AN ABSTRACT OF THE DISSERTATION OF

Evan Hilberg for the degree of Doctor of Philosophy in Kinesiology presented on June 7, 2019.

Title: Examining School-Day Physical Activity Opportunities and the Influence of Physical Activity at School on Weight Status in Rural Oregon Elementary School Children

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There is a known relationship between total physical activity (PA) and weight status in children; however, there is a paucity of data examining the prospective relationship between school day PA and obesity among rural elementary school children. A large number of cross-sectional studies have demonstrated that higher levels of PA are inversely associated with overweight and obesity in children. Longitudinal studies examining the prospective relationship between PA and weight status typically rely upon PA and weight data collected through the use of proxy measures (e.g., self-report), not objectively measured data. The majority of children spend around half of their waking hours in the school environment and as such, it is critical to understand how and when children are active at school. A review of school-based policies identified physical education (PE), classroom-based PA (CBPA), and recess as three of the primary intervention categories for increasing PA in children. It has been shown that rural children have greater odds of being obese and yet there is a lack information on how children in rural schools are accruing PA. The research presented in this dissertation narrows the identified research gaps about our understanding of the relationship between the rural school environment, PA, and children's weight status.

To address the first aim in this dissertation, we assessed the prospective relationship between baseline PA and future weight status in rural elementary school children. Objectively measured height and weight data were collected with pedometer data in 866 rural elementary school children. Linear models were used to evaluate the association between baseline PA and future BMI. Our results indicated that baseline BMI is the strongest predictor of future BMI whereas there is no association between baseline PA and future BMI after controlling for baseline BMI. This relationship did not vary by age, sex, or school.

To address the second aim, we quantified school-day activity levels during various PA opportunities (i.e. CBPA, recess, PE) and evaluated the relationship between PA opportunities and children's PA levels during the school day. Children from 1st, 3rd, and 5th grade were invited to participate and accelerometer data was collected on 230 children. Classroom schedules were provided by teachers and timestamped data from accelerometers were matched to the classroom schedules. Children accrued a mean of 27.5 minutes of moderate to vigorous PA (MVPA) during the school day and boys were more active than girls in our sample. We observed an interaction between PA domain and grade as the percentage of time in MVPA across domains varied by grade. Children were not meeting the recommended percentage of time in MVPA for PE or recess ($\geq$ 50%). Only 10% of time during CBPA opportunities was spent in MVPA.

Results from these studies suggest that baseline school day PA is not associated with future BMI and that baseline BMI is the best predictor of future BMI. PA patterns during school day PA opportunities varies by sex and grade with boys being more active than girls across all domains. Although results from this dissertation help fill in research gaps, additional exploration of 1) casual effects of weight change in rural elementary school children, and 2) identifying strategies to increase MVPA during the school day PA opportunities are warranted.

Examining School-Day Physical Activity Opportunities and the Influence of Physical Activity at School on Weight Status in Rural Oregon Elementary School Children

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Evan Hilberg, Author

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CHAPTER 1. INTRODUCTION

A substantial body of empirical evidence has demonstrated that physical activity (PA) is positively associated with an array of positive health outcomes among all age groups (Physical Activity Guidelines Committee, 2008). During 2008, the U.S. Department of Health and Humans Services (USDHHS) released the first evidence-based PA guidelines in an effort to promote public understanding of 1) the benefits of being physically active, and 2) the PA dosage required to achieve such benefits. In November of 2018, USDHHS released a second edition of the PA guidelines with updated evidence and recommendations; however, the recommendations for children and youth ages 6-17 remained unchanged from those outlined in previous guidelines released in 2008 (Physical Activity Guidelines Committee, 2008). Relationships discussed hereafter are in reference to data published based on the initial set of guidelines released in 2008. Of concern, objectively determined PA data from the National Health and Nutrition Examination Survey (NHANES; 2003-2004) indicated that only 42% of children aged 6-11 are meeting the recommendation of 60 minutes a day (Troiano et al., 2008). The proportion of boys meeting the recommendation was 48.9% whereas the proportion of girls was 34.7%. In general, the most recent objectively measured data on PA in the U.S. shows that boys are more active than girls and younger children are more active than older children (Troiano et al., 2008).

The inverse relationship between moderate-to-vigorous PA (MVPA) and age (i.e., decreasing levels of MVPA with increasing age) is typically accompanied by an increase in weight status (e.g., normal weight, overweight, obese) as children mature. Data from the 2015-2016 NHANES cycle indicate that 16.6% and 18.5% of children and adolescents aged 2-19 years are overweight and obese, respectively (NCHS; Fryar, Carroll, & Ogden, 2018). The prevalence of obesity in boys ages 6-11 years was 20.4% compared to similar ages of girls at 16.3%. These data also indicate that as children get older, they have an increase in weight status on average. The trend in weight status in children has seen a marked increase over the past 30 years as obesity rates increased 70% (10% to 17%) and extreme obesity rates (i.e. BMI $\geq 1.2 \times 95^{th}$ percentile) have nearly doubled (~3% to 5.8%; Ogden et al., 2016). Amongst children ages 6-11 years, the prevalence of overweight and obesity increased through 2008 and has since leveled off (Ogden et al., 2016).

Other studies have shown that there is a moderate to strong inverse relationship between PA levels and weight status (Jiménez-Pavón, Kelly, & Reilly, 2010; Kimm et al., 2005). There are also strong inverse relationships between MVPA levels and cardiometabolic biomarkers in children such as triglycerides, waist circumference, and insulin resistance (Ekelund et al., 2012). Additionally, it has been shown that obese children are around five times more likely to be obese in adulthood compared to non-obese children, which further highlights the importance of preventing children from reaching obesity (Simmonds, Llewellyn, Owen, & Woolacott, 2016). Beyond the general trends of higher prevalence of overweight and obesity in older children, rural children are 26% more likely to be obese than their urban counterparts (Johnson & Johnson, 2015). There is evidence that rural environments have less access to PA-related supports such as physical fitness facilities and membership sports and clubs which may contribute to the higher risk of overweight and obesity in these communities (Powell, Slater, Chaloupka, & Harper, 2006).

It is understood that many children spend approximately half of their waking day at schools and as such, the school environment serves an important role in promoting health behaviors (Guinhouya et al., 2009). There is considerable variability in children's activity patterns across school day segments and this can play a significant role in determining the total activity levels of children (Brusseau et al., 2011; Fairclough, Beighle, Erwin, & Ridgers, 2012; Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006). Children accumulate at least 70% of their daily MVPA during the school day and boys are more active than girls during most school-related PA opportunities (Guinhouya et al., 2009; Tudor-Locke et al., 2006). However, some research has reported that boys and girls accumulate similar amounts of PA during physical education (PE) opportunities, which present a primary opportunity for PA accrual during the school day (Brusseau et al., 2011; Tudor-Locke et al., 2006).

PHYSICAL ACTIVITY AND WEIGHT STATUS IN CHILDREN

Physical activity (PA) is an essential component of a healthy lifestyle for children and is important for chronic disease prevention, academic achievement, and quality of life (Ekelund et al., 2012; Poitras et al., 2016). Previous research has demonstrated that health outcomes such as body composition, cholesterol, blood pressure, insulin resistance, and other cardiovascular disease risk factors are inversely related with PA levels (Poitras et al., 2016). A large number of cross-sectional studies have explored the relationship between PA and weight status and have shown that higher levels of PA can be protective against increased weight status in children (Jiménez-Pavón et al., 2010). Longitudinal studies also have explored the relationship between PA and weight status and have shown similar results (Jiménez-Pavón et al., 2010; Kimm et al., 2005). One study has evaluated the prospective relationship between objectively-determined PA and weight status in school children and showed that higher levels of PA were associated with lower levels of obesity (White & Jago, 2012).

GLOBAL PHYSICAL ACTIVITY AND WEIGHT STATUS

Physical inactivity is a worldwide phenomenon and estimates from across the globe show that children are more active at younger ages and that boys are more active than girls across all ages (Cooper et al., 2015). Using accelerometer data from countries across the world, the average annual decline in PA per year in children is 4.2% when compared to a reference group of 5-year-old children. These same data indicated that only 9% of boys and 2% of girls were achieving the commonly recommended volume of at least 60 minutes of moderate-to-vigorous PA (MVPA) every day. The relationship between PA and weight status across these data show that children who are heavier are less active and that this relationship is more extreme in boys than in girls. Additionally, global weight status data indicates that mean BMI and the prevalence of obesity among children and adolescents has increased from 1975 to 2016 (Abarca-Gómez et al., 2017). These data also suggests that the increased mean BMI in high-income countries has leveled off since 2000.

NATIONAL PHYSICAL ACTIVITY AND WEIGHT STATUS

In the U.S., the Department of Health and Human Services released the first edition of the Physical Activity Guidelines for Americans in 2008 which recommends that children achieve at least 60 minutes a day of PA (HHS, 2008). The guidelines also recommend that the majority of those 60 minutes should be in in the form of MVPA and that vigorous PA should occur at least three times a week. Accelerometer data from the

2013-2014 NHANES cycle indicates that only 42% of children ages 6-11 are meeting the recommendation of 60 minutes of daily MVPA (Troiano et al., 2008). The proportion of boys meeting the recommendation was 48.9% whereas the proportion of girls was 34.7%. In general, data on PA in the U.S. show that boys are more active than girls and younger children are more active than older children (Troiano et al., 2008). Although estimates vary, it is clear that many children are not meeting current recommendations for daily PA.

Among 6 to 11 year-old children in the U.S., the prevalence of obesity in boys is 20.4% while the prevalence for girls is 16.3% (Fryar et al., 2018). It is well-known that children's body mass increases with age, thereby increasing the likelihood of overweight/obesity throughout childhood. Current data within the U.S. indicates that children 6-11 years old are 2.29 times more likely to be obese than 2-5-year-old children (Ogden et al., 2016). Research has shown that the trends for obesity prevalence in 6-11-year-old children steadily grew from 1988 to 2008 (Ogden et al., 2016). Although the current prevalence of overweight and obesity is high, the increase in prevalence appears to have flattened or declined over the past 10 years for those in this age group.

OREGON PHYSICAL ACTIVITY AND WEIGHT STATUS

PA behaviors for school children in Oregon have been understudied and there is a scarcity of data evaluating population levels of PA. School day PA data from rural elementary schools in Oregon indicated that boys were active (i.e., engaged in physical activity of at least light-intensity) for a total of 55 minutes a day and girls were active for a total of 46 minutes a day (Gunter, Nader, & John, 2015). Of those minutes, boys were engaged in MVPA for 19 minutes a day and girls were engaged in MVPA for 16.5

minutes a day. Previous research has shown that children who accrue 34 minutes of MVPA during the school day were likely to meet the recommendation of 60 minutes over the entire day (Guinhouya et al., 2009). As such, many in this sample of rural elementary school children in Oregon were likely not achieving daily PA recommendations (Gunter et al., 2015).

Although full day PA data is limited for elementary aged children in Oregon, self-report data among older children indicates that 57.5% of 8th graders are active for at least 60 minutes a day, 5 days a week (Oregon Public Health Division, 2012). The number of children meeting this threshold decreases to 44.3% by 11th grade. It has previously been noted that children tend to become less active as they get older, so we speculate that younger elementary age children would likely have a higher rate of compliance with this guideline. These data also suggest that children who are not overweight or obese have higher levels of PA independent of age (Oregon Public Health Division, 2012). Trends showing a decreased in PA as children age amongst Oregon school children are similar to those seen nationally and globally.

National samples of overweight and obesity prevalence (National Survey of Children's Health) have reported Oregon as having some of the lowest rates of overweight and obesity in the U.S. (Bethell, Simpson, Stumbo, Carle, & Gombojav, 2010). However, overweight and obesity estimates across the state of Oregon have varied widely depending on the data collection methodology and the geographic area in which data were collected, but have ranged from 9.6% to 38.1% (Gunter et al., 2015; Moreno, Johnson-Shelton, & Boles, 2013).

The aforementioned data highlight a widespread concern as children tend to accumulate less daily PA and experience less favorable body composition changes as they get older. In addition to the known relationships between PA, age, and weight status, there also exists relationships between rurality (rural vs. urban) and weight status. A systematic review evaluating the influence of rurality on overweight and obesity showed that rural children are 26% more likely to be obese than urban children (Johnson & Johnson, 2015). A single study within this review showed no differences in obesity between rural and urban children; however, that study only included 2 to 4-year-old children from low income households. All other studies within the review indicated that the prevalence of obesity in rural children was higher than that of urban children (Johnson & Johnson, 2015).

Data exploring the relationship between rurality and PA has shown heterogenous results in regard to children's PA levels. There is conflicting data with some studies suggesting urban children are more active and others suggesting that rural children are more active (Johnson & Johnson, 2015). Self-reported PA data from NHANES has shown that urban children are more active than rural children (Liu et al., 2012). Such findings are supported in results from the National Survey of Children's Health which indicated that urban children were significantly more likely to be physically active than rural children (Liu, Bennett, Harun, & Probst, 2008). Conversely, other research has demonstrated that rural children are more active than urban children from both small and large cities and the largest proportion of the observed difference was accounted for by less activity during lunch time at school (Joens-Matre et al., 2008). Moreover, these data also showed that urban children had less reported activity after school and during the evening, although the effect sizes were small. Research using objective measurements of PA have shown that rurality is supportive of MVPA in girls, but not boys (Moore, Beets, Morris, & Kolbe, 2014). Generally, the results of studies exploring the relationship between PA of rural and urban children tend to be heterogenous and often have small effect sizes (Moore et al., 2014; Sandercock, Angus, & Barton, 2010).

PHYSICAL ACTIVITY AND WEIGHT STATUS IN THE SCHOOL ENVIRONMENT

A report by the Institute of Medicine in 2012 titled "Accelerating Progress in Obesity Prevention: Solving the Weight of the Nation" laid out goals and recommendations to help address the nationwide epidemic of overweight and obesity (Institute of Medicine, 2012). Within this report, one of the goals was to have government entities work closely with communities and schools to make the school environment more accessible and effective for health promotion. As such, the school environment plays a critical role in the promotion of PA and other health behaviors. In particular, it may be difficult for children to accrue all of their PA outside of the school day because typical school day is 6-7 hours in duration, which represents approximately 50% of a child's waking day (Guinhouya et al., 2009; Office of Disease Prevention and Health Promotion, 2012).

The school environment has traditionally promoted PA through structured PE curriculums, recess and lunch time, after-school programs, and sports teams (Office of Disease Prevention and Health Promotion, 2012). There is an increasing interest in identifying effective interventions and policies to promote children's health through PA in the school environment (Morton, Atkin, Corder, Suhrcke, & van Sluijs, 2016). Prior research and policy efforts have focused primarily on PE opportunities, however, there are a variety of other opportunities during the school day where children can accumulate

PA (Bassett et al., 2013; Morton et al., 2016). Data on MVPA accrual within different school environment domains demonstrates that after PE (23 minutes), classroom-based PA (CBPA; 19 minutes), modified playgrounds (6 minutes), and modified recess (5 minutes) are all potential opportunities for promoting children's PA during the school day (Bassett et al., 2013).

There are a considerable number of cross-sectional studies exploring the relationship between PA and weight status in children, but there is a lack of longitudinal data (Jiménez-Pavón et al., 2010). Additionally, these longitudinal studies typically utilize subjective methods of PA assessment such as questionnaires (Kimm et al., 2005). A single study has evaluated the prospective relationship between adolescent girls' PA at age 12 and weight status at age 14 using objectively measured weight and PA data from a large cohort study (White & Jago, 2012). The findings from this multi-center study indicated a strong negative dose-response relationship between PA at age 12 and weight status at age 14. Children spend at least half of their waking hours at school and previous research has not identified the prospective relationship in rural children (Guinhouya et al., 2009). No studies to date have evaluated the prospective influence of objectively-determined school day PA on future weight status in rural elementary school children.

CHILDREN'S PHYSICAL ACTIVITY PATTERNS

It has been well documented that many children are not meeting current PA recommendations (Troiano et al., 2008). In order to reverse this trend, it is critical to understand when and where children accumulate PA and to identify opportunities for promoting PA. The most commonly identified PA opportunities among children are before school, after school, class time, PE, recess, lunch, evening, and weekends (Brooke, Atkin, Corder, Ekelund, & van Sluijs, 2016; Brooke, Corder, Atkin, & van Sluijs, 2014; Gao et al., 2017; Saint-Maurice et al., 2018).

Children appear to be more active on weekdays compared to weekends, and within weekdays total PA levels are higher outside of the school day compared to during the school day (Brooke et al., 2014). MVPA levels were slightly higher during the school day compared to non-school weekday time (Brooke et al., 2014; Saint-Maurice et al., 2018). Data also has shown that children accumulate greater volumes of MVPA on the weekend compared to weekdays (Brooke et al., 2014; Saint-Maurice et al., 2018). These data also show that boys are more active than girls during most PA opportunities, which is consistent with general PA trends seen across the globe (Brooke et al., 2016, 2014; Cooper et al., 2015; Saint-Maurice et al., 2018). Longitudinal data looking at changes in PA across opportunities in 10-14 year-olds indicated that as children get older, total PA and MVPA declined and showed greater declines on weekends and out of school time (Brooke et al., 2016). This further emphasizes the importance of maintaining and promoting PA opportunities during the school day given that children spend less time being active outside of school as they get older.

In general, children who are meeting current PA recommendations are more active across nearly all PA opportunities throughout the day when compared to those children not meeting current PA recommendations (Fairclough et al., 2012). We also have seen a general decrease in the number of children who are actively transporting to and from school over the last 25 years (Rothman, Macpherson, Ross, & Buliung, 2017; Sirard, Ainsworth, McIver, & Pate, 2005). Distance to schools was identified as the most strongly associated correlate to active transportation to school and children who live in rural areas generally live further away from schools (Gunter et al., 2015; Rothman et al., 2017). Consequently, long transport times and the inability to have active transportation to schools in rural settings reduces potential before and after school PA opportunities.

PHYSICAL ACTIVITY DURING THE SCHOOL DAY

Because the majority of children spend nearly half of their waking hours at school, the school environment serves a critical role in promoting and providing opportunities for PA and other important health behaviors (Guinhouya et al., 2009; Office of Disease Prevention and Health Promotion, 2012). There is also interest from an academic and policy perspective to optimize the school environment to increase PA and promote healthier children (Hatfield & Chomitz, 2015; Morton et al., 2016).

The Institute of Medicine of the National Academy of Sciences produced a recommendation for schools to provide at least 30 minutes of daily MVPA within regular school hours (National Academy of Sciences, 2013). Within the school day, there are multiple opportunities for children to accumulate PA; however, there continues to be pressure on schools to prioritize academics and standardized testing and many of these PA opportunities are being reduced or removed entirely (Pate et al., 2006). As such, there is a push for schools to support public health priorities and adopt comprehensive school PA programs (Hills, Dengel, & Lubans, 2015). The predominant school day opportunities for PA include class time, recess, PE, and lunch time (Brooke et al., 2014; Brusseau et al., 2011; Fairclough et al., 2012; Saint-Maurice et al., 2018; Tudor-Locke et al., 2006; Weaver et al., 2016).

Physical Education

PE has been a primary focus for enhancing children's PA during the school day (Pate et al., 2006). The Society of Health and Physical Educators (SHAPE; among other organizations) has recommended that elementary school children be offered at least 150 minutes of PE a week, while middle and high school students should be offered at least 225 minutes a week (SHAPE, 2016; National Academy of Sciences, 2013). These recommendations also state that at least 50% of PE class time should be spent in MVPA. It was reported in 2016 that 19 states had requirements for a certain volume of PE time to be offered by elementary schools, which was increased from 16 in 2012 (SHAPE, 2016). The 2016 Shape of the Nation report stated that only six states required the recommended 150 minutes a week of PE for elementary schools (SHAPE, 2016). Although the number of states mandating PE time and the number of states meeting guidelines have increased at the elementary school level over the past several years, the absolute values are still very low (SHAPE, 2016; Kahan & McKenzie, 2017).

The PE opportunities at school remain an important aspect of children's ability to accrue PA throughout the day. Data show that children accumulate more MVPA on school days where PE is offered compared to school days without scheduled PE (Weaver et al., 2016). A recent review of PE literature indicated that children spend 44.8% of PE lesson time in MVPA, which is higher than previously reported (Fairclough & Stratton, 2006; Hollis et al., 2016). There was significant heterogeneity among the included studies as the proportion of time spent in MVPA ranged from 11.4% to 88.5%. These differences could be attributed to the discrepant measurement techniques as several of the articles in the latest review utilized observational methods while others utilized accelerometers (Hollis et al., 2016). It has previously been shown that observational methods may overestimate the time children spend in MVPA (McClain, Abraham, Brusseau, & Tudor-Locke, 2008). Only one study has evaluated PE time for rural children and showed that children were engaged in MVPA for 27% of PE lesson time (Matthews-Ewald, Moore, Harris, Bradlyn, & Frost, 2013).

Recess

Recess time is not standardized, and the frequency and duration of recess time varies significantly from school-to-school. In addition, there are schools that utilize trained staff during recess time and implement specific recess curriculums such as Playworks (Bleeker, Beyler, James-Burdumy, & Fortson, 2015). Recent research has shown that Playworks is effective for increasing total PA time and vigorous PA during recess for girls but not for boys when compared to children participating in unstructured recess (Bleeker et al., 2015). Data also suggest that boys spend more time engaged in moderate PA than girls during unstructured recess time, which has been shown to be consistent across PA studies (Fairclough et al., 2012). A potential explanation for the discrepancy in activity levels between boys and girls across structured versus unstructured time is that girls of this age are more likely to spend time socializing while boys are more likely to engage in competitive games (Fairclough et al., 2012). Additional research has demonstrated that unstructured recess time accounted for 17 to 44% of total school-day step counts (Erwin et al., 2012).

Similar to PE class time, the Institute of Medicine recommended that children spend at least 50% of recess time in MVPA (National Academy of Sciences, 2013). However, results from studies published on recess time MVPA have indicated that there is heterogeneity in the proportion of recess time spent engaged in MVPA. A recent study showed that elementary aged children engaged in MVPA for 65% of recess time while other data showed that boys engaged in MVPA for 27.3% of their recess time compared to 16.7% among girls (Dessing et al., 2013). Highly active boys (upper 25th percentile for daily MVPA) spent 33.2% of recess time engaged in MVPA and highly active girls spent 25.3% of time engaged in MVPA, which is still well-under the recommended proportion of time spent in MVPA during recess (Weaver et al., 2016). These values were significantly lower for the low active (lower 25th percentile) boys and girls at 11.5% and 7.1%, respectively. It appears that children are not engaging in sufficient levels of MVPA during recess time during the school day.

Classroom-Based Physical Activity

CBPA is another primary PA opportunity during the school day and is considered to be one of the most cost-effective methods of promoting PA (Bassett et al., 2013). CBPA tools provide materials for classroom teachers to engage their children in short activity breaks before, during, or after their regularly scheduled class periods. A review of CBPA literature showed that CBPA opportunities had a positive effect on improving in-class behaviors and academic achievement but did not produce meaningful benefit in cognitive function or overall PA levels (Watson, Timperio, Brown, Best, & Hesketh, 2017). Longitudinal data from a subsample of children in a larger randomized-controlled trial on school-based PA showed that children who attended an intervention school (including a CBPA component) had 13% more PA than children in control schools (Donnelly et al., 2009). In rural elementary children, the implementation of CBPA increased total PA across the school day (Bershwinger & Brusseau, 2013). This study did not measure the specific time that was spent in MVPA, but rather compared full day PA before and after intervention. There is a severe lack of published data looking at how specific CBPA opportunities contribute to overall school day PA and how much MVPA children get from these opportunities.

PA levels within individual PA opportunities (e.g., PE, recess) have been explored in previous research in addition to out of school PA opportunities (e.g., weekend, after-school) to better understand when and how children are active (Brooke et al., 2014; Dessing et al., 2013; Weaver et al., 2016). Limited research has been done exploring these relationships in rural children who may experience PA opportunities differently compared to non-rural children (Bershwinger & Brusseau, 2013; Matthews-Ewald, Kelley, Moore, & Gurka, 2014). To date, no studies have explored the relationship between school-day PA opportunities (e.g., recess, PE, and CBPA) available during the school day and PA levels in rural elementary school children.

RESEARCH GAP

There are a considerable number of studies addressing the relationship between total PA and weight status in children; however, there is a paucity of data examining the prospective relationship between school day PA and obesity among rural elementary school children (Jiménez-Pavón et al., 2010; Must & Tybor, 2005). A large number of cross-sectional studies have demonstrated that higher levels of PA are inversely associated with overweight and obesity in children (Jiménez-Pavón et al., 2010). Longitudinal studies examining the prospective relationship between PA and weight status typically rely upon PA and weight data collected through the use of proxy measures (e.g., self-report), not objectively measured data. One study evaluated the prospective relationship between adolescent girls' PA at age 12 and weight status at age

14 using objectively measured weight and PA data from the Growth and Health Study cohort (White & Jago, 2012). Findings indicated a strong negative dose-response relationship between PA at age 12 and weight status at age 14. However, this study did not discriminate between different population segments (i.e., rural vs. urban dwellings) or environments where the PA may have been accrued (e.g., school day). No studies to date have evaluated the prospective influence of school day PA on future weight status in rural elementary school children.

A review of school-based policies identified physical education (PE), classroom-based PA (CBPA), and recess as three of the primary intervention categories for increasing PA in children (Bassett et al., 2013). There are several studies addressing PA accrued during different school day segments including recess, lunch time, and PE while utilizing objective PA measures (Dessing et al., 2013; Gao, Chen, Huang, Stodden, & Xiang, 2017; Saint-Maurice, Bai, Vazou, & Welk, 2018). Other studies have evaluated PA accrual during individual PA segments such as PE, recess, and CBPA (Bershwinger & Brusseau, 2013; Erwin et al., 2012; Hollis et al., 2016). It has been shown that rural children have greater odds of being obese, and yet there is a lack information on how children in rural schools are accruing their PA. No studies to date have evaluated objectively-determined PA accrual during different school day segments (PE, recess, and CBPA) in rural elementary school children to better understand opportunities for future PA promotion.

STUDY PURPOSE

To address the aforementioned literature gaps, the purpose of this study was to determine the influence of baseline school-day PA on weight status over time among rural elementary school children and to determine the amount and type (total PA, MVPA, etc.) of PA children engage in during the school day. Specifically, we examined how baseline PA levels in rural elementary school children are associated with weight status over a period of three years. Additionally, we quantified and described activity levels of children in various PA opportunities during the school day and examined how these PA levels varied as a function of child sex and age.

Specific Aim #1

To determine the relationship between rural children's PA at school and change in weight status over three school years.

Research Question #1

Does children's baseline PA at school predict change in weight status over three years?

We hypothesize that after adjusting for covariates such as grade, school, and baseline weight status, children with lower baseline PA at school will be more likely to be of a higher weight status over time.

Specific Aim #2

To quantify school-day activity levels during various PA opportunities (i.e. CBPA, recess, & PE) and to evaluate the percentage of time children are engaged in MVPA during each of the PA opportunities during the school day.

Research Question #2

How active are children during different PA opportunities in the school environment and does children's MVPA differ between opportunities?

We hypothesize that after adjusting for covariates such as grade, sex, school, teacher, BMI, and total time spent in each activity, time spent in MVPA will vary across PA opportunities.

CHAPTER 2. FIRST MANUSCRIPT

Evaluating the Prospective Relationship Between Physical Activity and BMI in Rural Elementary School Children

ABSTRACT

BACKGROUND: Physical activity (PA) is an essential component of a healthy lifestyle for children and is important for chronic disease prevention, academic achievement, and quality of life. Children spend approximately 50% of their waking time at school, schools are a critical setting to accrue PA. There is a well-established cross-sectional relationship between weight status and PA in children; however, there is a lack of prospective evidence of this relationship. To address this gap, we evaluated the prospective relationship between physical activity at school and weight status in rural Oregon elementary school children.

METHODS: PA and weight status data from 2013 and 2015 from six rural elementary schools within three geographically diverse Oregon counties were collected (n = 866). Children's school-day PA levels were measured utilizing pedometers and height and weight measurements were objectively recorded to calculate BMI. Linear regression was used to examine the association between baseline PA levels and future BMI.

RESULTS: After accounting for factors such as sex, age, school, and baseline BMI, there was no significant association between PA and future BMI in our sample ($p>0.05$). Age was a significant predictor of future BMI and showed that as children get older, they also tend to have higher BMI z-scores ($p <0.01$). Baseline BMI z-score was also significantly associated with future BMI z-score ($p <0.001$).

CONCLUSION: Baseline PA was not predictive of future BMI when accounting for baseline BMI in our sample. This indicates that current levels of school-day PA are not predictive of future BMI in rural Oregon elementary school children and that baseline BMI may be the most important predictor of future BMI.

INTRODUCTION

Physical activity (PA) is an essential component of a healthy lifestyle for children and is important for chronic disease prevention, promotion of academic achievement, and quality of life (Ekelund et al., 2012; Poitras et al., 2016). Previous research has shown that important health outcomes such as body composition, cholesterol, blood pressure, insulin resistance, and other cardiovascular disease risk markers are inversely related with PA levels (Poitras et al., 2016). A large number of cross-sectional studies have explored the relationship between PA and weight status and have shown that higher levels of PA can be protective of increased weight status in children (Jiménez-Pavón et al., 2010). Longitudinal studies also have explored the relationship between PA and weight status and have shown similar results (Jiménez-Pavón et al., 2010; Kimm et al., 2005). One study evaluated the prospective relationship between objectively-determined PA and weight status in school children and showed that higher levels of PA were associated with lower levels of obesity (White & Jago, 2012).

More than 95% of children are enrolled in schools, and a typical school day is six to seven hours in duration, which represents approximately 50% of a child's waking day (Guinhouya et al., 2009; Office of Disease Prevention and Health Promotion, 2012). As such, the school day serves as a critical environment for promoting and providing opportunities for PA and other health behaviors. There is also interest from an academic and policy perspective to optimize the school environment to increase PA and promote healthier children (Hatfield & Chomitz, 2015; Morton et al., 2016).

A systematic review examining the relationship between rurality and weight status showed that rural children are 26% more likely to be obese than urban children

(Johnson & Johnson, 2015). Only one study within this review showed no differences between rural and urban children. That study only included very young children from low income households, and all other studies within the review indicated a higher prevalence of obesity in rural children compared to urban children (Johnson & Johnson, 2015). Given the higher obesity levels among rural children and the positive influence of PA on weight status, it may be particularly important to promote PA among rural children and better understand the relationship between these factors.

Although there is substantial cross-sectional literature evaluating the relationship between PA and weight status in children, there is a lack of prospective data exploring the relationship between school-day PA and weight status in children (Jiménez-Pavón et al., 2010). Additionally, these longitudinal studies typically utilize subjective methods of PA assessment such as questionnaires, which typically overestimate PA levels (Kimm et al., 2005). A single study has evaluated the prospective relationship between adolescent girls' PA at age 12 and weight status at age 14 using objectively measured weight and accelerometer-derived PA (White & Jago, 2012). The findings from this study suggest that a negative dose-response relationship between PA at age 12 and weight status at age 14 exists.

PA at school may be particularly important for rural children as they tend to have longer distances from homes to schools and this requires long bus commutes and acts as a barrier to active transportation to schools. These factors reduce potential before and after school PA opportunities for children in rural areas that have been identified in previous literature (Gunter et al., 2015; Rothman et al., 2017). No studies to date have evaluated the prospective influence of objectively-determined school day PA on future weight status in rural elementary school children, who are at higher risk of overweight and obesity. Therefore, the purpose of the current study was to investigate the prospective relationship between baseline PA and future BMI among rural school-age children while accounting for individual factors such as age, sex, school, and baseline BMI.

METHODS

Study Setting

To evaluate the prospective relationship between children's PA levels and future weight status, we utilized data collected from a larger study, Generating Rural Options for Weight-Healthy Kids and Communities (GROW HKC). GROW HKC was a multi-level project funded by the USDA in which there were two primary objectives. The aims of this smaller study are nested within the second objective of GROW HKC: to plan, implement, and evaluate a multi-level intervention, targeting rural homes, schools, and communities while promoting healthy eating and increases in PA, with the main purpose to improve BMI among rural children in Oregon.

To assess the first aim in the current study, PA and weight status data from 2013 and 2015 from six rural elementary schools within three geographically diverse Oregon counties was used. GROW HKC defined rural as an area having a population of less than 10,000 people. PA data were collected on children during the school day, including step counts, total activity time, and activity time in different intensity levels. Children in grades 1-6 from each school wore a Walk4Life pedometer (Walk4Life, Plainfield, IL) for the duration of four school days. Previous PA assessment research has shown that as few as two days of PA data are sufficient and can yield reliable estimates of steps per day (Craig, Tudor-Locke, Cragg, & Cameron, 2010).

Child Recruitment

Every child attending each of the involved schools was invited to participate in all height and weight assessments as well as PA assessments. Children were given the option to opt-out of these assessments at the time of data collection, and parents received opt-out forms two weeks prior to the initial data collection. This recruitment method was utilized for each data collection period. Schools provided the information on which children were opted out via their sex and date of birth and these children were subsequently excluded from data collection. Children who opted-out had their data destroyed and were not included in any analyses.

Human Subjects Research Protocol

All protocols and procedures were approved by the Oregon State University (OSU) Institutional Review Board. Children were recruited through the aforementioned opt-out process. Those children who opted out were not included in any data analyses. All data from the collection periods are stored on a password protected university drive and are only accessible to approved study staff members.

Height and Weight Data

To evaluate changes in weight status over time, children's height and weight were directly measured at two time points each year during data collection. The protocol for height and weight measurements within the GROW HKC project has been described in detail previously (Gunter et al., 2015). Briefly, standing height (to nearest 1 mm) and body weight (to nearest 0.1 kg) were measured in stocking feet using a stadiometer and calibrated digital scale. BMI z-scores were derived from CDC cutoffs and were used to create age- and sex-specific percentiles to establish weight status categories (normal, overweight, obese; Centers for Disease Control and Prevention, 2018). Normal weight was defined as 5th to <85th percentile, overweight was defined as 85th to < 95th percentile, and obese was defined as greater than 95th percentile.

Physical Activity Device Settings

The Walk4Life pedometer utilized in the current study is a research-grade ambulatory measurement device (Beets, Patton, & Edwards, 2005; Erwin et al., 2012; Saunders et al., 2014). The pedometer is capable of measuring stepping volume and the amount of total time spent in different intensities of activity. The pedometer allows users to define a steps per minute threshold to estimate time spent in light, moderate, and vigorous PA (Beets et al., 2005). Data suggest that stepping rates exceeding 120 steps per minute among children qualify as moderate-to-vigorous PA (MVPA) and as such, we utilized a minimum step rate of 120 steps per minute as our MVPA threshold (Morgan, Tsuchida, Beets, Hetzler, & Stickley, 2015). In addition to the steps per minute threshold, a 4-step buffer was configured on the pedometer to mitigate the effect of incidental movements not associated with free-living PA behaviors. These settings were utilized at each PA data collection time point.

Device Preparation & Transportation

Appendix A was included in each box of devices delivered to classrooms which explained in detail the instructions for distributing, placing, and collecting the devices from children. Each device had a unique identifier, and devices were attached to an elastic belt for children to wear. Devices were worn on the children's right hip in line with the mid-axillary line for the duration of the school day. The devices were securely packed in the boxes prior to classroom delivery and returned to the same box at the end of the school day. After data was collected from the device, the devices were repackaged into boxes for the next day's data collection. The configured settings on the pedometers (e.g., step count threshold, buffer) were also double-checked to ensure consistency across the data collection days.

A dummy pedometer was included in each box to track activity that was recorded by the devices during transportation to and from the research locations. The values from each of these devices were recorded each day and were subtracted from the total PA for each child in that classroom.

Data Cleaning and Preparation

Pedometer data were downloaded and recorded in a spreadsheet at the end of each week of data collection by two trained research staff to minimize transcription errors. Total step counts, total minutes of activity time, and total minutes of MVPA time were recorded. Total activity and MVPA time were rounded to the nearest whole minute. In addition to the raw pedometer data, we tracked the number of days that children wore the pedometer using information provided on the attendance sheet given to each teacher. Average PA measures were computed using the number of days of attendance and the raw pedometer data for each child. Daily wear time was computed using the total wear time from classroom schedules and the number of days of attendance. Previous research has indicated that accruing less than 500 steps per day or more than 15,000 steps per day in the school setting should be considered as outliers. As such, we used these thresholds when cleaning the data (Kang & Brinthaupt, 2009).

Analyses

To determine the relationship between children's PA at school and change in weight status over three school years, we used PA data collected in the fall of 2013 and weight status data collected in the fall of 2013 and the spring of 2015.

Descriptive statistics were used to understand the sample distributions of PA outcomes and weight status across different ages and by child sex. To evaluate the prospective influence of PA on weight status, ordinary least squares (OLS) regression was used. Child BMI z-score was used as the response variable and was modeled against baseline PA (steps per week) as the primary predictor while covarying for baseline BMI z-score, grade, sex, and school. If covariates were non-significant as identified with a p-value > 0.05, they were removed from the model. Potential interactions between PA, sex, and grade were explored to determine if the influence of PA on future weight status differs by grade and/or sex. This model building process also was completed separately using minutes of MVPA as the primary predictor.

Model fit for OLS regression was evaluated using analysis of variance, and statistical significance was set at $\alpha = 0.05$. We hypothesized that children with lower baseline PA would be more likely to increase their weight status over time. All analyses were run using R version 3.5.1.

RESULTS

Descriptive Statistics

The final sample in this study included 866 children (55% boys) across six elementary schools in rural Oregon. Table 1.1 summarizes the physical activity and weight status variables across children in the study. The average steps per day for all children in the sample was 5225, with boys being more active than girls (5705 and 4642 steps per day, respectively). Older children tended to be less active than younger children at baseline.

Approximately 60% of children in our sample were normal weight whereas 39% were overweight or obese (18% and 21%, respectively). Amongst girls, 63% were normal weight and 36% were overweight or obese. The boys in our sample tended to be heavier on average than girls, with 19% being overweight and 23% being obese.

Table 1.1- Descriptive Summary of Rural Elementary School Children Participants by Sex

Variables	Boys* (n = 475, 55%)	Girls* (n = 391, 45%)
Height (m)*	1.4 (0.1)	1.4 (0.1)
Weight (kg)*	40.4 (13.0)	40.4 (13.8)
Normal Weight (%)	56.4	63.4
Overweight (%)	22.7	17.9
Obese (%)	18.9	17.9
Steps Per Day*	5704 (2026)	4642 (1518)
Total Activity (minutes)*	55.8 (24.4)	45.2 (19.4)
MVPA[a] (minutes)*	21.1 (9.5)	18.0 (6.7)

[a]Moderate to vigorous physical activity
*Data are presented as mean (standard deviation)

Associative Models

An ordinary least squares linear model was used to associate baseline physical activity with future BMI z-scores. Several covariates were included in the linear models including baseline BMI z-scores, sex, age, and school. Child sex and school were introduced into the model but did not reach statistical significance and therefore were not included in future models. Potential interactions were also explored between baseline PA and age as well as baseline PA and sex. Interaction terms in these models were not significant and therefore are not included in the results.

Model 1 was fit to determine if there was any association between average steps per week at baseline and future BMI z-score (Table 1.2). The results from this model indicate that more active children would have lower BMI z-scores in the future (-0.04, 95% CI -0.004, -0.08). The addition of age into the model showed that independent of physical activity, children's BMI z-scores will increase with age over time (0.06, 95% CI 0.01, 0.11). When baseline BMI z-score is included in the model as a covariate, the relationship between baseline PA and future BMI z-score is no longer statistically significant. Based on this, it appears that baseline BMI z-score is the strongest predictor of future BMI z-score whereas baseline PA is not a significant predictor of future BMI z-score.

Table 1.2- Summary of Linear Regression: Association of Baseline PA[a] and Endpoint BMI[b]

	Model 1- ß (95% CI)	Model 2- ß (95% CI)	Model 3- ß (95% CI)	Model 4- ß (95% CI)	Model 5- ß (95% CI)
Steps Per Day	-0.04 (-0.004, -0.08)*	-0.03 (-0.001, -0.07)*	-0.05 (-0.01, -0.08)*	0.006 (-0.01, 0.02)	0.001 (-0.01, 0.02)
Age		0.06 (0.01, 0.11)*	0.06 (0.01, 0.11)*	0.03 (0.01, 0.05)**	0.02 (0.004, 0.04)*
Sex			-0.13 (-0.27, 0.02)	0.04 (-0.01, 0.10)	0.04 (-0.01, 0.09)
Baseline BMI				0.97 (0.95, 1.0)***	0.97 (0.95, 1.0)***
School- CKE					-0.03 (-0.14, 0.08)
School- CQE					-0.03 (-0.17, 0.10)
School- CRE					-0.11 (-0.21, -0.02)*
School- HPE					-0.09 (-0.19, 0.01)
School- MES					-0.14 (-0.25, -03.)*

*p < 0.05, **p <0.01, ***p<0.001 ^Interaction term
[a] Physical activity
[b] Body Mass Index
1. Unadjusted Model
2. Model 1 + Age
3. Model 2 + Child Sex
4. Model 3 + Baseline BMI
5. Model 4 + School

In unreported data analyses, the models in Table 1.2 were also tested utilizing MVPA and total activity time as the response variable and the same patterns of results were identified. Baseline BMI z-score was the strongest predictor of future BMI z-score and MVPA and total activity time were not independently associated with future BMI.

DISCUSSION

Although work has been done to associate physical activity with future weight status, the relationship between school-day physical activity and future weight status has not been examined within the context of the rural environment. Understanding this relationship may provide support to schools to enhance their physical activity opportunities and combat rising weight status in children with effective promotion and programming. We evaluated this relationship in the presence of several important covariates such as age, sex, school, and baseline BMI. We hypothesized that after controlling for the aforementioned covariates, children's baseline PA levels would predict future weight status in rural elementary school children.

Our initial attempt at assessing this relationship found that higher PA levels at baseline accounted for lower weight status over a period of two school years in these children. However, when considering baseline BMI in our analyses, it appears that PA levels did not have predictive value for future BMI and that changes in BMI were primarily accounted for based on the children's initial BMI. We also found that as children get older, they were more likely to be heavier independent of PA levels. In our sample, we also found that the influence of baseline PA on future BMI varied by school. This may warrant additional investigation as to which factors within the school environments are affecting changes in weight independent of the factors we have explored. We also found that this relationship did not vary by child sex in our sample.

Our findings are conflicting with the scarce existing research on this topic examining the prospective relationship between daily PA and future weight status in children (White 2012). Previous research has shown that a negative dose-response relationship may exist between PA and weight status in a sample of 12 to 14-year-old girls. However, these data were collected on only on girls from ages 12 to 14 and included full-day PA measurements. This relationship was found to have racial differences and was only identified in the Caucasian girls in the sample. Similar to our results, other literature has shown that baseline PA does not predict future change in BMI over a period of three years in 5 to 10-year old children who were overweight or obese (Trinh 2013).

Our results indicate that PA levels during the school-day are not significantly associated with weight status over time in rural elementary school children. This finding suggests it would be important to understand the full context of these children's PA behaviors and to understand if these children are active outside of the school environment. Moreover, other factors may be critical in curbing future weight gain in these children such as dietary intake, access to PA opportunities, and enhancing existing PA opportunities. It would also be important to understand the full context of these children's PA behaviors and to understand if these children are active outside of the school environment. In spite of this limitation, the results from the current study indicate that school-day PA is not sufficient at preventing future weight gain on its own. This was the first study to prospectively evaluate the relationship between school-day PA and weight status in rural elementary school children and adds to the extant literature that suggests that BMI is difficult to change within the school environment and also proves challenging to influence over time.

Limitations

This study is limited by several factors. A primary limitation to this study is that only school-day physical activity data were collected and considered in the models. For logistical reasons, we were unable to capture PA behaviors before and after school or on the weekends. Data surrounding rural children's activity patterns during these other time periods are sparse, so it is difficult to know how this might affect the results. Another major limitation is our lack of data on other factors that influence weight status, specifically dietary intake and family-level factors (e.g., food insecurity and parental behaviors). Additionally, the pedometers used in this study may have been modified by children during wear time without the researchers' knowledge.

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CHAPTER 3. SECOND MANUSCRIPT

Evaluating Physical Activity Opportunities During the School Day in Rural Elementary School Children

ABSTRACT

BACKGROUND: The majority of children in the US are not meeting daily physical activity (PA) recommendations. Children spend approximately half of their waking hours in the school environment and therefore schools are a critical setting for PA opportunities. The purpose of this study was to understand activity patterns of rural elementary school children during the school day within recess, physical education (PE), and classroom-based PA (CBPA).

METHODS: Accelerometers were used to monitor 1st, 3rd, and 5th grade children's PA levels at school over four consecutive days in six elementary schools in rural Oregon (n= 230). Teachers provided details of PA opportunities children experienced over the 4-day assessment period in the form of classroom schedules. Linear mixed models were used to associate PA opportunities with children's moderate to vigorous PA (MVPA) behaviors, controlling for child sex, grade, BMI, and exposure to PA.

RESULTS: Children spend a higher percentage of time in MVPA during recess and PE (19.5% and 18.2%) compared to CBPA (10.5%; $p<0.001$). Additionally, boys spent a higher percentage of time in MVPA compared to girls ($p<0.001$). There was a significant interaction between PA domain and grade, as the difference in percentage of time spent in MVPA in each domain varied depending on grade level.

CONCLUSION: Children accrue MVPA differently across the different domains of PA during the school day and this varies by grade level. Boys accumulate higher percentages of time in MVPA across all domains. Schools may be able to increase PA during the school day by optimizing currently existing PA opportunities.

INTRODUCTION

It has been well documented that many children are not meeting current physical activity (PA) guidelines recommending the accrual of at least 60 minutes per day of mostly moderate to vigorous PA (MVPA; Troiano et al., 2008). To reverse this trend, it is critical to understand when and where children accumulate PA and to identify opportunities for optimizing and promoting PA in the school environment. The most commonly identified PA opportunities among children are before school, after school, class time, PE, recess, lunch, evening, and weekends (Brooke et al., 2016, 2014; Gao et al., 2017; Saint-Maurice et al., 2018).

Longitudinal data looking at changes in PA across opportunities in 10-14 year-olds indicated that as children get older, total PA and MVPA declined and showed greater declines on weekends and out of school time (Brooke et al., 2016). This finding further emphasizes the importance of maintaining and promoting PA opportunities during the school day as we know that children spend less time being active outside of school as they get older.

Nearly all children are enrolled in schools; a standard school day lasts six to seven hours, which accounts for nearly half of a child's waking hours during the day (Guinhouya et al., 2009; Office of Disease Prevention and Health Promotion, 2012). Because of this, schools serve as important environments for providing PA opportunities and promoting other health behaviors. Accruing PA during school hours may be particularly important for rural children who face additional barriers to engaging in PA outside of school such as long bus commutes, and the inability to have active transportation to schools in rural settings (Gunter et al., 2015; Rothman et al., 2017).

The Institute of Medicine of the National Academy of Sciences has produced a recommendation for schools to provide at least 30 minutes of MVPA within regular school hours (National Academy of Sciences, 2013). Within the school day, there are multiple opportunities for children to accumulate PA such as class time, recess, PE, and lunch time (Brooke et al., 2014; Brusseau et al., 2011; Fairclough et al., 2012; Saint-Maurice et al., 2018; Tudor-Locke et al., 2006; Weaver et al., 2016). However, there is additional pressure on schools to spend more time and resources on academics and standardized testing. As a result, many of these PA opportunities are being reduced or removed entirely (Pate et al., 2006).

Specific Aim #2

To quantify school-day activity levels during various PA opportunities that schools provide for their students during regular school hours, and to evaluate the relationship between PA opportunities and children's PA levels during the school day.

Research Question #2

How active are children during different PA opportunities in the school environment and does children's PA differ between opportunities?

We hypothesized that after adjusting for covariates such as grade, school, teacher, child BMI, and total time spent in each activity, time spent in MVPA will vary across PA opportunities.

METHODS

To evaluate children's PA levels during the school day, we utilized data collected from a larger study, Generating Rural Options for Weight-Healthy Kids and Communities (GROW HKC). GROW HKC was a multi-level project funded by the USDA in which there were two primary objectives. The aims of this smaller study are nested within the second objective of GROW HKC: to plan, implement, and evaluate a multi-level intervention, targeting rural homes, schools, and communities while promoting healthy eating and increases in PA, with the main purpose to improve BMI among rural children in Oregon.

To assess the aim of this study, PA data (fall 2015) collected with accelerometers at six elementary schools in Oregon were utilized. Classroom schedules were collected from teachers participating in the study and were used to match the time-stamped accelerometer data to the PA opportunities offered during regular school hours to understand when children were active during the school day.

Child Recruitment

Every child in grades 1, 3, and 5 attending each of the involved schools was invited to participate in the accelerometer PA assessments. As part of GROW HKC, height and weight data were also collected at this time. Children were given the choice to opt-out of these assessments at the time of data collection, and parents received opt-out forms two weeks prior to the initial data collection. Schools provided the information on which children were opted out via their sex and date of birth and these children were subsequently excluded from data collection. If they participated in the data collection process, their data were destroyed and not included in any analyses.

Human Subjects Research Protocol

All protocols and procedures were approved by the Oregon State University (OSU) Institutional Review Board. Children were recruited through the aforementioned opt-out process. Those children who opted out were not included in any data analyses. All data from the collection periods are stored on a password protected university drive and are only accessible to approved study staff members.

Height and Weight Data

Height and weight data were collected twice annually in the larger GROW HKC study to evaluate changes in weight status over time. Weight status data were utilized as variables of interest in the current study. The protocol for height and weight assessments within the GROW HKC project has been described in detail previously (Gunter et al., 2015). Briefly, standing height (to nearest 1 mm) and body weight (to nearest 0.1 kg) were measured in stocking feet using a stadiometer and calibrated digital scale. BMI z-scores were derived from CDC cutoffs and were used to create age and sex specific percentiles to establish weight status categories (normal, overweight, obese; Centers for Disease Control and Prevention, 2018).

Physical Activity Device Settings

ActiGraph GT3X (ActiLife, Pensacola, FL) accelerometers were utilized in the current study. The accelerometers were initialized prior to the first day of data collection to ensure that they were collecting data for the duration of each data collection week and the accelerometers were set to collect data in 15-second epochs at a sampling frequency of 30hz.

Device Preparation & Transportation

Appendix A was included in each box of devices delivered to classrooms which explained in detail the instructions for distributing, placing, and collecting the devices from children. Each device had a unique identifier, and devices were attached to an elastic belt for children to wear. Devices were worn on the children's right hip at the midaxillary line for the duration of the school day. The devices were securely packed in the boxes prior to delivery to classrooms and returned to the same box at the end of the school day. Accelerometers were initialized prior to the first day of data collection to record data for the duration of the week.

Data Cleaning and Preparation

Accelerometer data were downloaded from the devices and processed with Evenson cut-points to generate a daily average for PA outcomes such as total, light, moderate, vigorous, and moderate-to-vigorous PA time (Evenson et. al., 2008). Teachers were asked to provide detailed class schedules for the week of data collection from which we created variables indicating the time frames of the following potential school-day PA opportunities during the school day: recess sessions, PE sessions, and CBPA sessions. The lunch hour is comprised of a period of eating and a period of recess; however, these activities were not delineated on the classroom schedules and appeared only as lunch in the data provided by teachers. A non-trivial amount of recess time that is embedded within the lunch hour was not included in these analyses. Reference to the recess domain hereafter refers only to recess time that was provided outside of the lunch hour. After completing data cleaning, the accelerometer and class schedule variables were merged with important participant identifiers and covariates of interest.

Analyses

Classrooms schedules provided by teachers were used to define the start and end time for domain-specific PA opportunities during the school day. The start and end time data were then matched with accelerometer timestamps to quantify the exposure and activity time for each PA domain.

Descriptive statistics were used to better understand the distribution of PA across the different PA opportunities and how this distribution varies across sex and grade. Linear mixed-effects models were used with percentage of time spent in MVPA as the response variable and PA opportunities (PE, recess, CBPA) as the primary predictor variable while covarying for sex, school, BMI, and grade. Percentage of time in MVPA was calculated by dividing MVPA by the exposure time to each PA opportunity. A random effect for classroom and a random effect for school were included in the final models. To explore potential interactions, additional models were fit using grade and sex as interaction terms with the primary predictor.

Comparisons of competing model fits were evaluated using the Akaike information criterion (AIC) and Bayesian information criterion (BIC). Statistical significance was set at $\alpha = 0.05$. All analyses were done using R version 3.5.1.

RESULTS

Descriptive Statistics

The final sample in this study included 230 children (50% boys) in 1st, 3rd, and 5th grades attending six elementary schools in rural Oregon. Across our sample, children spent the highest percentage of time in MVPA in PE (19.5%) followed closely by recess (18.2%). Children only spent 10.5% of their time in MVPA during CBPA. The average amount of MVPA accrued during the full school day for children was 27.5 minutes and this was higher for boys than girls ($p<0.05$). Table 2.1 summarizes the PA and weight status variables across boys and girls in the study as they relate to PA opportunities during the school day. Amongst the most prevalent PA opportunities during the school day, boys appear to spend the highest percentage of time in MVPA during PE (23.7%). This is closely followed by recess, where boys spend 21.4% of time their time in MVPA. Only 11% of time allotted to CBPA was spent in MVPA. Girls had lower percentages across all domains, but also spent more time in MVPA during both PE (17.6%) and recess (16.1%) compared to CBPA (10.1%).

Table 2.1- Descriptive Summary of School-Day Physical Activity Opportunities by Sex

	Boys* (n = 115)	Girls* (n = 115)
Height (m)	1.3 (0.1)	1.3 (0.1)
Weight (kg)	33.8 (12.8)	31.3 (11.6)
Normal Weight (%)	58.9	63.0
Overweight (%)	17.8	19.7
Obese (%)	21.8	17.3
Total Activity (minutes)	154.5 (40.7)	143.5 (35.5)
MVPA[a] (minutes)	31.0 (11.0)	24.6 (8.7)
Domain (% in MVPA[a])		
Recess	21.4 (15.9)	16.1 (10.4)
Physical Education	23.7 (16.2)	17.6 (13.0)
CBPA[b]	10.9 (9.3)	10.1 (8.9)

*Data are presented as Mean (standard deviation)
[a]Moderate to vigorous physical activity
[b]Classroom-based physical activity

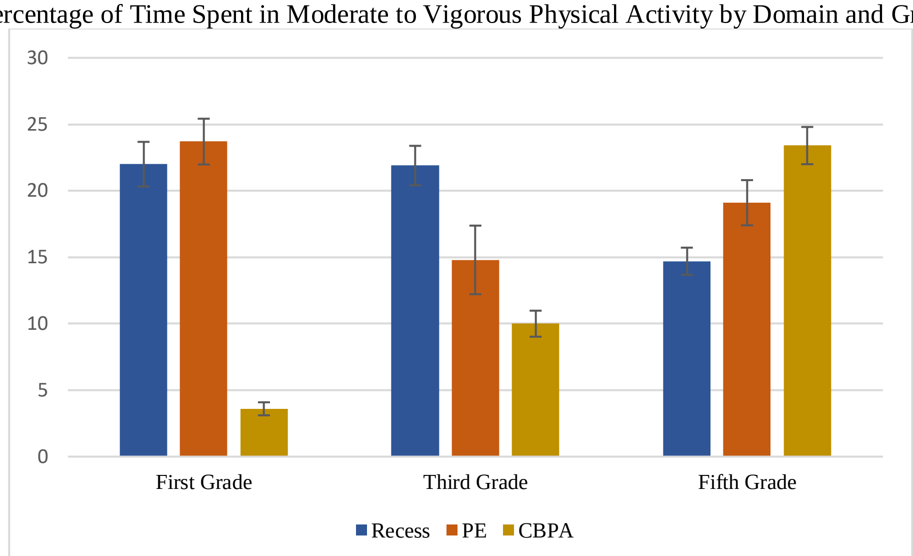
Table 2.2 summarizes PA and weight status variables across grade levels (1, 3, 5) as they relate to PA opportunities during the school day. First grade children spent nearly equal amounts of time in MVPA during recess and PE (22% and 23.7% respectively) whereas less than 4% of their time during CBPA was spent in MVPA. Third grade children spent the highest percentage of time in MVPA during recess followed by PE and CBPA. Children in fifth grade had the lowest percentage of time spent in MVPA during recess and the highest during CBPA (14.7% and 23.4% respectively). Overall, the percentage of time spent in MVPA varied across domains as well as across grades (Figure 1).

Table 2.2- Descriptive Summary of School-Day Physical Activity Opportunities by Grade

	First Grade (n = 79)	Third Grade (n = 84)	Fifth Grade (n = 88)
Height (m)*	1.2 (0.06)	1.3 (0.06)	1.4 (0.07)
Weight (kg)*	23.4 (5.2)	31.3 (8.3)	41.9 (13.2)
Normal Weight (%)	62.0	65.5	55.7
Overweight (%)	17.8	13.1	25.0
Obese (%)	19.0	20.2	19.3
Total Activity (minutes)*	171.3 (39.4)	154.9 (32.2)	123.1 (26.7)
MVPA[a] (minutes)*	30.6 (11.0)	28.5 (9.3)	24.5 (10.0)

*Data are presented as Mean (standard deviation)
[a]Moderate to vigorous physical activity

Figure 1- Percentage of Time Spent in Moderate to Vigorous Physical Activity by Domain and Grade



Approximately 60% of children in our sample were normal weight whereas 39% were overweight or obese (19% and 20%, respectively). Amongst girls, 63% were normal weight and 37% were overweight or obese (20% and 17%, respectively). The boys in our sample tended to be heavier on average than girls, with 18% being overweight and 22% being obese. The older children (grade 5) in this sample were the heaviest with over 45% being overweight or obese whereas only 37% of first graders were overweight or obese.

Associative Models

Linear mixed effects models were used to associate physical activity opportunities with time spent in MVPA (Table 2.3). The MVPA response variable was turned into a percentage by dividing the time spent in MVPA by the total time exposed to each PA opportunity. Domains of PA were the primary predictor and consisted of PE, recess, and CBPA. Random effects for school and teacher nested within school were added to the model to account for variation within and among schools. A random effect for student was also tested; the variance associated with that effect was nearly zero in all model fits and AIC values for models including the student random effect were always larger than models excluding the effect (when using the same fixed effects structure). Because adding the additional nesting of student into the random effect term yielded no additional beneficial information to the model, it was not included in the models presented in Table 3. Several covariates were included in the mixed models including sex, grade, and BMI. Potential interactions with the primary predictor variable were also explored for sex and grade. Interaction terms between domain and sex were not statistically significant in the models. However, interaction terms between domain and grade were statistically significant and therefore were included in the final model.

Table 2.3- Summary of Linear Mixed Models: Association of MVPA[a] and Different PA[b] Opportunities

	Model 1- ß (95% CI)	Model 2- ß (95% CI)	Model 3- ß (95% CI)
Domain- CBPA[c]	-15.3 (-17.8, -12.8)***	-15.5 (-18.0, -13.0)***	-20.1 (-17.9, -12.9)***
Domain- Recess	-3.2 (-5.2, -1.2)***	-3.2 (-5.2, -1.2)***	-5.8 (-5.2, -1.2)***
Child Sex (girl)		-3.1 (-4.8, -1.3)***	-3.3 (-4.7, -1.2)***
Grade 3		-0.8 (-5.3, 3.7)	-7.8 (-5.7, 3.8)*
Grade 5		-4.5 (-9.1, -0.01)*	-7.2 (-9.4, 0.1)*
BMI[d] (z-score)		-0.5 (-1.4, 0.4)	-0.6 (-9.4, 0.1)
Domain- CBPA[c]: Grade 3^			9.8 (4.5, 15.2)***
Domain- CBPA[c]: Grade 5^			10.2 (5.6, 14.8)***
Domain- Recess: Grade 3^			31.7 (25.4, 38.1)***
Domain- Recess: Grade 5^			1.2 (-2.9, 5.2)

*p < 0.05, **p <0.01, ***p<0.001 ^Interaction term
[a] Moderate to vigorous physical activity
[b] Physical activity
[c]Classroom-based physical activity
[d]Body mass index

1. Unadjusted Model
2. Model 1 + Child Sex + Grade + BMI
3. Model 2 + Interaction (Domain x Grade)

An unadjusted model was fit to determine if there was any association between PA domains and MVPA in rural elementary school children. The results from this model indicate that there are statistically significant differences between the three domains of CBPA, recess, and PE. Adjusted pairwise comparisons showed that the percentage of time in MVPA for both PE and recess were significantly higher than CBPA ($p<0.001$) and that there was no significant difference in percentage of time in MVPA between PE and recess ($p>0.05$). After adjusting for age, sex, and BMI, there was still a significant difference in the percentage of time spent in MVPA across the PA domains ($p<0.001$). The adjusted model also suggests that girls spent a lower percentage of time in MVPA compared to boys ($p<0.001$). There also appeared to be a relationship between grade and percentage of time spent in MVPA with older kids (grade 5 vs. grade 1) spending less time in MVPA ($p<0.05$). The addition of BMI into the adjusted model was not significant. Interaction terms were introduced into the model, and a significant interaction was found between grade and PA domain which suggests that the association between percentage of time in MVPA and domain varies based on grade. For example, children in grades 1 and 3 spend a higher percentage of time in MVPA during PE when compared to CBPA, but a lower percentage of time in MVPA during PE compared to CBPA in grade 5. When looking at percentage of time in MVPA in recess vs. PE, children in grades 1 and 5 are in MVPA for a higher percentage of the time compared to children in grade 3.

DISCUSSION

Children spent an average of 27.5 minutes in MVPA during the school day in our sample, which is just under half of the recommended 60 minutes of daily PA. Our results suggest that boys are more active than girls across both total activity and MVPA during the school day. This relationship also existed across each of the domains as boys were more active than girls in PE, recess, and CBPA. These data are consistent with published literature for PA opportunities during the school day as well as total PA behaviors (Brooke et al., 2016, 2014; Cooper et al., 2015; Saint-Maurice et al., 2018). Our data suggest that the relationship between the percentage of time spent in MVPA and PA domains varies by grade. Previously published literature has suggested that PE and recess account for the majority of school day PA and there have been inconsistent findings as to which domain accounts for the highest proportion (Erwin et al., 2012; Fairclough & Stratton, 2006; Hollis et al., 2016).

Only one existing study has evaluated MVPA accrual time during PE in rural children and showed that children were engaged in MVPA for 27% of PE lesson time

(Matthews-Ewald et al., 2013). Children in our rural sample spent substantially less time in MVPA during PE with an average of 19.5%. Boys spent a higher percentage of time in MVPA compared to girls and third grade children spent a significantly lower percentage of time in MVPA when compared to first and fifth grade children across all opportunities.

Data suggest that boys spend more time engaged in MVPA than girls during unstructured recess time and our findings confirm this. Boys spent an average of 21.4% of recess time in MVPA compared to girls who spent an average of 16.4% of recess time in MVPA. In previous data looking at unstructured recess time, boys engaged in MVPA for 27.3% of their recess time compared to 16.7% among girls (Dessing et al., 2013). Our results are similar to these previous findings in that boys are substantially more active than girls during recess time. We also identified that this relationship varied by age with third graders spending a significantly higher percentage of recess time in MVPA compared to first and fifth graders.

There is a scarcity of published literature on MVPA accrual patterns during CBPA and this study is the first to quantify the percentage of time spent in MVPA during CBPA. Our findings indicate that only 10% of CBPA time is spent in MVPA, which suggests that there may be room to better leverage CBPA to increase PA levels for rural children. Boys and girls had similar percentages of time spent in CBPA MVPA whereas the percentage increased steadily with grade in our sample. A further investigation into the administration of CBPA and teacher behavior may provide valuable insight into these differences across grades.

The Institute of Medicine has recommended that at least 50% of PE class time and recess time should be spent in MVPA (National Academy of Sciences, 2013). Children in our sample are not meeting the recommended percentage of time spent in MVPA for either PE or recess time. There were no children who exceeded the 50% threshold for recess time and only one child who exceeded the 50% threshold for PE. Although time is allotted to recess and PE during most school days, children are not meeting recommendations for time spent in MVPA. Exploring ways to modify PE and recess time to encourage additional time spent in MVPA may enhance children's overall MVPA levels and allow more children to reach recommended levels of MVPA.

Previously published longitudinal data looking at changes in PA across opportunities in 10-14 year-olds indicated that as children get older, total PA and MVPA declined (Brooke et al., 2016). These data also suggested greater declines on weekends and out of school time, which further implicates the importance of school day PA and optimizing opportunities that children have during the school day to be active. Schools should continue to provide ample opportunity for PA during the school day, but also find solutions to optimize the time that currently exists and increase the percentage of time that children are engaged in MVPA. The importance of school-day PA may be exacerbated in rural children as they tend to face additional challenges to accruing PA outside of the school day such as long bus commutes, and the inability to have active transportation to schools (Gunter et al., 2015; Rothman et al., 2017).

Limitations

This study is limited by several factors. A primary limitation to this study is that we relied on teachers to provide accurate and specific schedules of activities during the school day. We were unable to confirm that what they reported on the classroom schedules actually happened and as such, we expect there to be some level of misclassification amongst the data. Since CBPA opportunities happened during regularly scheduled class times, this domain had the highest potential for misclassification. Other PA opportunities were scheduled independently of regular class time. Additionally, we were unable to differentiate the recess portion of lunch during the school day. Most children had scheduled activity time during the lunch hour either before or after eating their lunch. This varied across the sample and teachers did not differentiate these segments on the classroom schedules. As such, there is a non-trivial amount of MVPA that is unclassified in our data. Despite these limitations, we present new information about how children engage in PA in rural elementary school settings. These findings may be important to inform PA promotion strategies in rural school settings.

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CHAPTER 4. CONCLUSION

Children who do not meet PA guidelines are at higher risk for a variety of negative health outcomes such as high blood pressure, increased adiposity, and insulin resistance (Andersen et al 2006). Almost all children in the US attend school for 6 to 7 hours a day, which accounts for nearly half of their waking hours (Guinhouya et al., 2009). As such, the school environment provides prime opportunity for children to accrue PA and achieve the associated health, academic, and psychosocial benefits over time. Research has examined how PA influences future BMI in children with conflicting results. A study of 12 to 14-year old girls demonstrated that PA levels were predictive of future BMI while another study in younger children demonstrated that PA levels were not predictive of future BMI (White 2012, Trinh 2013). These studies did not evaluate the relationship of PA and future BMI in rural children and were limited by either sex (girls only) or weight status (overweight and obese only).

The school environment has the potential to offer children a variety of opportunities in which to accrue PA; however, it is not well understood how rural children accrue PA within the school day and how that varies by sex and age. The primary opportunities during the school day to accrue PA are recess, PE, and CBPA (Bassett et al 2013). The Institute of Medicine recommends that children are engaged in MVPA at least 50% of the time during recess and PE time and also recommends that elementary schools provide at least 150 minutes a week of PE. Existing literature suggests that boys are more active than girls and that PE and recess are the two largest sources of MVPA during the school day. (Brooke et al., 2016, 2014; Cooper et al., 2015; Saint-Maurice et al., 2018) The evidence assessing the relationship between school day

PA domain and MVPA are not well defined in the context of rural schools and do not include specific measurement of CBPA.

To help fill the gaps in this literature in regard to the relationships between school-day PA, weight status, and PA domains, we conducted two studies within the context of the larger GROW HKC study. The aim of the first study was to determine the relationship between children's PA at school and change in weight status over time. The second study aimed to quantify and evaluate the relationship between school day PA levels and various PA domains such as PE, recess, and CBPA.

Preliminary results in the first study indicated that there was an association between baseline PA and future BMI in rural elementary school children in Oregon. However, after adjusting for baseline BMI, the association between PA and future BMI diminished and was not significant. This relationship of no association between baseline PA and future BMI remained consistent when looking at steps per day, total activity time, and MVPA. We also briefly examined this relationship with transition from weight categories as the primary outcome with the same PA variables as the primary predictors and no association was found. These results suggest that PA accrued during school hours is not an important predictor of future weight status in rural elementary school children and that children's weight will remain consistent over time independent of the amount of PA they engage in at school. This is not to suggest that PA is not important in children, as there are many health, academic, and cognitive benefits that come from routine PA outside of weight status. Results from this study might suggest that meaningful changes in BMI are difficult to achieve in relatively short timeframes and that it likely requires a multi-factorial solution including PA, nutrition, public policy, the school environment, and home environment, among others. BMI has clinical importance and studies have shown its association with a variety of health outcomes, but this study evaluating the prospective nature of the relationship between PA and weight suggests that it is difficult to change. It may be more fruitful for future research examining PA within the school environment to explore relationships between PA and other outcomes such as academic achievement, cognitive measures, and other cardiometabolic measures of health rather than BMI.

In the second study, we were able to quantify the amount and type of PA being accrued throughout the different PA domains during the school day (PE, recess, CBPA). On average, children in our study were accruing 27.5 minutes of MVPA and in alignment with previous research, time spent in MVPA was higher for boys than girls. Children did not reach the recommended threshold of 50% of time spent in MVPA during any of the domains. The highest percentage of time engaged in MVPA was during PE (19.5%) followed by recess and CBPA (19.2% and 10.5%). Results from this study of rural children were lower than other estimates in the existing literature for PE and recess (Matthews-Ewald et al., 2013) (Fairclough & Stratton, 2006; Hollis et al., 2016). This study was the first to examine the percentage of time spent in MVPA during specific CBPA opportunities across the school day. Additionally, younger children engaged in more MVPA than older children and this result is consistent with previous literature (Troiano et al., 2008).

Results from the second study give us insight into PA accrual patterns across the school day in rural elementary children. PE and recess are often the largest blocks of time allocated to PA during the school day and have been a focus of legislation and administrative efforts to increase PA. There are consistent efforts to realign time and resources to academics and test preparation within schools, so it is unlikely that schools will be able to create new PA time slots within the current school schedule. As such, it is important to maximize the amount of time that children are active in the pre-existing PA opportunities and look to enhance those with CBPA, which serve as short breaks throughout the classroom schedule. These results indicate that children are spending less than 20% of time in MVPA during the primary PA opportunities, which means there is significant room to increase health promoting MVPA without altering school schedules. Recent data show that even acute bouts of MVPA (i.e. 5 to 10 minutes) can promote immediate benefits to children's attention, executive function, and academic performance outcomes important for child- and school-level performance indicators (Donnelly et. al., 2016; Cerrillo et. al., 2015). Future research should investigate how to increase participation, inclusion, or other factors which may be contributing to the low rates of MVPA accrual. CBPA can enhance children's ability to engage in MVPA by serving as a low-cost, low-overhead method of administering PA. Additional research should be done to understand how CBPA opportunities are administered, how to minimize CBPA instruction and downtime, and how they can be best implemented to reach all children within schools.

In summary, we evaluated the relationship between baseline PA and future BMI and determined that PA did not have an independent effect on future BMI in our sample. Changes in BMI are likely difficult to achieve in the short-term and altering weight status is complex and requires a multi-faceted approach. We also quantified children's PA accrual patterns across PE, recess, and CBPA during the school day. Children in our sample accrued 27.5 minutes of MVPA and were engaged in MVPA for less than 20% of the total time allotted for PE, recess, and CBPA. Additional research is needed to better understand the complex nature of weight status in children and to find solutions to maximize the amount of time children are engaged in MVPA during pre-existing PA opportunities.

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APPENDICES

Appendix A- Pedometer Data Collection Repacking To-Do List

Before repacking pedometers please look for the following items:

1. Teacher Classroom Tracking Sheet
    a. Confirm that the teacher wrote corresponding times for putting on and taking off pedometer belts.
    b. Confirm that the teacher checked the box besides the names of children that were absent. If there are any absents please write pedometer ids on the "Pedometer Tracking Sheet".
    c. Look for any notes the teachers may have left and make sure we can understand them.
2. Look for the Teacher Daily Schedule form
    a. Look at the form and make sure the teacher confirmed the schedule (by checking the boxes next to each session).
3. Look for the BEPA-Toolkit Daily Use form
    a. Confirm that the teacher filled in the form. If they say they didn't use the BEPA-Toolkit don't worry about looking for any other information. On the other hand, if they say they used it confirm that they tell us what time they used it, for how many minutes and which activity they used.
4. Look inside the pedometer box
    a. Confirm that the pedometers that are left inside the box are either listed as absents on the teacher form sheet or not assigned to any student in the classroom, if there are any absences please write pedometer ids on the "Pedometer Tracking Sheet".

b. If you find pedometers in the box that are not listed on the sheet as absents. Open the pedometer check the data if there is very low activity on it (compared to other pedometers), it means that the pedometer was not worn and that probably the child was absent. Make sure you add the absent information to the teacher form, and please list the absents' pedometer ids on the "Pedometer Tracking Sheet". This one is a little tough to judge and confirm, run your case by Patrick and he will help you decide what to do.

5. Seek Clarification from teachers
    a. If there are any clarifications that needs to occur about any of the previous items, please do your best to follow up with teachers on the same day and get those clarifications.

Pedometer Repacking

Pedometer IDs

Each pedometer has a unique identifier they either start with "P.###" or "S.###". These pedometer IDs are also connected to a specific spot on each box.

Steps for repacking pedometers

1. Confirm that the pedometer is well attached to the belt. Re-do the wrapping if necessary, please use the Hicks_Klein_AbiNader method. The buckles of the belt must face the front of the person and the pedometer must be placed on the right side hip. The opening of the pedometer must face upwards.
2. Open the pedometer and look at the data for steps.
    a. If it's day one anything below 500 and anything above 15000 should be noted as an outlier on the "Pedometer Outlier Sheet".

b. If it's day two and you are looking at a pedometer that is being downloaded at the end of day 4, anything below 1000 and anything above 30000 steps should be noted as an outlier on the "Pedometer Outlier Sheet".

c. If it's day three and you are looking at a pedometer that is being downloaded at the end of day 4, anything below 1500 and anything above 45000 steps should be noted as an outlier on the "Pedometer Outlier Sheet".

3. Check MVPA setting for steps per minutes

    a. After you look at steps scroll using the "mode" button until you reach the screen for MVPA. Push the "set" button to confirm that the *threshold for MVPA* is still set at 120. Sometimes children mess up the settings of the pedometers if the number is not <u>exactly 120,</u> we may be underestimating or overestimating MVPA. Which will bias our results. BEFORE YOU CHANGE the setting back to 120, stop and write in the data of the pedometer in the appropriate location on the "Pedometer Wrong MVPA Setting Sheet".

    b. After you write the data change the setting back to 120 for MVPA. Reset the pedometer and repack it.

4. If the pedometer made it through all the previous steps

    a. Check if the pedometer is one of the 10 children that were randomly chosen for daily data recording. If they belong to that group, please write in their data and reset pedometer before repacking. If that child was absent for the day make sure you write child absent on the form and still reset pedometer before repacking. If it was an outlier or wrong setting also make that clarification. Write Data or clarifications on the “Pedometer Tracking Sheet”.

   b. If you are completing one of the boxes that need to be downloaded daily and that is connected to accelerometers. Please make sure you write all the data for each of the pedometers while confirming that nothing on the accelerometers was damaged or removed. Then reset the pedometers and repack them. The repacking will have to be done using two boxes. Write Data on the “Pedometer Tracking Sheet”.

5. After you completely repack the box, remove the transportation pedometer and write data collected on that pedometer in the appropriate spot of the “Pedometer Tracking Sheet”.
6. Answer all the questions on the “Pedometer Tracking Sheet”.
   a. Your accurate and clear answers will tremendously assist with data management, data cleaning, data checking, and will help us include in the analysis the best possible information.
   b. Make sure you Initial the Form that way we can follow up with you if we have any questions related to what you wrote on the forms.
7. Combine all the paper work related to the box and classroom and send it to have a new “Teacher Classroom Tracking Sheet” created for it.
8. After the new “Teacher Classroom Tracking Sheet” is created take back each box to the appropriate classroom with all the appropriate forms. The list of forms is:

“Teacher Classroom Tracking Sheet, Teacher Daily Schedule Form, and BEPA-Toolkit Daily Use Form”.

Appendix B- Pedometer Outlier Sheet

Confirming Outlier Status

1. If it's day one anything below 500 and anything above 15000 should be noted as an outlier.
2. If it's day two and you are looking at a pedometer that is being downloaded at the end of day 4, anything below 1000 and anything above 30000 steps should be noted as an outlier.
3. If it's day three and you are looking at a pedometer that is being downloaded at the end of day 4, anything below 1500 and anything above 45000 steps should be noted as an outlier.

Data Collection Date & Day #	Teacher ID	Grade	Outlier Pedometer ID	Step Count	Activity Time	Moderate Time

Appendix C- Pedometer Tracking Form

Data Collection Day (Please Circle): 1 2 3 4

Date:________/______/____________

School:_______________________

Teacher Last Name:___________________ Teacher_ID:_____________Grade:_______

______

Are there any absent children today? (Circle: Yes/ No): if yes list the pedometer ids of these children below.

____

____

____

____

Are there any missing pedometers? (Circle: Yes or No): if yes please list the ids of the missing pedometers below.

____

____

____

____

Are there any broken pedometers today? (Circle: Yes or No): If yes please list the ids of those pedometers below, replace the pedometers, reset and repack in box.

____

____

____

Are there any pedometers with dead batteries today? (Circle: Yes or No): If yes please list the ids of those pedometers below, replace the batteries, reset, change MVPA setting back to 120 and repack in box.

____

____

____

Were there any pedometers that were returned today? (Circle: Yes or No): if yes please list the ids of those pedometers below. Please consult with Patrick about what to do with returned pedometers. We may still be able to use future data collected with them.

____

____

____

Are there any outliers today? (Circle: Yes or No): if yes please fill in the outlier sheet with the appropriate information. Before repacking pedometer make sure you reset it.

Are there any pedometers with wrong MVPA settings today? (Circle: Yes or No): if yes please fill in the pedometer wrong MVPA sheet with the appropriate information. Before you repack pedometer change the setting to 120 and reset it.

Please list all the Information Collected on Transportation Pedometer	
Step Count	
Activity Time	
Moderate Time	

Below are the Children that were randomly selected for daily data entry. Please write all the necessary information.

Child Pedometer ID & Name	Step Count	Activity Time	Moderate Time

Appendix D- Pedometer Wrong MVPA Setting Sheet

1. Write in all the below information before you change the pedometer settings.
2. Make sure you also write the wrong setting of the pedometer we can statistically adjust for that change.
3. After you write down all the data fix back the setting of MVPA to 120 steps per minute.
4. Reset the pedometer and repack it.

Data Collection Date & Day #	**Teacher ID**	**Grade**	**Pedometer ID**	**MVPA Setting**	**Step Count**	**Activity Time**	**Moderate Time**

Appendix E- Template Classroom Roster

Teacher: **Grade:** **Date:**

Time all belts were put on	**:**	**AM / PM**
Time all belts were taken off	**:**	**AM / PM**

Let us know of important things such as late arrival, early leave, belt/pedometer removal, or any other problems you may encounter.

Mark an **X** for all students who are **ABSENT**.

Absent	Last Name	First Name	Pedometer ID	Notes
			P.001	
			P.002	
			P.003	
			P.004	
			P.005	
			P.006	
			P.007	
			P.008	
			P.009	
			P.010	
			P.011	
			P.012	
			P.013	
			P.014	
			P.015	
			P.016	
			P.017	
			P.018	
			P.019	
			P.020	
			P.021	
			P.022	
			P.023	
			P.024	
			P.025	
			P.026	
			P.027	
			P.028	
			P.029	
PLEASE DO NOT USE THIS PEDOMETER			P.030	

TOTAL STUDENTS HERE TODAY = __________

School

Appendix F- Classroom Schedule Letter

GROW Healthy Kids and Communities

Fall Physical Activity Assessment

Classroom Schedules

Dear [Teacher Name],

Thank you for all your help with the GROW Healthy Kids and Communities height, weight, and physical activity assessments. Your generous support has made our project possible. This fall we will once again be conducting physical activity assessments at your school. Unlike previous years, we will not be measuring students' height and weight. To best prepare for the coming fall physical activity assessments, we need each teacher's classroom-specific schedule to help us understand how often students have physical activity opportunities each day (e.g. recess, PE, etc.). This information will help us better relate the physical activity data we collect to students' activities during the school day. We would like to request a copy of your weekly classroom schedule with the following important details:

1. Your name and the grade level you teach
2. Start and end time of each subject session (e.g., 8:10 am to 9:20 am)
3. Subject taught in each session (e.g., Reading, Math, or Science)
4. Any time your students have opportunities to engage in physical activity (e.g., PE or recess)

5. Any additional time when you REGULARLY provide time for students to be active (e.g. classroom activity breaks)

This information will help us better understand our physical activity data and provide your school with suggested strategies and recommended supports to keep kids active during school.

The attached document shows a sample week's schedule that includes all the information we need. You may use this or provide this information to us in a form that you already have ready to go if that is easier. You could fill in the blank document (or provide a copy of your own) and send it to us by email. The attached blank Word document is named "template_classroom_schedule". If you choose to use our template, please rename your version by replacing "template" with your last name (i.e. "Smith_classroom_schedule"). If session times differ from one day to the next, please include that information.

We hope you are able to provide us with a copy of your classroom schedule by ____________________________ so we can best prepare for the upcoming physical activity assessment.

We appreciate all your efforts and support in this process!

Sincerely,

The GROW Team

First and Last name: ____________ Grade Level Taught: ______

School: ______________

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:00- 8:50	Reading	Reading	Reading	Reading	Reading
8:50-9:40	Geography	Enrichment	Geography	Enrichment	Geography
9:40-10:30	Science	Reading	Science	Reading	Science
10:30-11:00	Recess	Recess	Recess	Recess	Recess
11:00-12:00	Math	Geography	Math	Geography	Math 10-minutes of "active math"
12:00-12:30	Lunch	Lunch	Lunch	Lunch	Lunch
12:30-1:00	Writing	Science	Writing	Science	Writing
1:00-1:30	Music	Math	Music	Math	Music
1:30-2:00	Enrichment	Math	Enrichment	Math	Enrichment
2:00-2:20	Recess	Recess	Recess	Recess	Recess
2:20-3:10	Math	Writing	Math	Writing	Math
3:10-3:20	Clean up	Clean up	Clean up	Clean up	Clean up
3:20	End of school day	End of school day	End of school day	End of school day	End of school day

Appendix G- Template Classroom Schedule

First and Last name: ____________________ Grade Level Taught: __________

School: ______________________

Time	Monday	Tuesday	Wednesday	Thursday	Friday

Appendix H- Opt-Out School Form

Parent Notification of Health Screening

This fall, our school will be conducting well-child screenings for all students in grades 1-6 during the school day. The OSU Extension Service's GROW Healthy Kids & Communities program will work with school personnel to measure the amount of activity children do during their regular school activities using pedometers.

The data collected will be used to help us learn about our school's health. The information will also help researchers understand the effectiveness of the GROW Healthy Kids & Communities program. The data used will be de-identified. This means your child will not be identifiable in any report. For example, a report might read "75% of children were meeting or exceeding the recommended amount of daily physical activity."

Only sign and return this form if you would prefer NOT to have your child to participate in the health screening OR if you would prefer that your child's data NOT be used in reports.

☐ I **do NOT** want my child, ______________________________________ (name), to participate in the well-child assessments this year.

☐ I **do NOT** want my child, ______________________________________ (name), to have their data used for research or program evaluation (as described above) this year.

_______________________________	________________________________
Parent/Guardian Name	Parent/Guardian Signature
_______________________________	________________________________
Child's Name	Child's Teacher

Principal Name, Principal

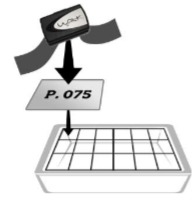
School Name Here

Appendix I- Classroom Pedometer Guide

CLASSROOM PEDOMETER BELT PLACEMENT & REMOVAL GUIDE

WE COUNT TOTAL STEPS AT THE END OF THE WEEK.

PLEASE DO NOT RESET THE PEDOMETERS.



AT THE BEGINNING OF SCHOOL or **WHEN YOUR STUDENTS START CLASS:**

1) Open this box and remove one pedometer belt at a time.
2) In each box compartment is a pedometer with its number (P.XXX). Each pedometer must only be given to the student it's assigned to. This assignment is indicated on the provided classroom roster.

   Call individual students to your desk, wrap the belt around the student's waist, and ensure the pedometer is facing forward and slightly off to the student's right hip. If capable, students can attach their own belts.
   ***Students may put on their own belts if capable. It is suggested that you physically assist younger children. In all cases, please glance over students to ensure proper pedometer placement. Please have students who are tardy to class wear their assigned belt and note their exact time of late arrival on the provided class roster.
3) Note the current time on our provided classroom roster after all students have received their belt.
4) If a student does not want to wear a belt or if a student is absent, roll up and place the pedometer back in the appropriate box compartment and make necessary notes on our provided class roster.
   ***In the event of accidental belt/device removal, in order to identify to which student the pedometer belongs to, open the device and look at the pedometer number (P.###). Search the class roster we provided to identify the corresponding student. Buckle the belt back on the student and make a note on our provided roster of what time this accidental removal occurred.

AT THE END OF SCHOOL or **WHEN YOUR STUDENTS GO HOME:**

1) Unbuckle and remove pedometer belts from all students.
2) Note current time on our provided class roster.
3) Place used pedometer belts and this box in the provided GROW grocery bag.
4) Leave the grocery bag in your classroom where it is visible and easy to access. A GROW team member will enter your classroom and will collect all items after school has finished.