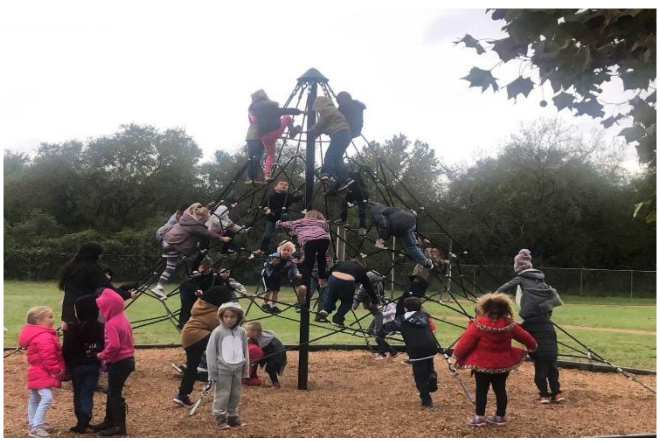


**Control Schools**

**Playground**







# David Farbo, M.S.
# Curriculum Vitae

**978-413-8311; d.farbo@tcu.edu**
**858 Golden Valley Ct., Burleson, TX, 76028**


---

## EDUCATION

| | |
|---|---|
| **Ph.D.** | Texas Christian University |
| *May 2022* | Health Sciences |
| | Dissertation Title: The effects of outdoor, unstructured play on physical activity and obesity in children. |
| **M.S.** | Texas Christian University |
| *May 2017* | Exercise Psychology |
| | Thesis Title: Creating healthier kids one step at a time: An exploratory study through LiiNK |
| **B.S**. | Bridgewater State University |
| *December 2014* | Physical Education, grades 5-12 certification |

---

## Professional Experience

**Research Associate**
*May 2017-Present*
The LiiNK Project (Let's Inspire Innovation 'N Kids)
Texas Christian University, Fort Worth, Texas.

## Teaching Experience

**Instructor of Record:**

**Texas Christian University**
*January 2021-Present*

- KINE 30343-Theory of Coaching
- KINE 40313-Individual and Dual Sports

August 2018-December 2020

- KINE 10101-Intro to Kinesiology

**Teaching Assistant:**

**Texas Christian University**
*August 2015-May 2017*

- PEAC 10721 Racquetball
- KINE 10603 Anatomical Kinesiology

- KINE 30523 Exercise Assessments & Prescription
- KINE 20313 Foundations of Sport Injuries
- KINE 30403 Motor Behavior
- KINE 20403 PHED For Elementary School Children
- KINE 40623 PHED For Secondary Youth

## Research Experience

**Graduate Research Assistant**
*August 2015-May 2017*
Department of Kinesiology, Texas Christian University, Fort Worth, Texas.
The LiiNK Project Director: Dr. Debbie Rhea

---

## RESEARCH GRANTS AND FUNDING

**External Grants**
**Unfunded:**

1. Shape America: Thomas L. Mckenzie Research Grant
   **Title:** Body composition of children with multiple recess daily
   Role: Principle Investigator
   Amount: $2,000
   *March 2021*

**Internal Grants**
**Funded:**

1. HCNHS Student Online Conference Grant Award *($300)*
   Texas Christian University, *February 2021*

2. HCNHS Student Travel Grant Award *($500)*
   Texas Christian University, *February 2020*

3. HCNHS Student Research Grant Award *($300)*
   Texas Christian University, *September 2019*

4. TCU Graduate Studies Travel Grant Award *($400)*
   Texas Christian University, *September 2018*

5. HCNHS Student Travel Grant Award *($500)*
   Texas Christian University, *September 2018*

6. HCNHS Research Grant Award *($500)*
   Texas Christian University, *February 2017*

7. HCNHS Student Travel Grant Award *($400)*
   Texas Christian University, *September 2016*

---

## RESEARCH PUBLICATIONS

1. **Farbo, D.,** & Rhea, D. (2022). The effects of a yearlong recess intervention on body fat shifts in elementary aged children. *The International Journal of Child Health and Nutrition*. **In Press**
2. **Farbo, D.,** & Rhea, D. (2021). A Pilot Study Examining Body Composition Classification Differences Between Body Mass Index and Bioelectrical Impedance Analysis in Children With High Levels of Physical Activity. *Frontiers in Pediatrics*, 9, 1304. https://www.frontiersin.org/article/10.3389/fped.2021.724053
3. **Farbo, D**., Maler, L. C., & Rhea, D. J. (2020). The Preliminary Effects of a Multi-Recess School Intervention: Using Accelerometers to Measure Physical Activity Patterns in Elementary Children. *International Journal of Environmental Research and Public Health*, *17*(23), 8919. https://doi.org/10.3390/ijerph17238919

---

## RESEARCH PRESENTATIONS

1. Rhea, D., **Farbo, D.,** & Campbell-Pierre, D. Outdoor playscapes make the difference for physical literacy. Health and Physical Literacy Summit, 2022, Birmingham, Alabama.
2. **Farbo, D.,** & Rhea, D. The effects of recess on physical activity patterns in elementary children. Health and Physical Literacy Summit, 2022, Birmingham, Alabama.
3. Rhea, D., **Farbo, D.**, & Moore, E. Engaging physical educators in assessing fitness differently. TAPHERD Convention, 2021, Arlington, Texas.
4. **Farbo, D.** & Rhea, D. Multi recess intervention effects on body composition in elementary school children. TAPHERD Convention, 2021, Arlington, Texas
5. Campbell-Pierre, D., & **Farbo, D.** The value of play is all in the design. U.S. Play Coalition Conference, 2021, Clemson, South Carolina.
6. **Farbo, D.,** Maler, L., & Rhea, D. J. The effects of a multi recess intervention on body composition in elementary school children. U.S. Play Coalition Conference, 2021, Clemson, South Carolina.
7. **Farbo, D.,** Maler, L., & Rhea, D. Determining obesity rates in children with multiple play breaks in school daily. U.S. Play Coalition Conference, 2020, Clemson, South Carolina.
8. Rhea, D. **Farbo, D.,** & Maler, L. Health disease trends in children: Is unstructured play reversing the trend? HCNHS Faculty Research Symposium, 2019, Fort Worth, Texas.
9. Rivchun, A**., Farbo, D.**, & Rhea, D. The effects of unstructured play on listening effort in elementary schools. U.S. Play Coalition Conference, 2019, Clemson, South Carolina
10. **Farbo, D.,** Rhea, D. & Clark, L. The effects of Play on overweight/obese children in elementary schools. U.S. Play Coalition Conference, 2019, Clemson, South Carolina
11. Rhea, D., **Farbo. D.,** & Clark, L. Children learning the value of play for like. U.S. Play Coalition Conference, 2019, Clemson, South Carolina
12. **Farbo, D.**, & Rhea, D. Creating healthier kids one step at a time: An exploratory

study through LiiNK. American School Health Association Conference, 2018, Indianapolis, Indiana.

13. Rhea, D.J., **Farbo, D.**, & Clark, L. The many faces of play: The many faces of children. U.S. Play Coalition Conference, 2018, Clemson, South Carolina
14. **Farbo, D.,** Clark, L., & Rhea, D. J. The LiiNK Project: Creating Healthier Kids One Step at Time. TAHPERD Convention, 2017, Fort Worth, Texas.
15. **Farbo, D.** The Effects of Play and Character on Physical Activity Levels and Emotional States of Elementary School Children. Texas Christian University – Student Research Symposium, 2017, Fort Worth, Texas.
16. **Farbo, D.** Creating healthier kids one step at a time: An exploratory study through LiiNK. Texas Christian University, HCNHS 3 Minute Thesis Competition, 2017, Fort Worth, Texas.

**Guest Lecturer:**

1. **Farbo, D.** How do we get both kids and adults active?
   HLTH 40203-Study of Human Disease, Texas Christian University, 2021, Fort Worth, Texas.

---

## HONORS AND AWARDS

**1. TCU Graduate Student Teaching Award**
Texas Christian University, *April 2022.*

**2. Recognized Exceptional Graduate Student**
Department of Kinesiology, Texas Christian University, *April 2017.*

**3. 3rd Place Student Research Symposium Presentation**
**Title:** Creating healthier kids one step at a time: An exploratory study through LiiNK
Harris College Student Research Symposium, Texas Christian University, *April 2017.*

**4. People's Choice Award**
**Title:** Creating healthier kids one step at a time: An exploratory study through LiiNK
TCU 3MT Competition, Texas Christian University, *March 2017.*

**5. People's Choice Award**
**Title:** Creating healthier kids one step at a time: An exploratory study through LiiNK
Harris College 3MT Competition, Texas Christian University, *March 2017.*

---

## PROFESSIONAL AFFILIATIONS

**AASP,** 2022-Present
**Shape America,** 2020-Present
**US PLAY Coalition,** *2016-Present*
**TAPHERD,** 2017-2018, 2021-Present

**Abstract**

The effects of outdoor, unstructured play on physical activity and obesity rates in children

By David Farbo, M.S.
Harris College of Nursing and Health Sciences
Texas Christian University

Dissertation Advisor: Dr. Debbie Rhea, Professor of Kinesiology, Director and Creator of the LiiNK Project

Obesity and inactivity in children are at all-time highs and have been steadily increasing over the last thirty years. The school environment provides the ideal setting to reach a large number of children across diverse populations to try to reverse these trends. However, there are many inconsistent results in school-based physical activity interventions due to implementation length, time for activity, and the use of structured physical activities. The LiiNK project is a whole child intervention addressing those gaps by providing children 60-minutes of outdoor, unstructured play each day that they are in school while control children receive 30-minutes. Previous physical activity data on LiiNK 1$^{st}$ and 2$^{nd}$ grade children has shown they will average more than 100-minutes of moderate to vigorous physical activity (MVPA) during the school day. Even with this increase in activity, prior data on body mass index (BMI) in LiiNK children has also shown inconsistent results. This raised the question whether BMI was the most accurate assessment in populations with high amounts of MVPA daily since it does not directly measure changes in body composition.

Our first study examined obesity classification differences between BMI and bio-electrical impedance analysis (BIA). We chose to use BIA over other body composition techniques since it directly measures body fat and has high specificity and sensitivity in

categorizing those who are obese. We found that there was about a 30% difference in how BMI and BIA categorized children into different obesity categories, with the biggest difference in overfat. Similar discrepancies were also seen in Studies 2 and 3. These results confirmed our prior suspicions that BMI may not be telling the whole story on the effects of the LiiNK project on childhood obesity.

This new measure was then used to examine changes in body composition among LiiNK intervention and control children in Studies 2 and 3. In Study 2, body composition was measured in $2^{nd}$-$5^{th}$ grade children finding $2^{nd}$ graders decreased obesity prevalence at a higher rate than other sub groups. This may have been a result of a daily increase in MVPA as demonstrated by prior LiiNK physical activity data, so in Study 3 we measured physical activity and body composition in $3^{rd}$ and $4^{th}$ grade children. We found that intervention $3^{rd}$ grade children with 60-minutes of recess had the highest MVPA minutes, which led to the greatest decrease in obesity prevalence. In addition, we found that physical activity decreased with age and that this may be due to differences in play preferences as children get older and by sex and race. Across both studies, we found lower obesity prevalence and body fat percentage in females and older children. Among older children, these results suggest there may be accumulative longitudinal effects from increased time for recess.

In conclusion, BMI should be used with caution when assessing body composition in populations with increased MVPA. More reliable measures such as BIA should be used to obtain more accurate results across all body fat categories. Additionally, outdoor, unstructured play is a reliable tool to increase physical activity and decrease obesity rates in children. Finally, 60-minutes of outdoor, unstructured play will allow children to experience the greatest improvements in physical activity and body composition.