PHYSICAL ACTIVITY OF PRESCHOOL AGED CHILDREN DURING CHILDCARE: EXAMINATION OF SEASONAL CHANGES AND AN EVALUATION OF A DANCE-BASED INTERVENTION

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

DOCTOR OF PHILOSOPHY

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ABSTRACT

The purpose of this dissertation was to prospectively track preschoolers' physical activity (PA) during childcare while investigating for seasonal differences in accelerometer measured PA between the fall and winter months in Fargo, North Dakota. This dissertation also evaluated the feasibility of a novel dance-based intervention for increasing PA and reducing sedentary (SED) time in childcare using short activity breaks (< 10 min) interspersed throughout the childcare day. Two studies were conducted as part of this dissertation. The first study (Paper 1) examined for seasonal differences in preschoolers' PA. The second study (Paper 2) evaluated the feasibility of a novel dance-based intervention for increasing PA and reducing SED time during childcare. Preschool aged children (3-5 years) were recruited from four childcare centers in Fargo, North Dakota, to participate in both studies.

Children (N = 59) in study one wore an accelerometer during childcare for 5 days in October/November 2011 (fall) and for 5 days in January/February 2012 (winter). Significant decreases in all intensities of PA were observed from fall to winter. Levels of moderate-to-vigorous PA (MVPA) decreased by 17% ($p < .01$), while SED time increased by 3.2% ($p < .01$). Children averaged 6.1 min/hr of MVPA across the two assessment periods. Levels of MVPA among preschool children from this study fell within the range of estimates reported in the current literature. Findings from study one suggest that preschoolers' PA levels can substantially change across seasons.

For study two, four childcare centers were randomly assigned (cluster randomized design) to take part in a novel dance-based PA intervention or to serve as a control site. Preschoolers (N = 61; intervention group [n = 30], control group [n = 31]) wore an accelerometer while at childcare for 5 days at baseline in January 2012 and for 5 days during

the intervention in February 2012. No significant differences between groups in baseline to intervention period changes for MVPA or SED time were observed. Results from study two indicate that adding an additional 15-20 min of dance to preschoolers' childcare day did not significantly increase MVPA or reduce SED time.

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My completion of this dissertation represents the culmination of a journey which started many years ago. Oddly enough, I would not have reached this level of academic achievement if not for my involvement in athletics. Although academic pursuits should take precedence over athletics, I am not afraid to say that I was most certainly an “Athlete-Student,” and not a “Student-Athlete,” during my years as an undergraduate. The story of how my career transitioned into its current path is far too long to discuss here. However, I would like to acknowledge a number of individuals for their support and assistance with the completion of this dissertation. In addition, I would also like to acknowledge several friends and family members for their support and assistance over the years.

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DEDICATION

This dissertation is dedicated to “The Crew.” The best group of friends I have ever had: Mark, Chris, Nate, and Scott.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ASOS....................................Automated Surface Observing System

BEACHES.............................Behaviors of Eating and Activity for Children's Health Evaluation System

BMI.......................................Body Mass Index

CARS....................................Children's Activity Rating Scale

CDC......................................Centers for Disease Control and Prevention

CPAF....................................Children's Physical Activity Form

CVD......................................Cardiovascular Disease

FATS ....Fargo Activity Timesampling Survey

LPA.......................................Light Physical Activity

MPA ....Moderate Physical Activity

MVPA...................................Moderate-to-Vigorous Physical Activity

NASPE ....National Association for Sport and Physical Education

OSRAC-P ....Observational System for Recording Physical Activity in Children-Preschool Version

PA...Physical Activity

SCAN-CAT...........................Studies of Children's Activity and Nutrition-Children's Activity Time

SED.......................................Sedentary

US...United States

USDHHS ....United States Department of Health and Human Services

VPA......................................Vigorous Physical Activity

INTRODUCTION

The prevalence of overweight and obesity continues to rise around the world. In the United States (US), approximately 68% of adults are overweight with a body mass index (BMI) greater than or equal to 25 (Flegal, Carroll, Ogden, & Curtin, 2010). More troubling is that roughly half of the overweight American population is obese with a BMI of 30 or greater. However, this obesity epidemic is not limited to American adults, as children and adolescents within the US have also experienced dramatic increases in overweight and obesity prevalence (C. Ogden & Carroll, 2010).

Data from the early 1970s indicated that 5.0% of 2-5 year-olds, 4.0% of 6-11 year-olds, and 6.1% of 12-19 year-olds were obese (C. Ogden & Carroll, 2010). However, two to four fold increases in obesity prevalence have been observed over the last four decades as recent estimates indicate that 10.4% of 2-5 year-olds, 19.6% of 6-11 year-olds, and 18.1% of 12-19 year-olds are currently obese (C. L. Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). This increase in obesity prevalence is particularly worrisome as increasing levels of body fat are associated with higher risks for a number of chronic diseases among children, such as hypertension, hyperlipidemia, and diabetes (Must & Anderson, 2003). Children may also suffer from a variety of economic, behavioral, and social problems as a result of being overweight or obese (Gortmaker, Must, Perrin, Sobol, & Dietz, 1993; Schwimmer, Burwinkle, & Varni, 2003; Strauss, 2000). Moreover, evidence suggests that obese children are at least twice as likely as nonobese children to become obese adults (Serdula et al., 1993). In light of these issues, preventive strategies to combat childhood obesity are warranted (Ward, 2010), with increases in physical activity (PA) recommended as an important obesity prevention measure for American children (American Academy of Pediatrics and Council on Sports Medicine and Fitness and Council on School Health, 2006).

It has been suggested that the preschool years (3-5 years old) are an important time period influencing the development of children's PA patterns (Ward, Vaughn, McWilliams, & Hales, 2010). Current recommendations from the National Association for Sport and Physical Education (NASPE) suggest preschool children should accumulate at least 60 min/day of structured PA, at least 60 min/day of unstructured PA, and limit the duration of waking sedentary (SED) bouts to less than 60 min/bout (NASPE, 2009). Considering 61% of American children aged 6 years or younger receive non-parental childcare on a regular basis (Federal Interagency Forum on Child and Family Statistics, 2010), the childcare setting represents an important location for preschoolers to be physically active in an effort to meet NASPE guidelines.

Objective assessments have consistently shown that typical PA levels among preschoolers in childcare settings, if extrapolated out to a full 8 hr day, would result in the accumulation of less than 60 min/day of moderate-to-vigorous PA (MVPA; Alhassan, Sirard, & Robinson, 2007; Cardon & De Bourdeaudhuij, 2007; Dowda, Pate, Trost, Almeida, & Sirard, 2004; K. J. Finn & Specker, 2000; Jackson et al., 2003; McKee, Boreham, Murphy, & Nevill, 2005; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Reilly et al., 2006; Trost, Fees, & Dzewaltowski, 2008). Ambiguity in the NASPE (2009) PA guidelines makes it difficult to judge the adequacy of a 60 min/day benchmark for childcare-related MVPA. However, it has generally been considered undesirable if preschoolers fail to accumulate at least 60 min of MVPA during a full-day of childcare (8 waking hours; Pate et al., 2004). Because reported MVPA levels among preschoolers in childcare settings have consistently been below the 60 min/day benchmark, preschoolers' childcare-related PA has been characterized as low (Reilly, 2010). These low levels of objectively measured PA during childcare, along with concerns related to childhood obesity, provide a rationale for increasing preschoolers' childcare-related PA with targeted interventions.

A number of previous investigations have evaluated interventions to increase preschoolers' PA during childcare (Alhassan et al., 2007; Binkley & Specker, 2004; Cardon, Labarque, Smits, & De Bourdeaudhuij, 2009; Eliakim, Nemet, Balakirski, & Epstein, 2007; Fitzgibbon et al., 2005, 2006; Hannon & Brown, 2008; Reilly et al., 2006; Trost et al., 2008). Results from this area of research have been mixed, with several interventions demonstrating PA improvements (Binkley & Specker, 2004; Eliakim et al., 2007; Hannon & Brown, 2008; Trost et al., 2008), while a number of other interventions demonstrated no significant improvement or effect on PA (Alhassan et al., 2007; Cardon et al., 2009; Fitzgibbon et al., 2005, 2006; Reilly et al., 2006). However, intervention research aiming to improve preschoolers' childcare-related PA is still an emerging area (Ward et al., 2010). As such, future investigations of novel approaches to increase preschoolers' PA during childcare are needed.

Besides the need for additional PA intervention studies among preschoolers, more longitudinal investigations examining preschoolers' PA patterns are needed. Nearly all published observational studies which have objectively measured preschoolers' PA were of a cross-sectional nature and offer little insight into how preschoolers' PA may change over time. Several studies have longitudinally measured preschoolers' PA with yearly intervals between assessment periods (Jackson et al., 2003; Pate, Baranowski, Dowda, & Trost, 1996). However, only three published studies have attempted to quantify PA among preschoolers at multiple time points within the same year (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Fisher et al., 2005; Poest, Williams, Witt, & Atwood, 1989). All three of these investigations were conducted in small geographic regions (Ohio and Texas, US; Glasgow, Scotland), which limits the generalizability of their findings. As such, the current body of literature has not adequately addressed how PA in preschool aged children may change within a given year.

Therefore, the purpose of this dissertation was twofold: 1) to prospectively track preschoolers' PA levels during childcare while investigating for seasonal differences in accelerometer measured PA between the fall and winter months in Fargo, North Dakota, and 2) to evaluate the feasibility of a novel dance-based intervention for increasing PA and reducing SED time in childcare using short activity breaks (< 10 min) interspersed throughout the childcare day.

Definition of Terms

Physical Activity: Any bodily movement produced by skeletal muscle contractions that requires energy expenditure (World Health Organization, 2011).

Sedentary Behavior: A range of human behaviors which elicit an energy expenditure of no more than 1.5 times' resting energy expenditure (Owen, Leslie, Salmon, & Fotheringham, 2000).

Organization of Dissertation

Following this introduction, a review of literature is presented which discusses the importance of PA for health and well-being, evaluates current PA recommendations for preschool aged children, and briefly overviews the different techniques used to assess childhood PA. In addition, published studies of childcare-based PA interventions and investigations examining preschoolers' seasonal PA patterns are reviewed. Paper 1 follows the review of literature and is the first of two original research articles titled, "Seasonal Changes in Preschoolers' Physical Activity and Sedentary Time at Childcare." Following Paper 1, Paper 2 is the second research article titled, "Initial Evaluation of a Dance-based Physical Activity Intervention in Preschool Children." The methods are described in detail in each article. A brief summary of the two research articles is presented following Paper 2. References for each article are listed at the end of each article. References pertaining to the entire dissertation are presented following the summary.

REVIEW OF LITERATURE

The Beneficial Role of Physical Activity in Health and Well-being

The importance of physical activity (PA) as a means to promote health and well-being is not a new concept. In ancient China, records of exercise for health promotion date back to approximately 2500 B.C. (Lyons & Petrucelli, 1978). Following this, teachings from the Greek physician Hippocrates of the 5th and 4th century B.C. detailed the importance of exercise for health and well-being (Hippocrates, trans. 1953). Despite this ancient knowledge that PA confers health benefits, an understanding of the pathways and mechanisms through which PA influences health and well-being remained poorly understood until recent times.

Beginning in the early- to mid-twentieth century, researchers became interested in identifying the causes of heart disease and other chronic conditions. This interest was driven by the dramatic increase in cardiovascular disease (CVD) mortality, which occurred during the first half of the century. In an attempt to identify and understand the underlying causes of CVD and other chronic conditions, a number of large-scale epidemiological studies (e.g., Framingham Heart Study, Harvard Alumni Health Study) were initiated during the middle decades of the century.

The first epidemiological evidence linking greater amounts of PA with reduced risks of CVD was presented by Morris, Heady, Raffle, Roberts, and Parks (1953), after studying double-decker bus workers in London, England. The major finding from this research was that physically active bus conductors suffered roughly half the coronary events than more sedentary (SED) bus drivers. Further illustrating the potential health benefits of being physically active, later work by Paffenbarger, Laughlin, Gima, and Black (1970) demonstrated that work-related energy expenditure and risk of death from coronary heart disease were inversely related among longshoreman in San Francisco, California. A number of subsequent large-scale epidemiological investigations demonstrated an inverse relationship between PA and CVD incidence and mortality (Lee & Paffenbarger, 2000; Lee, Rexrode, Cook, Manson, & Buring, 2001; Leon, Connett, Jacobs, & Rauramaa, 1987; Morris, Pollard, Everitt, Chave, & Semmence, 1980; Sesso, Paffenbarger, & Lee, 2000; Slattery, Jacobs, & Nichaman, 1989). In general, these investigations showed a dose-response relationship between PA and CVD, as greater levels of PA were associated with incremental reductions in risk for developing CVD.

Besides the potential CVD-related health benefits associated with being physically active, research has shown that increases in PA energy expenditure are associated with significant reductions in body mass (Racette et al., 2006; Ross et al., 2000; Ross et al., 2004; Slentz et al., 2004). Such findings have become especially pertinent considering more than two-thirds of United States (US) adults are either overweight or obese (Flegal et al., 2010), while PA continues to be promoted as a treatment and prevention modality for obesity. However, regular PA confers health benefits regardless of any changes in body composition resulting from PA-related increases in energy-expenditure (Janiszewski & Ross, 2007). Additional health benefits of regular PA include, but are not limited to, reduced risks for type 2 diabetes (F. B. Hu et al., 1999; Manson et al., 1992), hypertension (Hayashi et al., 1999; Pereira et al., 1999), and all-cause mortality (G. Hu et al., 2005).

Physical Activity Recommendations

The gradual accumulation of evidence supporting the beneficial role of PA for a variety of health-related outcomes resulted in the publication of a joint position statement regarding PA and health by the American College of Sports Medicine (ACSM) and the

Centers for Disease Control and Prevention (CDC; Pate et al., 1995). Based upon current evidence at the time, the joint position statement recommended that every adult accumulate 30 min or more of moderate-intensity PA on most, preferably all, days of the week. Soon to follow the ACSM/CDC joint position statement, the US Department of Health and Human Services (USDHHS) published the Surgeon General's Report on Physical Activity and Health (USDHHS, 1996). This report presented a thorough review of the available evidence regarding PA and its relation to numerous health problems, while stating that people of all ages could benefit from meeting the PA recommendations put forth by the joint ACSM/CDC position statement.

After a 12 year interim, with several updates to the original ACSM/CDC PA recommendations (Haskell et al., 2007; USDHHS, US Department of Agriculture, 2005), the USDHHS published the 2008 Physical Activity Guidelines for Americans (USDHHS, 2008). This document was the first comprehensive set of PA guidelines put forth by the US government. The guidelines presented recommendations for three different age groups (children and adolescents, adults, and older adults) and incorporated specific recommendations regarding aerobic, muscle-strengthening, and flexibility activities. Unlike previous PA recommendations, the 2008 Physical Activity Guidelines for Americans did not specify a weekly frequency for aerobic PA (e.g., ≥ 5 days/week). Instead, the guidelines simply called for an accumulation of at least 150 min of moderate-intensity PA on a weekly basis, while suggesting that the cumulative duration of PA be spread throughout the week.

The Beneficial Role of Physical Activity During Childhood

In comparison to adults, there is substantially less evidence supporting PA as a means to improve or maintain health during childhood. Despite this, current research suggests children who engage in regular PA enjoy many health benefits. Although no direct cause-and-effect relationship between childhood PA and obesity has been established, lower levels of PA during childhood are associated with greater odds of being overweight or obese (Janssen et al., 2005; Singh, Kogan, Van Dyck, & Siahpush, 2008). Moreover, evidence suggests that being physically active during childhood and adolescence positively influences metabolic risk factors related to type 2 diabetes (Ku, Gower, Hunter, & Goran, 2000; Raitakari et al., 1994). In addition, sufficient amounts of PA are also important for healthy musculoskeletal development during childhood. An adequate stimulus via structured exercise and/or PA can help increase bone accretion during youth and adolescence (D. A. Bailey, McKay, Mirwald, Crocker, & Faulkner, 1999). In turn, greater peak bone mineral density may be attained in early adulthood, helping to reduce the risk or delay the onset of osteoporosis in later life (Hernandez, Beaupré, & Carter, 2003).

Physical Activity as a Mode to Prevent Childhood Obesity

The emerging body of evidence linking childhood obesity to various health risks (e.g., hyperlipidemia, hypertension, diabetes) has motivated researchers to better understand the behavioral factors which moderate these relationships. In particular, PA and sedentariness have been identified as modifiable behaviors which may have substantial impacts on a child's weight status (Dencker et al., 2006; Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005; Klesges, Klesges, Eck, & Shelton, 1995; Moore et al., 2003; Moore, Nguyen, Rothman, Cupples, & Ellison, 1995; Must et al., 2007; O'Loughlin, Gray-Donald, Paradis, & Meshefedjian, 2000). As such, it has been recommended that preschool aged children increase PA and reduce SED time in an effort to help prevent childhood obesity (American Academy of Pediatrics and Council on Sports Medicine and Fitness and Council on School Health, 2006).

Physical Activity Recommendations for Preschool Aged Children

Current guidelines from the USDHHS state that children should accumulate at least 60 min of daily PA, the majority of which should be of a moderate- or vigorous-intensity (USDHHS, 2008). However, these guidelines are only pertinent to the needs of children and adolescents between 6-17 years of age, as no specific recommendations were made for younger children.

Despite the lack of federal PA guidelines for children aged 0-5 years, the National Association for Sport and Physical Education (NASPE) published PA guidelines for children in this age range beginning in 2002 (NASPE, 2002). A recent update to these guidelines has changed minimally and recommends that preschool aged children (3-5 years) accumulate at least 60 min/day of structured PA and at least 60 min/day of unstructured PA (NASPE, 2009). Additionally, the guidelines call for limiting waking SED bouts to no more than 60 min/bout. Although no qualification about PA intensity is made within the NASPE guidelines, it is recommended that preschoolers engage in indoor and outdoor activities which develop fundamental motor skills.

An important location for children to be physically active in an attempt to meet current NASPE guidelines is the childcare setting (Ward, 2010; Ward et al., 2010). Presently, the childcare environment is primarily evaluated on the basis of its safety and compliance with licensure requirements (Ammerman et al., 2007). However, regulations and licensure requirements for PA at childcare centers are essentially non-existent. Therefore, childcare facilities aiming to improve their PA environments must accomplish such tasks through voluntary or self-initiated efforts.

Evidence of Low Physical Activity Levels in Childcare Settings

In general, the current body of research among preschool aged children has indicated that PA levels within childcare settings are typically very low (Reilly, 2010). Objective assessments across a variety of preschool aged populations have shown that most children accumulate less than 60 min of moderate-to-vigorous PA (MVPA) per 8 hr in childcare (Alhassan et al., 2007; Cardon & De Bourdeaudhuij, 2007; Dowda et al., 2004; K. J. Finn & Specker, 2000; McKee et al., 2005; Pate et al., 2004; Reilly et al., 2006; Trost et al., 2008). However, as previously noted, NASPE guidelines do not qualify a required intensity of PA to accompany their recommendations for daily PA durations. This dilemma clouds any potential judgments about the adequacy of preschoolers PA in childcare settings (Beets, Bornstein, Dowda, & Pate, 2011).

Further confusing the issue regarding PA adequacy during childcare is the substantial variability in reported levels of childcare-related PA within the current literature. Reported levels of objectively measured MVPA have ranged from less than 5 min to greater than 55 min per 8 hr in childcare (K. J. Finn & Specker, 2000; Pate et al., 2004). Evidence suggests this substantial variability in childcare-related PA may be the result of systematic differences between facilities (Cardon, Van Cauwenberghe, Labarque, Haerens, & De Bourdeaudhuij, 2008; Pate et al., 2004; Worobey, Worobey, & Adler, 2005). However, this conclusion is tenuous as it relies on comparing studies that used different PA assessment techniques which could have substantially influenced PA estimates. Furthermore, recent evidence has suggested that childcare providers may have more influence on children's PA than the childcare facility itself (Copeland, Kendeigh, Saelens, Kalwarf, & Sherman, 2012).

Despite the many issues complicating potential judgments of PA adequacy during childcare, currently reported PA levels among preschoolers can be evaluated against NASPE guidelines (2009) after the acceptance of several assumptions. First, if it is assumed that PA is spread equally throughout the day, children should accumulate approximately two-thirds of their daily PA during every 8 waking hours at childcare (based on 12 hr of daily wake time). This assumption takes into consideration current recommendations which call for 11-13 hr of daily sleep among 3-5 year-old children (National Sleep Foundation, 2011). Second, it must be further assumed that the minimum 120 min/day of accumulated PA recommended by NASPE guidelines be in the form of MVPA. After taking into consideration these two assumptions, preschoolers should accumulate approximately 70-80 min of MVPA during every 8 waking hours in childcare. Although the development of this adequacy threshold relies on several assumptions, it is clear that currently reported levels of MVPA in childcare fall well below 70-80 min per 8 waking hours.

Physical Activity Assessment in Children

A variety of different assessment methods have been developed to measure PA. In general, these methods can be separated into two measurement categories: 1) PA assessment or 2) energy expenditure assessment (LaMonte & Ainsworth, 2001). Assessing PA consists of measuring a particular behavior, whereas energy expenditure assessment entails measuring the energy cost of a particular behavior (Ainsworth, 2010). Examples of methods which can be used to measure PA include: 1) accelerometry, 2) pedometry, 3) global positioning systems, 4) direct observation, 5) PA recalls, 6) PA logs, and 7) PA questionnaires. Energy expenditure measurement methods include: 1) whole room calorimetry, 2) doubly labeled water, and 3) indirect calorimetry. The aforementioned lists of PA and energy expenditure measurement methods are by no means exhaustive, but represent the majority of methods commonly used in currently published research.

Energy expenditure and PA assessment methods can be further sub-classified as either subjective or objective measures (Ainsworth, 2010). Subjective PA measures include all those methods which rely on proxy- or self-reports of PA. Examples of subjective PA measures include PA recalls, logs, and questionnaires. In contrast, objective measures of PA or energy expenditure utilize devices, tools, or scientific measurement techniques that are not reliant on subjective human reports. Whole room calorimetry, doubly labeled water, and indirect calorimetry are all examples of objective energy expenditure measures. Objective PA measures include accelerometry, pedometry, direct observation, heart-rate monitoring, and global positioning systems.

Despite the multitude of available techniques to measure PA or energy expenditure, many are unsuitable for use with preschool aged children (Pate, O'Neill, & Mitchell, 2010). As an example, serious concerns regarding the validity and reliability of subjective PA self-reports among young children make them unfeasible for use in this population (Pate, 2007; Sallis, 1991; Welk, Corbin, & Dale, 2000). Moreover, other objective methods of measuring energy expenditure, such as whole room calorimetry, indirect calorimetry, and doubly labeled water, typically involve a high degree of participant burden. As such, using these assessment methods with preschool populations is impractical in most situations. Unfortunately, there is no universally agreed upon method for assessing PA in preschool aged children (Oliver, Schofield, & Kolt, 2007). As a result, many different PA assessment methods have been used to evaluate preschoolers' PA levels within the current literature. This inter-study variability in assessment methodologies makes comparisons between studies problematic. Despite these issues, accelerometry and direct observation are well accepted PA measures which have become the most commonly used methods to assess preschoolers' PA.

Direct Observation

Direct observation is used to describe PA behaviors without any input from the participant(s) being observed (Ainsworth, 2010). Among young children, direct observation is generally accepted as a "criterion" PA measure because of its comprehensive and practical nature (Sirard & Pate, 2001). Direct observation requires a trained observer to record the PA behavior of an individual(s) over a specified time period, lasting anywhere from 30 min to an entire day (Pate et al., 2010). Specific coding schemes are usually employed to describe the characteristics of the PA being observed. Information obtained from direct observation can include the context, intensity, location, and type of PA being observed. A number of direct observation tools have been developed to assess PA among young children: the Behaviors of Eating and Activity for Children's Health Evaluation System (BEACHES; McKenzie et al., 1991), the Children's Activity Rating Scale (CARS; Puhl, Greaves, Hoyt, & Baranowski, 1990), the Children's Physical Activity Form (CPAF; O'Hara, Baranowski, Simons-Morton, Wilson, & Parcel, 1989), the Fargo Activity Timesampling Survey (FATS; Klesges et al., 1984), the Observational System for Recording Physical Activity in Children-Preschool Version (OSRAC-P; Brown et al., 2006), and the Studies of Children's Activity and Nutrition-Children's Activity Time sampling method of observation (SCAN-CAT; Klesges, Eck, Hanson, Haddock, & Klesges, 1990).

One of the most widely used PA direct observation measures is CARS (Oliver, Schofield, & Kolt, 2007). This tool has served as the criterion measure of preschoolers' PA in a number of validation studies for accelerometers (K. J. Finn, Finn, & Flack, 2001; K. J. Finn & Specker, 2000; Noland, Danner, DeWalt, McFadden, & Kotchen, 1990; Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005) and pedometers (Louie & Chan, 2003; McKee et al., 2005; Oliver, Schofield, Kolt, & Schluter, 2007). The CARS allows for the categorization of PA across a range of intensity levels: 1) resting, 2) low, 3) medium, 4) medium-to-high, and 5) vigorous (Puhl et al., 1990). Another commonly used direct observation tool for assessing preschoolers' PA is the CPAF, which has been used as the criterion measure of PA in several accelerometer validation studies (Fairweather, Reilly, Grant, Whittaker, & Paton, 1999; Kelly, Fairweather, Grant, Barrie, & Reilly, 2004; Reilly et al., 2003). Like CARS, the CPAF classifies PA across a range of intensities: 1) stationary – no movement, 2) stationary – limb movement, 3) slow trunk movement, and 4) rapid trunk movement (O'Hara et al., 1989). However, a limitation of both the CARS and CPAF instruments is that they only measure PA intensity without assessing other characteristics of the observed behavior (Pate et al., 2010).

Other direct observation systems, such as the BEACHES, FATS, OSRAC-P, and SCAN-CAT, measure additional PA characteristics beyond activity intensity. The FATS instrument represents the first attempt to develop a direct observation tool to assess children's PA and related parental behavior (Klesges et al., 1984). A later development by the same research group was the SCAN-CAT, which measures PA across four domains: 1) intensity, 2) environment, 3) participants and those in the child's presence, and 4) type of interaction (e.g., PA promoting or PA deterring; Klesges, Eck, et al., 1990). The BEACHES instrument, developed by McKenzie and co-workers (1991), represents the most comprehensive direct observation tool for assessing children's PA. The BEACHES instrument measures a number of different PA characteristics, such as the activity level, physical location, and involvement of other people.

Validation studies of direct observation instruments have been conducted using a variety of different criterion measures. The CARS instrument was validated against indirect calorimetry (Puhl et al., 1990) and several different accelerometers (K. J. Finn et al., 2001; Noland et al., 1990). Conversely, the CPAF and BEACHES instruments were validated against a questionable criterion measure in heart-rate telemetry (McKenzie et al., 1991; O'Hara et al., 1989).

The main advantage of direct observation for PA assessment is its ability to measure a variety of different PA characteristics, such as the PA type, intensity, and environment (Pate et al., 2010). Additionally, direct observation can be used in both home and preschool settings (Brown et al., 2006; McKenzie et al., 1991). Disadvantages of direct observation include long durations of observer training and in-person data collection (Pate et al., 2010). In addition, some participants may exhibit reactivity when being observed (Puhl et al., 1990).

Accelerometers

Accelerometers used in PA assessments are electro-mechanical devices which can provide an objective measure of PA when worn on the body (Ainsworth, 2010). Specifically, accelerometers measure the rate and magnitude of physical movement. Accelerometry has been extensively used as an objective PA measure in preschool aged children (Oliver, Schofield, & Kolt, 2007; Pate et al., 2010). Accelerometers are lightweight, small, and unobtrusive devices which children can wear quite easily. The devices are typically worn on an elastic waist-belt and placed in front of the right hip (Kelly et al., 2007; Pate et al., 2004;

Toschke, von Kries, Rosenfeld, & Toschke, 2007). Accelerometer users can specify a data collection interval (epoch) before initializing the device to allow for the collection of detailed information regarding the duration and intensity of PA. Output for each epoch is expressed as a dimension-less unit, "counts," which can be used to characterize the PA intensity for a given epoch (Troiano, 2006).

Accelerometers used to measure PA come in several varieties. Uniaxial accelerometers measure movement in the vertical plane. Biaxial and triaxial accelerometers can measure movement in the vertical, anterior-posterior, and/or medial-lateral planes, with outputs given for each distinct plane as well as an overall composite vector. In addition, omnidirectional accelerometers can measure movement in all three planes, but only provide output for a composite vector (K. Y. Chen & Bassett, 2005; Crouter, Churilla, & Bassett, 2006). However, omnidirectional accelerometers have the highest movement sensitivity in a single plane, which is directionally dependent upon the physical orientation of the device (Crouter et al., 2006). Commercially available accelerometers frequently used for PA research include the uniaxial ActiGraph (ActiGraph LLC, Pensacola, FL), the triaxial RT3 (Stayhealthy Inc., Monrovia, CA), and the omnidirectional Actical and Actiwatch devices (Mini Mitter Company Inc., Bend, OR; Rowlands & Eston, 2007).

Several studies have indicated that triaxial accelerometers may provide better estimates of children's PA than uniaxial accelerometers (Eston, Rowlands, & Ingledew, 1998; Louie et al., 1999; Ott, Pate, Trost, Ward, & Saunders, 2000). Despite this, differences between uniaxial and triaxial accelerometers appear to be small, as the two measures are strongly correlated, and are generally providing similar information (Trost, McIver, & Pate, 2005). However, this conclusion may not be valid in all circumstances as evidence suggests that uniaxial accelerometer counts may plateau or decline at high horizontal velocities (Brage, Wedderkopp, Andersen, & Froberg, 2003; Brage, Wedderkopp, Franks, Andersen, & Froberg, 2003). This is most likely attributable to a dampening of vertical acceleration at high rates of horizontal displacement (Brage, Wedderkopp, Franks, et al., 2003). In such cases, a triaxial accelerometer would not be adversely affected by the dampening of vertical acceleration as the increase in horizontal velocity would be reflected in the composite vector measured by the device. Despite potential concerns surrounding this dampening effect when using uniaxial accelerometers, the relevance of this phenomenon to the measurement of children's PA has yet to be determined (Rowlands & Eston, 2007).

Only two PA accelerometers have been validated for use with preschool children. The ActiGraph has demonstrated high validity in comparison to indirect calorimetry and direct observation for the measurement of vigorous PA (VPA; Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006), MVPA (Pate et al., 2006), and SED behavior (Reilly et al., 2003) in preschool aged children. Research by Pfeiffer, McIver, Dowda, Almeida, and Pate (2006) also validated the Actical against indirect calorimetry for measuring MVPA and VPA among preschoolers. However, the Actiwatch and Computer Science Applications (CSA – former name for ActiGraph) accelerometers have demonstrated poor validity in comparison to doubly labeled water for measuring energy expenditure in young children (Lopez-Alarcon et al., 2004; Montgomery et al., 2004).

In order to evaluate the PA of participants using accelerometer assessments, cut points must be chosen to interpret outputted counts by delineating the boundaries between different intensities of activity. Several validation studies among preschool aged children have developed both absolute and age-specific accelerometry cut points for classifying PA levels

(Pate et al., 2006; Pfeiffer et al., 2006; Reilly et al., 2003; Sirard et al., 2005; Van Cauwenberghe, Labarque, Trost, De Bourdeaudhuij, & Cardon, 2011). It has yet to be determined whether a specific set of cut points are superior to the rest; however, appropriate cut points must be chosen based upon the specific accelerometer used, the population being assessed, and the research questions being asked. In general, an epoch length of 15 s or less is recommended with this age group (Pate et al., 2010; Vale, Santos, Silva, Soares-Miranda, & Mota, 2009) in order to adequately measure the intermittent bursts of MVPA common among young children (R. C. Bailey et al., 1995; Berman, Bailey, Barstow, & Cooper, 1998; Trost, 2001; Welk et al., 2000).

The main advantage of accelerometry for assessing PA is its ability to avoid biases introduced from techniques like proxy- or self-reports, while providing an objective measure of PA (Pate et al., 2010). Accelerometers can be used to quantify the intensities and patterns of children's PA for an extended period of time (e.g., 1 week) among a large number of participants. Physical risks from wearing accelerometers are minimal; however, there is a potential for participant reactivity to the device (Pate et al., 2010). The main disadvantage of accelerometers is their inability to measure the type or context of PA. Moreover, accelerometer assessments with preschool children put an additional burden on parents and staff members to ensure the devices are worn properly (Oliver, Schofield, Kolt, et al., 2007; Pate et al., 2010).

Pedometers

Pedometers, otherwise known as step counters, like accelerometers, can be used to objectively measure PA. Pedometers measure the frequency of movement in the vertical plane but cannot measure movement intensity or duration (Pate et al., 2010). Vertical motion above a threshold level is recorded by a pedometer as a "step." Steps are typically recorded continually and added to a running total. Similar to accelerometers, pedometers are small, lightweight, and can be worn when attached to an elastic waist-belt.

Current evidence indicates that pedometers can be used to adequately assess PA in preschoolers (Pate et al., 2010). Work by Cardon and DeBourdeaudhuij (2007) demonstrated that pedometer derived step counts were highly correlated (r = 0.73) with accelerometer measured MVPA. Moreover, results from several studies indicated that pedometer step counts and the CARS direct observation system were strongly correlated, with correlation coefficients ranging from 0.59-0.86 (Louie & Chan, 2003; McKee et al., 2005; Oliver, Schofield, Kolt, et al., 2007).

Pedometers offer several advantages over other PA assessment methods when used with preschool aged children. Collected data from pedometers are easier to interpret than data from accelerometers (Pate et al., 2010). Furthermore, no pre-use initialization or data downloading is required and there is minimal participant burden. Perhaps the most attractive feature of pedometers is their relatively low cost per device in comparison to accelerometers. Despite these advantages, as previously noted, pedometers only measure the frequency of movement and cannot measure movement intensity. In addition, preschool aged children may wish to tamper with the pedometer or reset the step counter (Pate et al., 2010). However, research conducted with elementary school children indicated there was no participant reactivity to either sealed or unsealed pedometers (Ozdoba, Corbin, & Le Masurier, 2004; Vincent & Pangrazi, 2002).

Proxy-Reports

As previously mentioned, PA should not be assessed using self-report with preschool aged children (Pate, 2007; Sallis, 1991; Welk et al., 2000). However, a number of studies have evaluated proxy-reports of PA for preschool aged children in relation to PA measured by pedometers (Saris & Binkhorst, 1977), accelerometers and/or direct observation (Burdette, Whitaker, & Daniels, 2004; X. Chen et al., 2002; Klesges, Haddock, & Eck, 1990), and measured energy expenditure via doubly labeled water (Goran, Hunter, Nagy, & Johnson, 1997). Despite the multitude of studies evaluating PA proxy-reports among young children, no standardized questionnaire for use by a proxy (e.g., parent/guardian, childcare provider, teacher, etc.) has been developed and sufficiently evaluated to justify its use (Oliver, Schofield, & Kolt, 2007). Still, the use of proxy approaches to assess PA among preschoolers warrants further research (Oliver, Schofield, & Kolt, 2007), but results using such measures need to be interpreted carefully (Pate et al., 2010).

Seasonal Changes in Preschoolers' Physical Activity

Literature examining seasonal changes in PA among preschool aged children is limited. However, it is certainly plausible that variations in daylight hours, precipitation, and temperature influence PA behavior (Yusuf et al., 1996). More specifically, windy and cold weather climates typically experienced in the Northern US and parts of Canada may act as a deterrent to PA (Tucker & Gilliland, 2007). Unfortunately, only three published studies have assessed preschoolers' PA across seasons (Baranowski et al., 1993; Fisher et al., 2005; Poest et al., 1989).

Data from parental and teacher proxy-reports of preschoolers' PA in Ohio indicated that children (*N* = 514) were significantly less active in winter than during spring, summer, or fall (Poest et al., 1989). Results from this investigation need to be interpreted with caution though due to methodological concerns surrounding the use of proxy-reports for PA in young children (Oliver, Schofield, & Kolt, 2007; Pate et al., 2010). A more recent investigation by Baranowski and co-workers (1993) did report seasonal changes in preschoolers' PA using direct observation methodologies. Children (*N* = 191, aged 3-4 years) in this investigation were less active during summer than winter. However, this study only observed children from a small coastal region in the state of Texas, which limits the generalizability of the study's findings.

The most recent investigation to examine for seasonal differences in preschoolers' PA was conducted by Fisher and colleagues (2005) in Glasgow, Scotland. Four independent samples of children (*N* = 209, *M* ± *SD* age = 4.8 ± 1.2 years) had their PA objectively assessed using accelerometers for 3-6 days in the spring, summer, fall, or winter. Findings indicated that total PA was significantly lower during spring than all other seasons, while sedentary time was significantly higher in the spring than during summer or fall. However, the magnitude of observed seasonal differences in PA and sedentary time in this study were rather small. Moreover, although significant changes in temperature, daily hours of sunshine, and daily quantities of precipitation were found across seasons, the authors concluded that seasonal climatic variation was not a major barrier to PA among their sample.

Despite the lack of evidence indicating the existence of substantial seasonal variability in preschoolers' PA, it does seem plausible and likely that preschoolers' activity levels change across seasons; however, the potential mechanism(s) for such a change is not fully understood. Seasonal weather variations may have a mediating impact on preschoolers' PA by decreasing outdoor play time (Tucker & Gilliland, 2007), which has been strongly correlated with preschoolers' PA levels (Baranowski et al., 1993). However, preschool aged children require adult supervision and parents have reported a lack of interest in spending time outdoors in the cold (Irwin, He, Bouck, Tucker, & Pollett, 2005). Moreover, parents have indicated that warmer seasons are more conducive to preschoolers' PA, while colder seasons present more challenges (Irwin et al., 2005). To address this concern, increasing PA opportunities at indoor facilities has been identified as a potential method for fomenting year-round PA participation (Tucker, Irwin, Sangster Bouck, He, & Pollett, 2006).

Childcare Physical Activity Interventions

Published studies evaluating PA interventions in childcare settings have focused on several different health-related goals, such as improved bone health, obesity prevention, and increased PA (Ward et al., 2010). To date, 11 published investigations have used targeted interventions attempting to increase PA in childcare settings while employing assessment techniques to measure changes in the quantity and/or intensity of PA. A total of 7 of these 11 studies have evaluated the effectiveness of particular PA curriculums or movement programs (Binkley & Specker, 2004; Deal, 1993; Eliakim et al., 2007; Fitzgibbon et al., 2005, 2006; Parish, Rudisill, & St. Onge, 2007; Reilly et al., 2006), while 4 studies examined the effectiveness of environmental or policy changes on impacting PA levels (Alhassan et al., 2007; Cardon et al., 2009; Hannon & Brown, 2008; Trost et al., 2008).

Curriculum-based Interventions

Curriculum-based PA interventions in the childcare setting have shown mixed results. Deal (1993) demonstrated that participants in The Preschool Mover program, a 2 hr movement session incorporating various activities (e.g., gymnastics, climbing, etc.), were significantly more active (higher monitored heart-rate) during the movement session in comparison to children in a day care program measured at the same time of day. However, the sample size for this investigation was small (*N* = 33, aged 3-5 years, movement program [*n* = 15], day care program [*n* = 18]) and participants were not randomized to groups.

Another curriculum-based intervention utilizing heart-rate monitors to measure preschoolers' PA was conducted by Parish and colleagues (2007). Heart-rates of 21 children (aged 1.5-3.2 years) were measured during six mastery motivational physical play sessions and six unstructured free play sessions over 3 weeks. The mastery play sessions consisted of various activities (e.g., climbing a cargo net, kicking balls into a net, jumping down from platforms, etc.), while teachers administering the sessions provided evaluative feedback and encouragement. Mean heart-rate during the mastery play sessions was 15 beats per minute higher than during free play sessions. However, no control group was used and the sample was relatively small. In addition, the validity of using heart-rate monitors to assess PA can be questioned since heart-rate is influenced by many factors other than PA or movement (Dishman, Heath, & Washburn, 2004).

Other curriculum-based childcare PA interventions have utilized proxy-report measures to quantify PA. Fitzgibbon and colleagues (2005, 2006) used parental proxy-reports of children's PA with the Hip-Hop to Health Jr. intervention. Two large samples of predominantly African-American (*N* = 409, aged 2-5 years) and Latino children (*N* = 401, aged 3-5 years) took part in separate studies that randomized head start programs to intervention (Hip-Hop to Health Jr.) or control conditions. The Hip-Hop to Health Jr. intervention was implemented for 14 weeks in each study and consisted of 45 min sessions, 3 days/week, with 20 min devoted to nutrition education and 20 min devoted to PA. Cumulative results demonstrated some favorable effects post-intervention among the predominantly

African-American cohort (Fitzgibbon et al., 2005), with smaller increases in BMI occurring among intervention children in comparison to control children. However, no such benefit was demonstrated among the predominantly Latino cohort (Fitzgibbon et al., 2006). Moreover, there were no significant differences in the frequency and/or intensity of parental reported PA between intervention and control conditions at baseline, 1-year follow-up, or 2-years follow-up for both cohorts.

The three curriculum-based PA intervention studies yet to be reviewed all used motion sensing devices to assess PA. Binkley and Specker (2004) examined the effectiveness of PA and calcium supplementation on children's bone health. With respect to the PA intervention, children (*N* = 178, aged 3-5 years) at 11 childcare centers were randomly assigned to a gross-motor or fine-motor group. Both the gross-motor and fine-motor groups completed activity sessions lasting 30 min, 5 days/week, for 12 months. The gross-motor group completed bone loading activities such as hopping, jumping, and skipping during activity sessions. In contrast, the fine-motor group completed activities which were usually performed in a seated position (e.g., arts and crafts) during the activity sessions. Accumulated PA was assessed using Actiwatch accelerometers for 2 days at baseline, intervention mid-point, intervention completion, 6 months post-intervention, and 12 months post-intervention. Participants in the gross-motor group demonstrated significantly higher VPA at intervention completion and 6 months post-intervention in comparison participants in the fine-motor group.

Another curriculum-based childcare PA intervention was conducted by Reilly et al. (2006) in Scotland. Obesity prevention was the primary aim of this study. Children (*N* = 545, *M* age = 4.2 years) from 36 nursery schools participated in a 24-week protocol. Nursery schools were randomized to an intervention (*n* = 268) or control condition (*n* = 277). The intervention consisted of 30 min PA sessions delivered 3 days/week. The general focus of the intervention was to increase PA and fundamental movement skills. Participants wore ActiGraph accelerometers for 6 days at baseline and at 6 months post-intervention. There were no significant differences in mean values of absolute PA between control and intervention conditions at 6 months post-intervention.

The most recent curriculum-based childcare PA intervention was conducted by Eliakim and colleagues (2007) in Israel as part of an obesity prevention program. Children (*N* = 101, aged 5-6 years) from four preschool classes participated in the 14-week study. Children were randomized to an intervention (*n* = 54) or control (*n* = 47) condition. The intervention consisted of 45 min activity sessions, 6 days/week, with two sessions per week led by trained personnel. Sessions consisted of indoor and outdoor exercise circuits emphasizing endurance, coordination, and flexibility exercises, with PA assessed using pedometers. Intervention group children accumulated significantly more steps during and after preschool than those in the control group.

Review of Curriculum-based Interventions. Although both investigations utilizing heart-rate monitors to assess PA showed positive intervention effects (Deal, 1993; Parish et al., 2007), each had small sample sizes and relatively weak research designs. Conversely, the two investigations by Fitzgibbon and colleagues (2005, 2006), using the Hip-Hop to Health Jr. intervention, had much stronger research designs, yet showed limited positive effects. However, these results could be largely influenced by the very poor measure of PA (parental report of child's PA) used by Fitzgibbon et al. (2005, 2006)

Similar to the investigations by Fitzgibbon and colleagues (2005, 2006), the large-scale intervention by Reilly et al. (2006) had a very strong research design and large sample size. Despite this, the intervention did not significantly affect preschoolers' PA. This finding came as a surprise considering the intervention's success during its initial pilot (Reilly & McDowell, 2003). The investigations by Binkley and Specker (2004) and Eliakim et al. (2007) were the only two curriculum-based PA interventions using motion sensing devices to show positive results. Interestingly, increased PA was not the primary goal for either intervention.

Environmental/Policy Interventions

Unlike the curriculum-based interventions mentioned above, the primary goal of all published studies evaluating childcare-based environmental or policy PA interventions was to increase childcare PA. However, similar to the curriculum-based PA interventions, studies evaluating environmental or policy interventions displayed mixed results. The first study utilizing policy change in an attempt to increase childcare-related PA was conducted by Alhassan, Sirard, and Robinson (2007). Latino children (*N* = 33, aged 3-5 years) at one head-start facility were randomized to an intervention (*n* = 18) or control condition (*n* = 15). The intervention lasted for 2 days. Children in the intervention group received two additional 30 min outdoor recess periods (morning and afternoon), while the control group maintained their normal daily schedule. Actigraph accelerometers were used to measure PA for both groups during the 2 day intervention. Results during the intervention indicated there were no significant differences in PA between the intervention and control groups while at school, after school, or for the entire day.

Hannon and Brown (2008) conducted an investigation into the usefulness of adding additional playground equipment at a preschool in an attempt to increase PA. Children (*N* = 64, aged 3-5 years) at a university preschool participated in the study. Approximately $1,000 worth of portable playground equipment was setup at the preschool's outdoor playground for 5 days. Actigraph accelerometers were used to assess PA for 5 days before and during the intervention. Light PA, moderate PA, and VPA all significantly increased from pre to post, while SED time significantly decreased by 16%.

As a follow-up to the investigation by Hannon and Brown (2008), Cardon and colleagues (2009) examined the effects of providing additional playground equipment and playground markings on preschoolers' PA levels. Forty public preschools were randomized to one of four conditions: 1) preschools were provided with playground markings, 2) preschools were provided with supplementary playground equipment, 3) preschools were provided with playground markings and supplementary playground equipment, and 4) preschools received no intervention and served as control sites. Preschoolers' (N = 583, $M \pm SD$ age = 5.3 ± 0.4 years) PA during recess was assessed using accelerometry prior to the intervention and 4-6 weeks following the intervention's implementation. None of the intervention conditions were effective in increasing PA levels or decreasing SED time.

The final environmental/policy childcare PA intervention reviewed here was conducted by Trost and colleagues (2008). In this investigation, children (N = 42) from four preschool classrooms were randomized to a control (2 classrooms [n = 22]) or intervention group (2 classrooms [n = 20]). Teachers in intervention classrooms participated in a 3 hr training session which detailed different techniques and methods to incorporate PA into the preschool curriculum. The overall goal of the intervention was to include at least two 10 min PA-oriented lessons into each day's curriculum for a period of 8 weeks. Accumulated PA was assessed with ActiGraph accelerometers worn 2 days/week for 2 weeks preceding the intervention. In addition, accelerometers were worn for 2 days/week during the 8-week intervention period. Results indicated that MVPA was significantly greater at weeks 7 and 8 among the intervention group in comparison to the control group.

Review of Environmental/Policy Interventions. Besides the investigation by Cardon and colleagues (2009), the aforementioned environmental/policy PA interventions can most aptly be described as feasibility or pilot studies (Ward et al., 2010). As such, it is not surprising that these investigations had relatively weak research designs. Providing more recess time had no effect on PA levels. However, supplemental portable playground equipment and PA-oriented teacher training showed positive results in the short term.

Rationale for Assessments of Physical Activity Across Seasons

Only three published studies have examined for seasonal differences in preschoolers' PA. Although results from these studies indicate that preschoolers' PA levels may change across seasons (Baranowski et al., 1993; Fisher et al., 2005; Poest et al., 1989), concerns surrounding the generalizability of findings from these investigations suggest more research in this area is needed. Moreover, no published investigations have longitudinally assessed preschoolers' PA levels during childcare across seasons using accelerometry. Therefore, the first purpose of this dissertation was to prospectively track preschoolers' PA levels during childcare while investigating for seasonal differences in accelerometer measured PA between the fall and winter months in Fargo, North Dakota.

Rationale for Physical Activity Interventions in Childcare Settings

The primary justification for evaluating the efficacy and feasibility of PA interventions among preschoolers is the lack of success a number of previous interventions have demonstrated (Alhassan et al., 2007; Cardon et al., 2009; Fitzgibbon et al., 2005, 2006; Reilly et al., 2006). A common theme among interventions which did not improve preschoolers' PA was that PA program components were often implemented in large time blocks (30-45 min). Conversely, one childcare-based PA intervention that demonstrated some of the most promising results incorporated program components lasting only 10 min in duration (Trost et al., 2008). Therefore, the second purpose of this dissertation was to evaluate the feasibility of a novel dance-based intervention for increasing PA and reducing SED time in childcare using short activity breaks (< 10 min) interspersed throughout the childcare day.

PAPER 1. SEASONAL CHANGES IN PRESCHOOLERS' PHYSICAL ACTIVITY AND SEDENTARY TIME AT CHILDCARE

Physical activity (PA) guidelines from the United States (US) Department of Health and Human Services (USDHHS) recommend that children accumulate a minimum of 60 min of daily PA at moderate- or vigorous-intensities (USDHHS, 2008). This recommendation is only applicable to children and adolescents aged 6-17 years, as no guidelines for preschool aged children (3-5 years) have been published by the USDHHS. However, the National Association for Sport and Physical Education (NASPE) has developed and published PA guidelines for children 0-5 years of age (NASPE, 2002, 2009). The NASPE guidelines recommend that 3-5 year-old children accumulate at least 60 min/day of structured PA and at least 60 min/day of unstructured PA from a combination of indoor and outdoor activities (NASPE, 2009). The guidelines also recommend that preschool aged children limit waking sedentary (SED) bouts to no more than 60 min/bout.

The ability of a child to meet current PA guidelines is dependent upon many factors, such as the external environment. Objective monitoring studies have demonstrated that children's activity levels change in different environments while tending to be lower on weekend days than weekdays (Gavarry, Giacomoni, Bernard, Seymat, & Falgairette, 2003; Rowlands, Eston, & Ingledew, 1999; Rowlands, Pilgrim, & Eston, 2009) and higher during the summer than winter (Rowlands & Hughes, 2006; Rowlands et al., 2009). Seasonal differences in PA may result from changes in temperature, precipitation, and daylight hours (Yusuf et al., 1996). Specifically, windy and cold weather climates typically experienced in the Northern US, Europe, and parts of Canada may act as an impediment to PA (Tucker &

Gilliland, 2007). In addition, there is evidence that excessive heat may act as a barrier to PA as well (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993).

Proxy-reports of preschoolers' PA have indicated that children were significantly less active in winter than during spring, summer, or fall (Poest, Williams, Witt, & Atwood, 1989). However, results from proxy-reports need to be interpreted with caution considering well justified concerns about their validity and overall utility (Oliver, Schofield, & Kolt, 2007; Pate, O'Neill, & Mitchell, 2010). Despite this, one previous longitudinal investigation did report lower levels of PA among preschoolers during summer than winter using direct observation (Baranowski et al., 1993). In addition, a cross-sectional study by Fisher et al. (2005) reported that accelerometer measured PA among preschoolers was significantly lower in the spring than during all other seasons. Considering this evidence, it does seem plausible and likely that seasonal weather variation does influence preschoolers' PA in a variety of settings. Inclement weather may have a mediating influence on preschoolers' PA by decreasing time spent outdoors (Tucker & Gilliland, 2007), which has been strongly associated with PA levels among preschoolers and older children. (Baranowski et al., 1993; Cleland et al., 2008).

An important location where preschoolers' PA could be negatively influenced by seasonal forces (e.g., temperature, precipitation, daylight hours, etc.) is the childcare setting, as approximately 61% of American children 0-6 years old receive non-parental childcare on a regular basis (Federal Interagency Forum on Child and Family Statistics, 2010). Previous research using objective monitoring methods has demonstrated that PA levels within the childcare setting are typically low with most studies reporting an average of less than 60 min of moderate-to-vigorous PA (MVPA) for every 8 hr in childcare (Alhassan, Sirard, &

Robinson, 2007; Cardon & De Bourdeaudhuij, 2007; Dowda, Pate, Trost, Almeida, & Sirard, 2004; K. J. Finn & Specker, 2000; McKee, Boreham, Murphy, & Nevill, 2005; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Reilly, 2010; Reilly et al., 2006; Trost, Fees, & Dzewaltowski, 2008). These observations of low childcare PA may be influenced by seasonal forces; however, no observational studies have longitudinally assessed preschoolers' childcare-related PA across seasons using wearable monitors.

Therefore, the purpose of this study was to prospectively track preschoolers' PA levels during childcare while investigating for seasonal differences in accelerometer measured PA between the fall and winter months in Fargo, North Dakota. This locale was chosen as a point of interest due to its potential for extreme seasonal temperature variations (*M* daily temperature - January = -12.72 °C, July = 21.6 °C; National Weather Service, 2012b). We hypothesized that preschoolers in this sample would be less physically active and more sedentary during winter than fall.

Methods

Study Design

This study was conducted over a 4 month period with PA assessments in the childcare setting occurring at two time points. The first data collection occurred in October/November 2011 (fall) and the second data collection occurred 12 weeks later in January/February 2012 (winter). All PA assessments were completed within a 3-week period at each time point.

Setting and Recruitment

The study was conducted at four childcare centers offering preschool services in Fargo, North Dakota. Eight licensed childcare centers were initially recruited to participate in the study. Of the six centers agreeing to participate, four were randomly selected to take part in the study. The study was conducted in all preschool rooms (10-12 children per room) within the four participating facilities.

All parents of 3-5 year-old children in preschool rooms within the four childcare centers were given a letter introducing and describing the study three weeks prior to the study start date. The following week a research team member attended each childcare center for an informational session to answer questions from parents and childcare providers about the study. Parents were provided with informed consent packets at the informational sessions (*Appendix A*). Interested parents were asked to sign and return informed consent documents before their child could participate. Those parents who signed informed consent documents were asked to fill out a short survey about their child before the start of the study (*Appendix B*). The study protocol was approved by the North Dakota State University – Institutional Review Board before recruitment began (*Appendix C*).

Participants

Of the 98 informed consent packets distributed to parents, 80 were signed and returned by parents of children from the four childcare centers. Five of the 80 children whose parents returned informed consent documents were excluded from participating for not meeting the age requirement (3-5 years). A total of 75 children (40 boys, 35 girls; $M \pm SD$ age = 4.22 ± 0.72 years) participated in the study. The sample was comprised of primarily Caucasian children (89.3%) with smaller proportions of mixed-race (6.7%), African-American (2.7%), Hispanic (1.3%), and Native American children (1.3%).

Physical Activity Assessment

Accumulated PA was objectively assessed using an ActiGraph accelerometer (ActiTrainer model [8.6 cm x 3.3 cm x 1.5 cm; 51 g]; Actigraph LLC, Pensacola, FL). The

ActiGraph is a solid state accelerometer which can effectively measure acceleration in the vertical plane over a dynamic range of ± 3 g (Actigrah LLC, 2011). The device adequately detects normal human motion while rejecting high-frequency vibrations caused by automated machinery (e.g., operation of an automobile). Vertical plane acceleration is digitized by the accelerometer at a frequency of 30 Hz, while being filtered and integrated through a user-specified summary data collection interval referred to as an epoch.

Previous research has demonstrated that the Actigraph has acceptable reliability and validity for quantifying PA among preschool aged children (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005). An epoch length of 15 s is generally recommended for accelerometry assessments among preschool aged children (Pate et al., 2010). However, children’s PA is highly sporadic with the vast majority of moderate- or higher-intensity activities occurring in bouts lasting less than 10 s (Bailey et al., 1995; Berman, Bailey, Barstow, & Cooper, 1998). Therefore, a 5 s data collection epoch was chosen for use in this study to better capture the intermittent PA patterns of preschoolers (Vale, Santos, Silva, Soares-Miranda, & Mota, 2009).

Protocol. Children whose parents returned signed informed consent documents were asked to wear an accelerometer during their attendance at preschool for 5 days (Monday through Friday) at the fall and winter assessment periods. A trained research assistant fitted participating children with an adjustable elastic waist-belt and attached accelerometer at the beginning of each day. Accelerometers were positioned directly in front of each child’s right hip. Elastic waist-belts and attached accelerometers were removed at the start of naptime and children were refitted with the devices at the conclusion of naptime. The research assistant removed the accelerometers as children left the childcare center each day. Time of arrival and departure from the childcare center for all participating children was recorded each day. A separate form was used to record the start and end times of naptime and any periods spent outdoors (*Appendix D*). To ensure accurate recording of starting and ending times for naptime and time spent outdoors, childcare centers were provided with electronic clocks synchronized with the PA accelerometers. Accelerometers were collected at the conclusion of each week's data collection. Device data was downloaded onto a laboratory computer using ActiLife (version 4.3.0; ActiGraph LLC, Pensacola, FL).

Anthropometric Assessment

Height and weight measurements of all participating children were conducted prior to the first PA assessment. Height was measured to the nearest 0.01 m using a portable stadiometer (Seca Road Rod #214; Seca GmbH & Co. KG., Hamburg, Germany). Weight was measured to the nearest 0.1 kg using a portable digital scale (Tanita TBF-300A; Tanita Corporation, Tokyo, Japan). Body mass index (BMI) was calculated by dividing weight by height squared ($kg \bullet m^{-2}$). Sex- and age-specific Centers for Disease Control and Prevention growth charts were used to classify participants (Kuczmarski et al., 2002), based upon BMI score, as nonoverweight (BMI < 85^{th} percentile), overweight (85^{th} percentile $\leq$ BMI < 95^{th} percentile), or obese (BMI $\geq 95^{th}$ percentile; Barlow, 2007).

Temperature Assessment

Dry bulb temperature (air temperature) was measured during each data collection period. Minute-by-minute temperature readings were recorded by an Automated Surface Observing System (ASOS; National Weather Service, 2012a) station in Fargo, North Dakota. Temperature data was retrieved from the National Climatic Data Center webpage (National

Climatic Data Center, 2012). All childcare facilities which participated in the study were located within a 7.5 mile straight-line radius of the ASOS recording station.

Data Analysis

Accelerometer Data Reduction. Raw accelerometer data was processed using the "PhysicalActivity" package (Choi, Liu, Matthews, & Buchowski, 2010) in R version 2.14.1 (R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria). Non-wear time was calculated by summing each interval of consecutive zero counts lasting 10 or more minutes. Valid wear time was derived by subtracting non-wear time from the total duration of each child's daily attendance while at childcare (excluding naptime). Days with at least 180 min of wear time were deemed "valid." Participants with at least 3 or more valid days at each data collection period were retained for further analysis (Penpraze et al., 2006).

All PA data was summarized using a custom aggregation program written in the R statistical programming language (*Appendix E*). The PA intensity for each epoch of valid wear time was classified as light PA (LPA), moderate PA (MPA), or vigorous PA (VPA) using cut points of 373 counts/15 s for LPA, 585 counts/15 s for MPA, and 881 counts/15 s for VPA (Van Cauwenberghe, Labarque, Trost, De Bourdeaudhuij, & Cardon, 2011). All valid wear time below 373 counts/15 s was classified as SED. To accommodate the 5 s recording epoch used in this study, all cut points were divided by three. Daily totals (min) for each PA classification were calculated by counting the number of epochs within the same intensity category and dividing by 12. Daily MVPA was calculated by summing MPA and VPA for each day. Absolute PA (counts/day) was calculated by summing the activity counts across all minutes of valid wear time for each day. Activity intensity (counts/min) during valid wear time was derived by dividing absolute PA estimates by the duration of daily wear time. Daily totals for SED time, LPA, MPA, VPA, and MVPA were partitioned into indoor and outdoor time based upon the recorded starting and ending times of all outdoor activities. Daily totals of all PA variables for each participant were averaged across days at each assessment period to create aggregate values for each PA variable.

Statistical Analyses. All statistical analyses were conducted using SAS (version 9.2; SAS Institute, Cary, NC) or R (version 2.14.1). Assumption tests (e.g., normality [Shapiro-Wilk's test]; homogeneity of variance [Levene's Test]) preceded formal analysis procedures and revealed violations of normality and homogeneity of variance for several dependent variables across potential grouping factors. Natural logarithm and square root transformations were used to correct for non-normality and heterogeneous variance. McNemar's test was used to compare the proportion of children accumulating ≥ 7.5 min/hr of MVPA between the two assessment periods as this threshold represents the MVPA accumulation rate needed to achieve a desirable total of ≥ 60 min of MVPA for every 8 waking hours in childcare (Pate et al., 2004; Reilly, 2010).

A series of mixed-model repeated measures ANCOVAs were fit using PROC MIXED to examine for potential seasonal changes in SED time, LPA, MPA, VPA, MVPA, and absolute PA. Models were fit with time (fall vs. winter) as a fixed effect, with childcare center and children nested within centers as random effects, and total accelerometer wear time entered as a time-varying covariate. An additional mixed-model repeated measures ANOVA was fit to examine for potential changes in activity intensity across seasons using the same fixed and random effects modeling structure described above. Separate mixed-model repeated measures ANOVAs were also fit to examine for changes in indoor and outdoor SED time, LPA, MPA, VPA, and MVPA. Models included time (fall vs. winter) as a fixed effect, with childcare center and children nested within centers as random effects. The separate indoor and outdoor models were also fit as mixed-model repeated measures ANCOVAs using the same fixed and random effects structured previously noted, with total accelerometer wear time entered as a time-varying covariate.

Because previous research has reported differences in preschoolers' PA between gender and BMI classifications (Pate et al., 2004; Trost, Sirard, Dowda, Pfeiffer, & Pate, 2003), we conducted separate analyses to evaluate whether these same trends were present within the current sample. To this end, aggregate values for each PA variable from the fall and winter assessments were averaged for each participant. The averaged value for SED time, LPA, MPA, VPA, MVPA, and absolute PA then served as the dependent variable in a series of mixed-model ANCOVAs where gender or BMI classification served as the sole fixed effect, with childcare center as a random effect, and accelerometer wear time entered as a covariate. Separate mixed-model ANOVAs were fit to examine for differences in activity intensity with gender or BMI classification used as the sole fixed effect and childcare center entered as a random effect. Because the individual proportions of overweight and obese participants were relatively small, the two groups were combined into a single BMI classification category (overweight/obese) for all analyses.

All ANCOVA and ANOVA models were fit using Restricted Maximum Likelihood to obtain unbiased estimates of the covariance parameters. Diagnostic plots of model residuals were used to visually inspect the quality of model fit. The level of significance α was set at .05 for all analyses.

Results

Compliance

Fifty-nine of the original 75 children who participated in the study met wear time requirements at both data collection periods (78.7% compliance). Four participants were lost to follow-up and no longer attending the childcare centers during the second assessment period. Data from another five children were excluded due to accelerometer malfunction. Another seven participants were excluded for not meeting wear time requirements at both data collection periods. Descriptive characteristics of study participants are presented in Table 1. The 59 children meeting compliance criteria averaged 4.56 valid days of accelerometer wear time during fall and 4.47 valid days during winter. Cumulatively, compliant children completed an average of 9.03 valid accelerometer assessments across the two time points.

Table 1

Descriptive Characteristics of Participating Children

Characteristic	Male (n = 33)	Female (n = 26)	Total (N = 59)
Age (years)	4.25 ± 0.67	4.29 ± 0.70	4.27 ± 0.68
Height (cm)	107.03 ± 6.02	104.83 ± 6.87	106.06 ± 6.45
Weight (kg)	18.55 ± 2.75	18.11 ± 4.05	18.36 ± 3.36
BMI (kg•m^{-2})	16.12 ± 1.17	16.29 ± 1.96	16.20 ± 1.55
Weight Status (%)			
Nonoverweight	84.8	65.4	76.3
Overweight	9.1	15.4	11.9
Obese	6.1	19.2	11.9

Note. Values for Age, Height, Weight, and BMI are presented as $M \pm SD$.

Seasonal Changes

Children accumulated similar amounts of accelerometer wear time during the fall (M = 329.99 min) and winter (M = 320.37 min) assessments (F[1, 3] = 2.91, p = .187). No significant differences in wear time between genders or BMI classifications (nonoverweight vs. overweight/obese) were found. The proportion of children accumulating ≥ 7.5 min/hr of MVPA significantly declined from 28.8% in fall to 13.6% in winter ($\chi^2[1] = 7.11$, $p = .008$).

Adjusted means for absolute PA and activity intensity during fall and winter are shown in Figure 1. Absolute PA decreased by 13.1% between the fall and winter ($F[1, 3] = 35.25$, $p = .010$), while activity intensity significantly decreased by 13.9% during the same period ($F[1, 3] = 48.89$, $p = .006$). Changes in SED time, LPA, MPA, VPA, and MVPA are shown in Figure 2. Mean values of wear time adjusted SED time increased by 8.6 min ($F[1, 3] = 37.31$, $p = .009$), while LPA decreased by 2.5 min ($F[1, 3] = 21.05$, $p = .020$), MPA decreased by 3 min ($F[1, 3] = 39.77$, $p = .008$), VPA decreased by 2.6 min ($F[1, 3] = 27.43$, $p = .014$), and MVPA decreased by 5.7 min ($F[1, 3] = 39.97$, $p = .008$) falling from ($M \pm SE$) 33.05 ± 2.62 min in fall to 27.40 ± 2.18 min in winter.

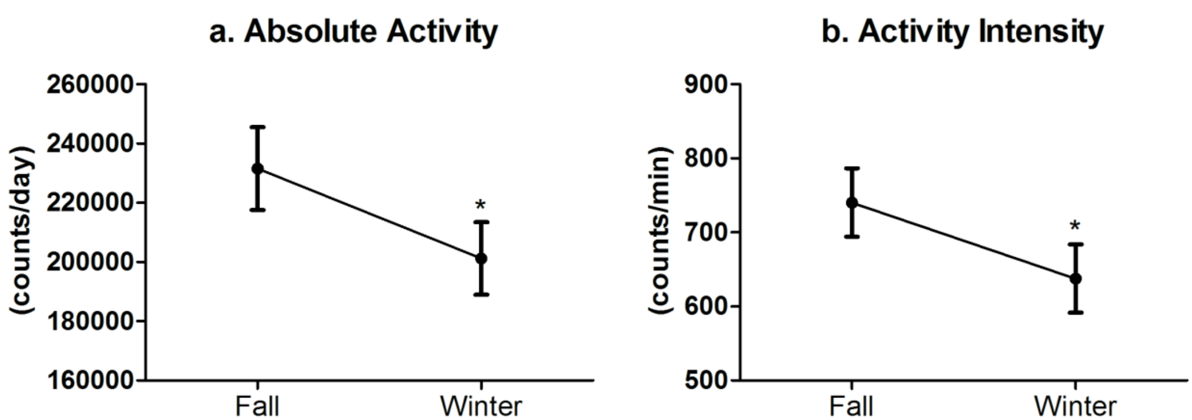

Figure 1. Changes in absolute physical activity and activity intensity from fall to winter. Physical activity variables are displayed in panels: absolute activity (a) and activity intensity (b). Values for absolute physical activity represent back-transformed geometric means from ln(x) transformed data. Error bars represent ± *SE*. *$p \leq .01$.

Indoor and Outdoor Changes

Accelerometer wear time indoors significantly increased from fall ($M = 273.82$ min) to winter ($M = 297.25$ min; $F[1, 3] = 12.67$, $p = .038$). However, only unadjusted indoor SED

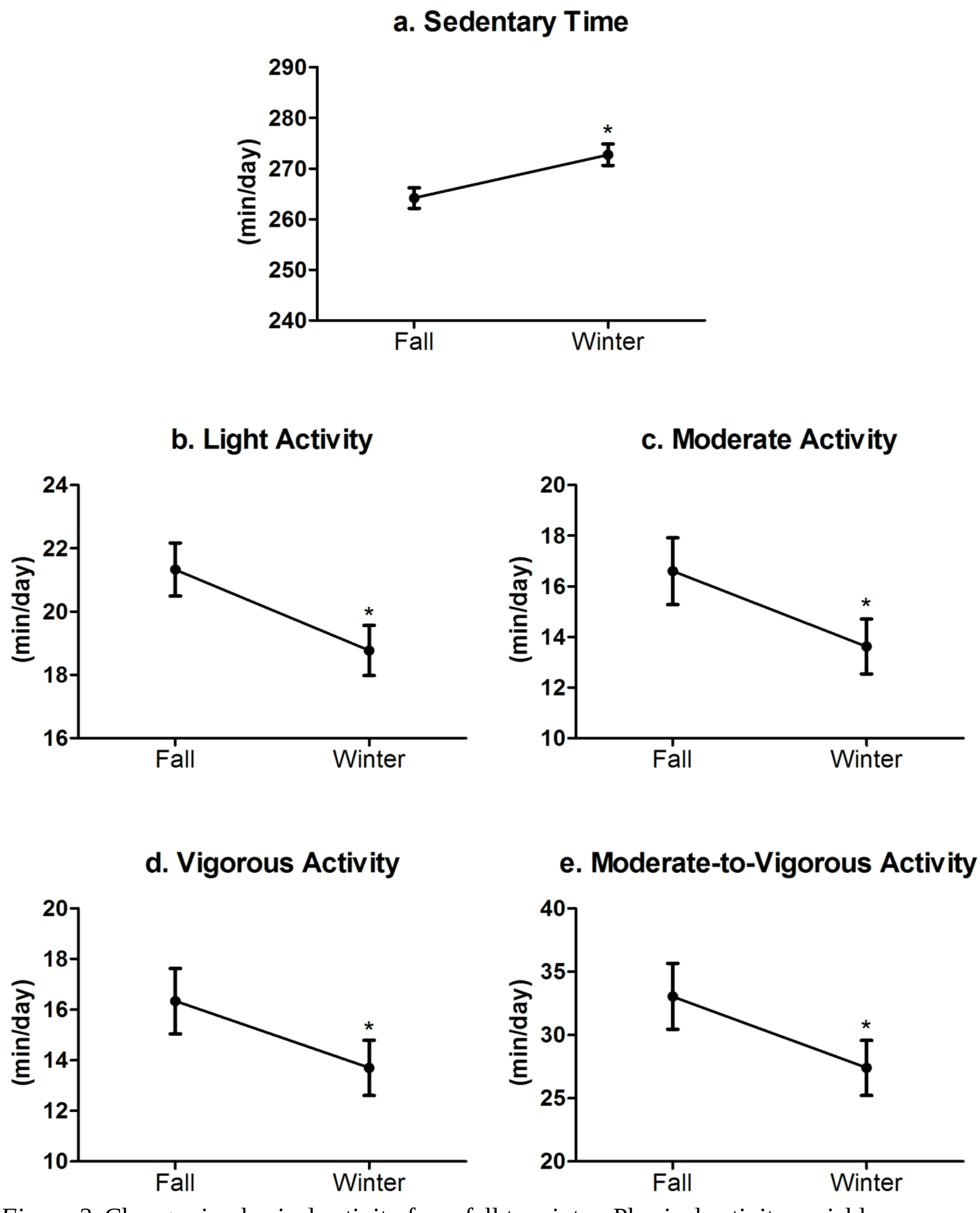

Figure 2. Changes in physical activity from fall to winter. Physical activity variables are displayed in panels: sedentary time (a), light activity (b), moderate activity (c), vigorous activity (d), and moderate-to-vigorous activity (e). Mean values for sedentary time, moderate activity, vigorous activity, and moderate-to-vigorous activity represent back-transformed geometric means for ln(x) transformed data. Error bars represent ± *SE*. **p* < .05.

time significantly changed across seasons (Table 2; *F*[1, 3] = 16.48, *p* = .027). After wear time adjustment, the significant indoor SED time difference remained (*F*[1, 3] = 13.09, *p* = .036), with a wear time adjusted increase of 7.3 min observed from fall to winter. Changes in indoor LPA, MPA, VPA, and MVPA remained non-significant after adjustment for wear time.

Table 2

Changes in Indoor Physical Activity from Fall to Winter

	Fall		Winter		
Variable	*M*	*SE*	*M*	*SE*	*p*
Moderate-to-Vigorous Activity (min/day)*	19.63	3.25	20.92	3.46	.427
Vigorous Activity (min/day)*	9.85	1.68	10.61	1.81	.415
Moderate Activity (min/day)*	9.72	1.56	10.21	1.64	.493
Light Activity (min/day)*	12.90	1.91	13.87	2.06	.294
Sedentary Time (min/day)†	220.40	16.10	245.07	16.98	.032

Note. Values are adjusted means from repeated measures ANOVA models (no wear time adjustment).
*Adjusted mean values represent back-transformed geometric means for ln(x) transformed data.
†Adjusted mean values represent back-transformed geometric means for √(x) transformed data.

All accumulated outdoor wear time during the fall and winter assessments took place between the hours of 9:00 a.m. and 5:30 p.m. Mean (± *SD*) outdoor air temperature during this time period fell from 4.90 ± 5.58 °C in fall to -7.75 ± 8.56 °C in winter. Concurrent with the decrease in temperature, outdoor time significantly declined by over 50% from fall (*M* = 56.17 min) to winter (*M* = 23.12 min; *F*[1, 3] = 35.23, *p* < .010). Significant decreases in outdoor SED time (*F*[1, 3] = 33.85, *p* = .010), LPA (*F*[1, 3] = 28.85, *p* = .013), MPA (*F*[1, 3] = 32.09, *p* = .011), VPA (*F*[1, 3] = 28.62, *p* = .013), and MVPA (*F*[1, 3] = 31.48, *p* = .011) were observed from fall to winter (Table 3). However, changes in outdoor SED time, LPA,

Table 3

Changes in Outdoor Physical Activity from Fall to Winter

	Fall		Winter		
Variable	*M*	*SE*	*M*	*SE*	*p*
Moderate-to-Vigorous Activity (min/day)	11.32	2.02	4.13	1.55	.011
Vigorous Activity (min/day)	5.38	0.99	1.92	0.72	.013
Moderate Activity (min/day)	5.96	1.07	2.24	0.86	.011
Light Activity (min/day)	6.50	1.20	2.63	1.00	.013
Sedentary Time (min/day)	36.63	6.34	14.65	5.36	.010

Note. Values are adjusted means from repeated measures ANOVA models (no wear time adjustment).

MPA, VPA, and MVPA all fell to non-significance after adjustment for accelerometer wear time.

Gender and BMI Classification Differences

Adjusted means for measured PA variables stratified by gender are presented in Table 4. Compared to girls, boys accumulated more MVPA (F[1, 3] = 16.47, p = .027), VPA (F[1, 3] = 20.76, p = .020), and MPA (F[1, 3] = 10.41, p = .048), while accumulating lesser amounts of SED time (F[1, 3] = 15.08, p = .030). In addition, although not significant, boys accumulated more absolute PA (F[1, 3] = 7.54, p = .071), and LPA (F[1, 3] = 3.18, p = .173) than girls, while averaging a higher activity intensity as well (F[1, 3] = 6.08, p = .090).

Comparisons of PA variables between nonoverweight and overweight/obese children are presented in Table 5. No significant differences in any measured PA variables were found between nonoverweight and overweight/obese children. However, non-significant lower mean values of SED time (F[1, 3] = 1.19, p = .335), and non-significant higher mean values of LPA (F[1, 3] = 0.38, p = .581), MPA (F[1, 3] = 0.98, p = .396), VPA (F[1, 3] = 2.17, p = .237), MVPA (F[1, 3] = 1.78, p = .280), and absolute PA (F[1, 3] = 1.40, p = .323) were observed

Table 4

Comparisons of Physical Activity and Sedentariness Between Genders

	Boys		Girls		
Variable	*M*	*SE*	*M*	*SE*	*p*
Absolute Activity (counts/day)†	241,690	12,787	208,685	12,701	.071
Activity Intensity (counts/min)	726.07	59.60	628.51	62.00	.090
Moderate-to-Vigorous Activity (min/day)*	33.75	2.98	27.35	2.49	.027
Vigorous Activity (min/day)†	17.65	1.25	13.91	1.18	.020
Moderate Activity (min/day)	18.07	1.30	14.34	1.39	.048
Light Activity (min/day)	21.60	0.94	19.54	1.03	.173
Sedentary Time (min/day)*	264.04	3.45	275.39	3.07	.030

Note. Values are adjusted means from mixed-model ANCOVAs.
*Adjusted mean values represent back-transformed geometric means for ln(x) transformed data.
†Adjusted mean values represent back-transformed geometric means for √(x) transformed data.

Table 5

Comparisons of Physical Activity and Sedentariness Between BMI Classifications

	Nonoverweight		Overweight/Obese		
Variable	*M*	*SE*	*M*	*SE*	*p*
Absolute Activity (counts)†	224,477	10,161	250,350	14,274	.323
Activity Intensity (counts/min)	679.75	47.23	729.08	57.29	.426
Moderate-to-Vigorous Activity (min/day)*	30.33	2.08	35.82	3.17	.280
Vigorous Activity (min/day)†	15.63	0.98	18.76	1.59	.237
Moderate Activity (min/day)	16.25	0.96	17.94	1.27	.396
Light Activity (min/day)	20.66	0.90	21.78	1.14	.581
Sedentary Time (min/day)*	269.94	2.62	263.93	3.55	.355

Note. Values are adjusted means from mixed-model ANCOVAs.
*Adjusted mean values represent back-transformed geometric means for ln(x) transformed data.
†Adjusted mean values represent back-transformed geometric means for √(x) transformed data.

among overweight/obese children in comparison to nonoverweight children. Observed activity intensity was also non-significantly higher among overweight/obese children than nonoverweight children (F[1, 3] = 0.84, p = .426).

Discussion

This study examined PA patterns among preschoolers across the fall and winter seasons in a northern tier state. In agreement with our hypothesis, significant reductions in time spent within all intensities of PA and a concomitant increase in SED time were observed from fall to winter. The decrease in outdoor PA was quite substantial as outdoor time declined by more than 50%, which was accompanied by significant unadjusted declines of 60-65% in outdoor SED time, absolute PA, LPA, MPA, VPA, and MVPA. However, declines in outdoor PA appear to be explained by decreases in time spent outdoors as all changes fell to non-significance after adjustment for wear time. Results suggest that rates of outdoor PA accumulation in all categories of PA (i.e., LPA, MPA, VPA, and MVPA) remain relatively stable from fall to winter, with observed decreases in outdoor PA being the result of a reduction in time spent outdoors. In comparison to time spent outdoors, less variability in indoor activity patterns was observed across seasons as only SED time changed from fall to winter.

Due to the observational design of this study, cause and effect relationships between the observed decline in temperature and reductions in PA cannot be established. However, reductions in temperature did cause each childcare center to suspend all outdoor activity time in accordance with center policies for at least one day during the winter assessment period. This is not uncommon in cold climates as many states have regulations limiting childcare facilities from going outside during inclement weather. Therefore, it is not surprising that outdoor activity time would decrease during winter in areas with cold climates. Evidence from this study would suggest that such reductions could have substantial impacts on PA accumulation as unadjusted outdoor MVPA significantly declined by more than 7 min/day from fall to winter. This accounts for 97% of the unadjusted observed seasonal decline in total MVPA during the childcare day. This finding is in agreement with previous research which has shown that time spent outdoors is significantly related to overall PA among preschoolers (Baranowski et al., 1993).

To the authors' knowledge, this is the first investigation to prospectively track preschoolers' accelerometer measured PA across seasons. Prior cross-sectional research has indicated that preschoolers' accelerometer measured PA was lower during spring than any other season, while no significant differences in PA between summer, fall, or winter were observed (Fisher et al., 2005). At face value it may seem appropriate to compare findings from the present study to previous work by Fisher et al. (2005); however, any comparisons between the results from Fisher et al. and the work presented here are problematic for a number of reasons. First, the investigation by Fisher et al. assessed preschoolers' PA during the entire waking day, while our investigation only assessed PA in the childcare setting. Second, this study and the investigation by Fisher et al. used different data reduction techniques to interpret accelerometer data. Lastly, the geographic regions where preschoolers' PA was assessed in the present study (Fargo, North Dakota) and the investigation by Fisher et al. (Glasgow, Scotland) are quite different. Collectively, the vast methodological differences between our study and the investigation by Fisher et al. present a number of problems for comparing results between the two studies. Regardless of the differences between this study and the investigation by Fisher et al., both studies provide evidence that preschoolers' PA patterns do change across seasons.

Similar to previous investigations, levels of MVPA in this study were less than optimal. Overall, preschoolers in this sample averaged 6.1 min/hr of MVPA. This equates to approximately 48.8 min of MVPA for every 8 waking hours in childcare. Although there is considerable ambiguity in current PA guidelines for preschool aged children, it has generally been considered undesirable for children to accumulate less than 60 min of MVPA per every 8 hr in childcare (7.5 min/hr of MVPA; Pate et al., 2004). The majority of children in this study did not meet the 7.5 min/hr MVPA threshold. Moreover, the proportion of children meeting this threshold declined by more than 50% from fall to winter, which provides further evidence of significant changes in PA across seasons.

Disconcerting among the findings of this investigation was the significant increase in wear time adjusted SED time of 8.5 min/day from fall to winter. This increase appears to be largely due to increased time spent indoors which had a higher rate of SED time accumulation (51.36 min/hr) than time spent outdoors (40.27 min/hr). The biological significance of such an increase in SED time (≈ 8.5 min over 5.5 hr) is unknown. However, among adults, increased sedentariness has been independently associated with increased risks for obesity (Hu, Li, Colditz, Willett, & Manson, 2003), cardiovascular disease (Katzmarzyk, Church, Craig, & Bouchard, 2009; Morris, Heady, Raffle, Roberts, & Parks, 1953), diabetes (Hu et al., 2003), the metabolic syndrome (Ford, Kohl, Mokdad, & Ajani, 2005), and all-cause mortality (Katzmarzyk et al., 2009). More research is needed to clarify whether or not the same relationships between sedentary behavior and negative health consequences exist among younger individuals such as preschoolers.

Similar to previous investigations objectively assessing PA among preschoolers, boys in this sample were significantly more active than girls (K. Finn, Johannsen, & Specker, 2002; Jackson et al., 2003; Pate et al., 2004). Boys accumulated less SED time, and more MPA, VPA, and MVPA than girls. To date, no singular explanation for this phenomenon has been agreed upon. Nonetheless, gender differences in PA may be due to contrasting activity preferences as results from a recent investigation indicated that young boys tend to engage in sporting-type activities during unstructured playtime while young girls participate in lower-intensity and sedentary activities (Ridgers, Carter, Stratton, & McKenzie, 2011).

Although differences in PA variables between overweight/obese children and nonoverweight children were not significant, the higher mean values for all PA variables and lower SED time among overweight/obese children in comparison to nonoverweight children was not expected. Previous research has demonstrated that obese preschool aged boys were significantly less active than nonoverweight boys (Trost et al., 2003). The non-significant lower levels of observed SED time, and higher LPA, MPA, VPA, and MVPA among overweight/obese children in comparison to nonoverweight children in this study may simply be an artifact of this sample. However, a recent literature review of cross-sectional and longitudinal studies among preschool children demonstrated that no definitive relationship between BMI and PA in preschoolers has been observed (Sijtsma, Sauer, Stolk, & Corpeleijn, 2011).

While the present study provides valuable information to the empirical literature base, it is not without limitations. The primary limitation of this study was that PA was measured solely in the childcare setting. As such, our measurements do not reflect any PA which may have occurred outside of childcare. The observed changes across seasons during childcare may or may not have been reflected in other settings (e.g., home). However, our goal and primary objective was to measure and quantify changes in PA which occurred in the childcare setting and not during the entire day in all settings. Another limitation worth noting relates to the research design of this study, as all collected data were from a small geographic region in eastern North Dakota, which limits the generalizability of our results to larger geographic areas or regions. Also, PA was only measured during fall and winter, so we are unable to make determinations as to how PA levels may change during summer and spring.

Conclusion

The ability of children to remain physically active is often influenced by a number of external factors. Results from this investigation indicate that PA may be negatively influenced by seasonal forces such as cold temperatures. Objective measurements of LPA, MPA, VPA, MVPA, absolute PA, and activity intensity all significantly decreased, while SED time increased, from fall to winter. Observed PA changes in this study appear to be heavily influenced by reductions in time spent outdoors during winter. Future investigations are needed to clarify the role of climatic forces (e.g., rain, wind, etc.) on PA in preschool children. Findings from this investigation support recommendations for increased PA in the childcare setting (Ward, 2010), as less than optimal amounts of MVPA were observed. The reduction of outdoor time and related PA observed in this study provides a further rationale for the development of novel interventions to increase PA levels in indoor settings (i.e., preschool classroom).

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PAPER 2. INITIAL EVALUATION OF A DANCE-BASED PHYSICAL ACTIVITY INTERVENTION IN PRESCHOOL CHILDREN

The prevalence of overweight and obesity among United States (US) children has risen dramatically over the last several decades. Since the 1970s, two to four fold increases in obesity prevalence have been observed with current estimates indicating that 10.4% of 2-5 year-olds, 19.6% of 6-11 year-olds, and 18.1% of 12-19 year-olds are currently obese (C. Ogden & Carroll, 2010; C. L. Ogden, Carroll, Curtin, Lamb, & Flegal, 2010). This increase in childhood obesity is particularly worrisome as higher levels of body fat are associated with greater risks for a number of chronic diseases among children, such as hypertension, hyperlipidemia, diabetes, orthopedic impediments, and respiratory problems (Dietz, 1998; Must & Anderson, 2003). Children may also suffer from a number of social, economic, and behavioral difficulties as a result of being overweight or obese (Gortmaker, Must, Perrin, Sobol, & Dietz, 1993; Schwimmer, Burwinkle, & Varni, 2003; Strauss, 2000). Furthermore, evidence suggests that obese children are at least twice as likely to become obese adults as nonobese children (Serdula et al., 1993). Due to the seriousness of the many issues surrounding childhood obesity, preventive strategies to combat this disease are warranted (Ward, 2010). Increasing energy expenditure through physical activity (PA) has been recommended as a primary prevention measure against the development of childhood obesity (American Academy of Pediatrics and Council on Sports Medicine and Fitness and Council on School Health, 2006).

The preschool years (3-5 years old) have been identified as an important time period influencing the development of children's PA patterns (Ward, Vaughn, McWilliams, & Hales, 2010). Regular PA during this period assists children in the development of fundamental motor skills, including object manipulation and locomotor skills (Williams et al., 2008). Recommendations from the National Association for Sport and Physical Education (NASPE) suggest preschool aged children should accumulate at least 60 min/day of unstructured PA, and at least 60 min/day of structured PA, while limiting waking sedentary (SED) bouts to durations of less than 60 min (NASPE, 2009).

Recent statistics indicate that 55% of US children aged 3-6 years, not yet in kindergarten, are enrolled in center-based childcare (Federal Interagency Forum on Child and Family Statistics, 2011). As such, the childcare center represents a key location for preschool aged children to be physically active in an effort to meet current PA guidelines. Unfortunately, objective assessments of preschoolers' PA have consistently shown that typical activity levels in center-based childcare would result in the accumulation of less than 60 min of moderate-to-vigorous PA (MVPA) during every 8 waking hours (Alhassan, Sirard, & Robinson, 2007; Cardon & De Bourdeaudhuij, 2007; Dowda, Pate, Trost, Almeida, & Sirard, 2004; Finn & Specker, 2000; Jackson et al., 2003; McKee, Boreham, Murphy, & Nevill, 2005; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004; Reilly et al., 2006; Trost, Fees, & Dzewaltowski, 2008).

The low levels of PA observed in center-based childcare settings, in addition to concerns related to childhood obesity, provide a rationale for increasing childcare PA with targeted interventions. A number of previous PA intervention studies using objective monitoring methods have been conducted with preschoolers. Several studies have evaluated the efficacy of environmental or policy changes to influence preschoolers' PA levels (Alhassan et al., 2007; Cardon, Labarque, Smits, & De Bourdeaudhuij, 2009; Hannon & Brown, 2008; Trost et al., 2008). A number of other studies have evaluated the effectiveness of particular movement programs or curriculums at impacting PA levels (Binkley & Specker, 2004; Deal, 1993; Eliakim, Nemet, Balakirski, & Epstein, 2007; Fitzgibbon et al., 2005, 2006; Parish, Rudisill, & St. Onge, 2007; Reilly et al., 2006). In general, results from previous PA intervention studies among preschool children have been mixed, with many interventions having only marginal to no measureable impact on PA levels. A common theme among many of the intervention studies that have shown limited success was that PA program components were implemented in large time blocks (30-45 min) during the day (Alhassan et al., 2007; Fitzgibbon et al., 2005, 2006; Reilly et al., 2006).

Therefore, the purpose of this study was to evaluate the feasibility of a novel dance-based intervention for increasing PA and reducing sedentary time in childcare using short activity breaks (< 10 min) interspersed throughout the childcare day. We hypothesized that preschoolers exposed to the dance-based intervention would display significantly greater levels of indoor MVPA and lower levels of SED time than preschoolers participating in their normal childcare day.

Methods

Setting and Recruitment

This study was conducted during the winter of 2012 at four childcare centers offering preschool services in Fargo, North Dakota. Eight licensed childcare centers were initially recruited to participate in the study. Of the six centers agreeing to participate, four were randomly selected to take part in the study. The study was conducted in all preschool rooms (10-12 children per room) within the four participating facilities.

All parents of children enrolled in preschool programs (3-5 years of age) within the four participating childcare centers were given a letter introducing and describing the study three months before the study start date. The following month a research team member attended each childcare center for several hours to answer questions from parents and childcare providers about the study and to provide parents with informed consent documents (*Appendix A*). Interested parents were asked to sign and return the informed consent documents before their child could participate. Those parents who signed informed consent documents were asked to fill out a short questionnaire about their child before the start of the study (*Appendix B*). The study protocol was approved by the North Dakota State University – Institutional Review Board before recruitment began (*Appendix C*).

Study Design

This study employed a cluster-randomized research design. Data collection occurred over a 6-week period with PA assessments in the childcare setting occurring at baseline and during the intervention. Participating childcare centers were proportionally randomized (2 groups per condition) to an intervention or control condition following baseline data collection. Baseline data collection occurred in January 2012 while data collection during the intervention took place in February 2012. All PA assessments were completed within a 3-week period at baseline and during the intervention.

Intervention

The primary goals of the intervention evaluated in this study were to increase indoor MVPA and reduce SED time among preschoolers while attending childcare. Short dance sessions were incorporated into the childcare day in an attempt to achieve these goals. The intervention was designed by drawing on principles of social cognitive theory (Bandura, 1986) with the intent of reducing barriers to PA by providing more PA opportunities during the childcare day. Intervention sites received an electronic mp3 player and portable docking speaker loaded with child friendly dance music to deliver the intervention. Childcare providers were familiarized with the intervention several weeks before implementation. Childcare providers actively participated and led all dance sessions to encourage involvement and PA among the children.

Childcare centers in the intervention group incorporated two dance sessions into each day during the intervention period. Childcare providers at the participating centers were instructed to use the intervention as a PA supplement and that the dance sessions should not displace any other planned outdoor or indoor PA periods (*Appendix F*). Dance sessions were delivered for durations of 7.5-10 min, with one session delivered before lunch and the other following naptime in the afternoon. Sessions were scheduled according to the needs of each facility; however, all morning dance sessions took place between 9:00 a.m. and 11:00 a.m. and all afternoon sessions were held between 2:30 p.m. and 4:00 p.m. Childcare providers in the control group were instructed to continue their normal practices and not to incorporate any new PA programs or activities into the curriculum during the intervention period.

Participants

Of the 110 informed consent packets distributed to parents, 85 were signed and returned by parents for children from the four childcare centers. Three of the 85 children whose parents returned signed informed consent documents were excluded from participating in the study for not meeting the age requirement (3-5 years). A total of 82 children (46 boys, 36 girls; $M \pm SD$ age = 4.35 ± 0.70 years) participated in the study. The sample contained a high proportion of Caucasian children (85.4%) with smaller proportions of mixed-race (8.5%), African-American (3.7%), and Hispanic children (2.4%).

Physical Activity Assessment

Accumulated PA was objectively assessed using an ActiGraph accelerometer (ActiTrainer model [8.6 cm x 3.3 cm x 1.5 cm; 51 g]; Actigraph LLC, Pensacola, FL). The ActiGraph is a solid state accelerometer which can effectively measure acceleration in the vertical plane over a dynamic range of ± 3 g (Actigrah LLC, 2011). The device adequately detects normal human motion while rejecting high-frequency vibrations caused by automated machinery (e.g., operation of an automobile). Vertical plane acceleration is digitized by the accelerometer at a frequency of 30 Hz, while being filtered and integrated through a user-specified summary data collection interval called an epoch.

Previous research has demonstrated that the Actigraph has acceptable reliability and validity for quantifying PA among preschool aged children (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Sirard, Trost, Pfeiffer, Dowda, & Pate, 2005). An epoch length of 15 s is generally recommended for accelerometry assessments among preschool aged children (Pate, O'Neill, & Mitchell, 2010). However, children's activity can be highly sporadic with the vast majority of moderate- or higher-intensity activities occurring in bouts lasting less than 10 s (Bailey et al., 1995; Berman, Bailey, Barstow, & Cooper, 1998). Therefore, a 5 s data collection epoch was chosen for use in this study to better capture the intermittent PA patterns of preschoolers (Vale, Santos, Silva, Soares-Miranda, & Mota, 2009).

Protocol. Children whose parents returned signed informed consent documents were asked to wear an accelerometer during their preschool attendance for 5 days (Monday through Friday) during the baseline and intervention assessment periods. A trained research assistant fitted participating children with an adjustable elastic waist-belt and attached accelerometer at the beginning of each day. Accelerometers were positioned directly in front of each child's right hip. Accelerometers were removed at the start of naptime and children were refitted with the devices at the conclusion of naptime. The research assistant removed the accelerometer and attached belt as children left the childcare center each day. Time of arrival and departure from the childcare center for all participating children was recorded each day. A separate recording form was used to record the start and end times of naptime, outdoor activities, and intervention dance sessions (*Appendix G*). To ensure accurate recording of starting and ending times for different activities, childcare centers were provided with electronic clocks synchronized with the accelerometers used to assess PA. Accelerometers were collected at the conclusion of each week's data collection. Device data was downloaded onto a laboratory computer using ActiLife (version 4.3.0; ActiGraph LLC, Pensacola, FL).

Anthropometric Assessment

Height and weight measurements of all participating children were conducted prior to baseline PA data collection. Height was measured to the nearest 0.01 m using a portable stadiometer (Seca Road Rod #214; Seca GmbH & Co. KG., Hamburg, Germany). Weight was measured to the nearest 0.1 kg using a portable digital scale (Tanita TBF-300A; Tanita Corporation, Tokyo, Japan). Body mass index (BMI) was calculated by dividing weight by height squared ($kg \cdot m^{-2}$).

Data Analysis

Accelerometer Data Reduction. Raw accelerometer data was processed using the "PhysicalActivity" package (Choi, Liu, Matthews, & Buchowski, 2010) in R version 2.14.0 (R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria). Non-wear time was calculated by summing each interval of consecutive zero counts lasting 10 or more minutes. Valid wear time was derived by subtracting non-wear time from the total duration of each child's daily attendance while at childcare (excluding naptime). Days with at least 180 min of wear time were deemed "valid." Participants with at least 3 or more valid days at each data collection period were retained for further analysis (Penpraze et al., 2006).

All PA data was summarized using a custom aggregation program written in the R statistical programming language (*Appendix E*). The PA intensity for each epoch of valid wear time was classified as light PA (LPA), moderate PA (MPA), or vigorous PA (VPA) using cut points of 373 counts/15 s for LPA, 585 counts/15 s for MPA, and 881 counts/15 s for VPA (Van Cauwenberghe, Labarque, Trost, De Bourdeaudhuij, & Cardon, 2011). All valid wear time which fell below 373 counts/15 s was classified as SED. To accommodate the 5 s recording epoch used in this study, all cut points were divided by three. Daily totals (min) for each PA classification were calculated by counting the number epochs within the same intensity category and dividing by 12. Daily estimates of MVPA were calculated by summing MPA and VPA for each day. Estimates of absolute PA (counts/day) during each day were calculated by summing the activity counts across all minutes of valid wear time. Activity intensity (counts/min) during valid wear time was derived by dividing absolute PA estimates by the duration of daily wear time. Daily totals for all PA variables were also partitioned into indoor and outdoor time based upon the recorded starting and ending times of all outdoor activities. Daily totals of all PA variables for each participant were averaged across days at each assessment period to create aggregate values for each PA variable. To characterize the unique activity patterns occurring during dance sessions, data from children in the intervention group was further partitioned into indoor time (excluding dance sessions), dance session time, and outdoor time. Variables were then created representing relative time (min/hr) spent in SED time, LPA, MPA, VPA, and MVPA during these distinct time periods.

Statistical Analyses. All statistical analyses were conducted using SAS (version 9.2; SAS Institute, Cary, NC). Assumption tests (e.g., normality [Shapiro-Wilk's test]; homogeneity of variance [Levene's Test]) preceded formal analysis procedures and revealed violations of normality and homogeneity of variance for several variables. Natural logarithm and square root transformations were used to correct for non-normality and heterogeneous variance.

To investigate for potential baseline differences in demographic factors between the intervention and control groups, independent samples *t*-tests were used to compare groups on continuous measures (e.g., age, height, weight, BMI) and a χ^2 test was used to assess gender proportionality. A series of mixed-model repeated measures ANCOVAs were fit using PROC MIXED to examine for intervention-related changes in full-day SED time, LPA, MPA, VPA, MVPA, and absolute PA. Models were fit using time (baseline vs. intervention period), condition (control vs. intervention), and the time x condition interaction as fixed effects, with childcare center and children nested within centers as random effects, and total accelerometer wear time entered as a time-varying covariate. A mixed-model repeated measures ANOVA was fit to examine for differences in activity intensity using the same fixed and random effects modeling structure described above. Separate mixed-model repeated measures ANCOVAs were fit to examine for changes in indoor only SED time, LPA, MPA, VPA, MVPA, and absolute PA. A separate mixed-model repeated measures ANOVA was fit to examine for changes in indoor only activity intensity. The indoor only ANCOVA and ANOVA models were fit using the same modeling structures described for the full-day analyses. A final set of mixed-model repeated measures ANOVAs were fitted to compare the PA patterns among intervention group children during indoor time (excluding dance sessions), dance session time, and outdoor time. Separate models were fit for SED time, LPA, MPA, VPA, MVPA, and activity intensity. Activity location (indoor, dance session, outdoor) was a fixed effect in each model, with children nested within childcare center as a random effect. Tukey-Kramer pairwise comparisons were used to compare differences between activity locations following significant activity location fixed effects in the mixed-model repeated measures ANOVAs.

All ANCOVA and ANOVA models were fit using Restricted Maximum Likelihood to obtain unbiased estimates of the covariance parameters. Diagnostic plots of model residuals were used to visually inspect the quality of model fit. The level of significance α was set at .05 for all analyses.

Results

Compliance

Sixty-one of the original 82 children who participated in the study met wear time requirements at baseline and during the intervention period (74.4% compliance). Two participants were lost to follow-up and no longer attending the childcare centers at the second assessment period. Data from six children were excluded due to accelerometer malfunction. An additional 13 children were excluded for not meeting wear time requirements at both data collection periods. Children averaged 4.45 valid days of accelerometer wear time at baseline and 4.62 valid days during the intervention. Overall, participating children averaged 9.08 valid days across both assessment periods. Descriptive characteristics of study participants are presented in Table 6. No significant differences in age, height, weight, BMI, or gender proportionality were found between the intervention and control groups.

Table 6

Descriptive Characteristics of Study Participants

Characteristic	Intervention (n = 30)	Control (n = 31)	Total (N = 61)
Age (years)	4.31 ± 0.76	4.57 ± 0.64	4.44 ± 0.71
Height (cm)	106.50 ± 6.32	107.87 ± 6.21	107.07 ± 6.27
Weight (kg)	18.92 ± 4.00	18.36 ± 2.95	18.63 ± 3.49
BMI (kg•m^{-2})	16.59 ± 2.07	15.69 ± 1.60	16.13 ± 1.89
Gender (%)			
Male	46.7	61.3	54.1
Female	53.3	38.7	45.9

Note. Values for Age, Height, Weight and BMI are presented as $M \pm SD$.

Intervention Changes

Total accelerometer wear time for the 61 children meeting compliance criteria during baseline (M = 322.15 min) and the intervention period (M = 326.14 min) was not significantly different (F[1, 3] = 0.77, p = .446). Group stratified changes for all full-day (indoor + outdoor) PA variables are presented in Table 7. No significant differences were found between the control and intervention group at baseline or during the intervention period for any full-day PA variable. In addition, no significant changes in full-day PA variables were found from baseline to intervention, nor were there any significant time x condition interaction effects.

Indoor accelerometer wear time significantly decreased from baseline (M = 292.72 min) to the intervention period (M = 275.83 min; F[1, 3] = 21.98, p = .018). Group stratified changes in indoor PA variables are presented in Table 8. No significant between group differences in any measured variables were found at baseline or during the intervention

Table 7

Changes in Full-Day Physical Activity

	Control Group		Dance Group	
Variable	Baseline	Intervention	Baseline	Intervention
Absolute Activity (counts/day)*	195,152 ± 15,378	224,108 ± 16,514	216,821 ± 15,669	233,618 ± 16,268
Activity Intensity (counts/min)	598.69 ± 62.63	683.81 ± 62.63	676.77 ± 61.14	734.43 ± 61.14
Moderate-to-Vigorous Activity (min/day)*	26.35 ± 2.39	31.14 ± 2.61	31.06 ± 2.51	32.71 ± 2.57
Vigorous Activity (min/day)†	12.63 ± 1.28	15.23 ± 1.55	15.32 ± 1.50	16.05 ± 1.58
Moderate Activity (min/day)*	12.65 ± 1.22	14.97 ± 1.33	15.15 ± 1.30	16.10 ± 1.34
Light Activity (min/day)*	17.05 ± 1.53	19.61 ± 1.64	18.79 ± 1.57	20.88 ± 1.65
Sedentary Time (min/day)†	273.69 ± 2.71	266.80 ± 2.65	271.16 ± 2.64	268.03 ± 2.61

Note. All values are presented as adjusted $M \pm SE$.
*Adjusted mean values represent back-transformed geometric means from √(x) transformed data.
†Adjusted mean values represent back-transformed geometric means from ln(x) transformed data.

period. In addition, no significant changes from baseline to intervention, or time x condition interactions, were found among the individual models for all indoor PA variables.

Intervention Activity Characteristics

Characteristics of activity patterns for participants receiving the intervention are presented in Table 9. Children in the intervention group averaged 17.32 min of dance per day (8.66 min/session) during the intervention period. Significant differences in the proportion of time spent in SED behavior (F[2, 44.8] = 130.97, $p < .001$), LPA (F[2, 51] = 170.27, $p < .001$), MPA (F[2, 44.9] = 106.53, $p < .001$), VPA (F[2, 47.4] = 81.45, $p < .001$), and MVPA (F[2, 42.4] = 87.41, $p < .001$) were found between indoor time (excluding dance sessions), dance session time, and outdoor time. In addition, activity intensity varied quite dramatically across the distinct time periods (F[2, 50.5] = 132.95, $p < .001$). Despite the relatively high

Table 8

Changes in Indoor Physical Activity

	Control Group		Dance Group	
Variable	Baseline	Intervention	Baseline	Intervention
Absolute Activity (counts/day)*	164,990 ± 10,831	180,081 ± 11,278	173,514 ± 10,732	180,430 ± 11,033
Activity Intensity (counts/min)	577.74 ± 43.51	618.02 ± 43.51	604.08 ± 42.12	618.71 ± 42.12
Moderate-to-Vigorous Activity (min/day)*	21.81 ± 1.60	23.81 ± 1.66	24.19 ± 1.63	24.34 ± 1.65
Vigorous Activity (min/day)*	11.21 ± 0.90	12.03 ± 0.92	12.65 ± 0.93	13.02 ± 0.95
Moderate Activity (min/day)*	10.44 ± 0.87	11.49 ± 0.92	11.50 ± 0.89	11.24 ± 0.88
Light Activity (min/day)*	14.23 ± 1.21	16.04 ± 1.28	15.07 ± 1.19	15.07 ± 1.21
Sedentary Time (min/day)*	250.84 ± 2.77	247.50 ± 2.74	249.12 ± 2.66	249.13 ± 2.69

Note. All values are presented as adjusted *M* ± *SE*.
*Adjusted mean values represent back-transformed geometric means from √(x) transformed data.

Table 9

Physical Activity Patterns During Intervention Period

	Indoors		Dance Program		Outdoors	
Variable	*M*	*SE*	*M*	*SE*	*M*	*SE*
Activity Intensity (counts/min)*	531.99[a]	22.46	1,743.96[b]	103.30	1,131.78[b]	56.50
Moderate-to-Vigorous Activity (min/hr)*	4.36[a]	0.24	15.74[b]	1.11	12.32[b]	0.82
Vigorous Activity (min/hr)*	2.15[a]	0.14	10.10[a]	0.90	5.24[a]	0.48
Moderate Activity (min/hr)	2.14[a]	0.10	5.06[b]	0.28	6.76[b]	0.37
Light Activity (min/hr)	2.92[a]	0.12	5.69[a]	0.22	7.98[a]	0.27
Sedentary Time (min/hr)	52.72[a]	0.34	38.58	1.18	39.70	0.98

Note. *Mean values represent back-transformed geometric means from √(x) transformed data
[a] Significantly different from all other mean values in the same row, *p* < .001.
[b] Significantly different from values in same row with same superscript, *p* < .05.

activity levels observed during dance sessions, an average of only 4.53 min of MVPA was accumulated during the 17.32 min/day spent dancing.

Discussion

This study examined the feasibility of a novel dance-based intervention to improve PA levels of preschool aged children while in childcare. Despite small increases in PA among the intervention group, no differential effects between the control group and intervention group were found. Moreover, observed increases in PA during this study appear to be largely the result of increased outdoor play time as changes in indoor activity levels were negligible. Counter to our hypothesis, the intervention group did not display higher levels of indoor MVPA and lower levels of SED time in comparison to the control group during the intervention period. Overall, the dance-based intervention evaluated in this study did not produce significant or meaningful impacts on preschoolers' PA.

Similar to previous investigations which provided more opportunities for preschoolers to accumulate PA (Alhassan et al., 2007; Reilly et al., 2006), little change in activity levels was observed. Previous epidemiological evidence has suggested that increases in outdoor activity time might be sufficient to significantly increase PA among preschoolers (Burdette & Whitaker, 2005; Zask, van Beurden, Barnett, Brooks, & Dietrich, 2001). However, an empirical evaluation of this hypothesis was unable to demonstrate that increasing outdoor activity time had any substantial impact on preschoolers' PA (Alhassan et al., 2007). Some research has suggested that changing the PA environment by adding outdoor play equipment to recreation areas can increase preschoolers' PA (Hannon & Brown, 2008). However, a confirmatory study with large sample size and rigorous methodological design, employing similar intervention strategies to those used by Hannon and Brown (2008), was unable to replicate the same positive PA benefits from adding supplementary playground equipment to outdoor recreation areas (Cardon et al., 2009). Other investigations using supervised PA or movement sessions have demonstrated mixed results (Binkley & Specker, 2004; Reilly et al., 2006; Trost et al., 2008). Nonetheless, those investigations which incorporated structured PA sessions on a daily basis into the childcare setting were effective in increasing preschoolers' PA (Binkley & Specker, 2004; Trost et al., 2008).

Despite the lack of change in activity levels among children participating in this study's intervention group, the dance-based activity sessions appeared to be very active. Average activity intensity during dance sessions was over three times higher than all other time spent indoors and over 50% higher than all time spent outdoors. In addition, the rate of MVPA accumulation during dance sessions was three and a half times higher than during all other indoor time and 28% higher than during all outdoor time. Still, it is noteworthy that over 50% of dance session time was spent being sedentary. Similarly, over 50% of outdoor time was sedentary as well. This finding is somewhat puzzling considering that outdoor time is usually designated as a time for being physically active. However, Trost and colleagues (2008) demonstrated that preschool children only spent 25% of their outdoor time in MVPA, which is relatively similar to findings from this study as children in the intervention group only spent 20.5% of their outdoor time in MVPA.

Feedback from childcare providers who delivered the dance-based intervention was primarily positive. One childcare provider remarked that "… the kids certainly had fun. I can't remember a time when naptime was so quiet and uneventful." Other comments reflected similar attitudes about the dance sessions. In general, most childcare providers believed participating children enjoyed the dance sessions. However, one provider did mention that “It was difficult to get the kids to stop dancing after 10 minutes because they wanted to keep going.”

Several limitations of this study are worth noting. First, this study had relatively low statistical power to detect moderate changes in PA. This was considered acceptable for the purposes of this research as this was an initial feasibility study. Moreover, although PA during the dance sessions was relatively high, we had expected to see cumulative MVPA durations of approximately 10 min during the dance sessions. However, MVPA accumulations during dance sessions were less than half (4.53 min) of the 10 min duration we had expected. This may have been due to a lack of control over how dance sessions were delivered as childcare providers implemented the intervention. However, this approach was chosen to increase the generalizability of results as it is unfeasible for many childcare centers to bring in outside personnel to lead PA sessions. Another limitation of this study was that PA was only measured during the childcare day. As such, no determination as to how PA may or may not have changed outside of the childcare center during the intervention program can be made.

Conclusion

The dance-based intervention introduced in this study, consisting of twice daily 7.5-10 min dance breaks, was unable to significantly increase preschoolers’ PA and reduce SED time. Verbal feedback from childcare providers indicated that the intervention was well received by children and by the providers themselves. Activity levels during the intervention’s dance sessions were significantly higher than all other time spent indoors and outdoors. This finding holds promise for future interventions incorporating indoor PA programs into the preschool curriculum. Considering the relatively high activity levels observed during the dance sessions, future investigations may wish to use the intervention framework introduced in this study and increase the amount and/or duration of dance sessions delivered during the intervention. Such efforts may demonstrate beneficial improvements in children's PA during childcare.

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SUMMARY

The purpose of this dissertation was twofold: 1) to prospectively track preschoolers' PA levels during childcare while investigating for seasonal differences in accelerometer measured PA between the fall and winter months in Fargo, North Dakota, and 2) to evaluate the feasibility of a novel dance-based intervention for increasing PA and reducing SED time in childcare using short activity breaks (< 10 min) interspersed throughout the childcare day. For clarification, Paper 1 of this dissertation addressed the first research purpose, while Paper 2 addressed the second research purpose.

The primary finding from Paper 1 was that PA levels of preschoolers within this sample significantly changed from fall to winter. Concurrent with a 12.65 °C reduction in outdoor temperature from fall to winter, children accumulated lesser amounts of moderate-to-vigorous PA (MVPA) and greater amounts of sedentary (SED) time during winter than fall. Daily MVPA declined by 17.1% (-5.7 min/day) from fall to winter, while daily SED time increased by 3.2% (+8.6 min/day) during this period. Observed declines in PA appear to be largely influenced by reductions in outdoor play time which occurred during the winter assessment. The biological significance of the observed declines in MVPA and increases in SED time from this study are unknown. Nonetheless, two fold increases in obesity prevalence among preschool aged children over the last 40 years, along with mounting evidence linking childhood obesity to many adverse health outcomes, suggest that any significant decrease in daily MVPA would not be desirable. This is especially pertinent considering that sufficient PA accumulation has been identified as a primary means for preventing childhood obesity (American Academy of Pediatrics and Council on Sports Medicine and Fitness and Council on School Health, 2006)

In addition to the seasonal PA declines observed in Paper 1, mean levels of MVPA across the two assessment periods were less than desirable. Children accumulated an average of 6.1 min/hr of MVPA, which extrapolates to approximately 48.8 min of MVPA per every 8 waking hours in childcare. Ambiguity in current PA guidelines for preschoolers makes it difficult to judge the adequacy of observed MVPA levels from this study. However, it has been suggested that less than 60 min of MVPA accumulation per every 8 hr in childcare is undesirable (Pate et al., 2004). On the basis of this suggestion it appears that PA levels within this study were insufficient. In general though, the 6.1 min/hr of MVPA observed among preschoolers in this study falls within the range of daily MVPA estimates published from other studies (Reilly, 2010). However, differences in assessment methodologies (e.g., accelerometer type, epoch length, cut points used, etc.) make it difficult and often impractical to compare PA estimates between studies.

The primary finding from Paper 2 was that the dance-based intervention implemented during the study did not significantly increase daily levels of MVPA or decrease SED time. No appreciable increases in MVPA or SED time were noted for the intervention group during the dance intervention period. In addition, no between group differences in any measured PA variables were found between the intervention and control groups at baseline or during the intervention period. Childcare centers which received the intervention averaged 17.32 min/day of dance from the two daily dance sessions; however, only 4.53 min/day of MVPA was accumulated during this time. Nevertheless, it is worth noting that relative MVPA levels (min/hr) during the intervention's dance sessions were over three and a half times higher than all other indoor time and 28% higher than all time spent outdoors.

Design limitations of the study detailed in Paper 2 preclude us from making definitive judgments regarding the overall efficacy of the dance-based intervention. Although a moderate sized sample was recruited for the study, the cluster randomized design used to evaluate the intervention significantly reduced statistical power. This was deemed acceptable for this investigation as it was an initial feasibility study. Moreover, we had expected to see MVPA accumulations during the dance sessions of approximately 10 min/day in comparison to the observed 4.5 min/day. However, future investigations aiming to evaluate the effectiveness of dance-based interventions for preschoolers would benefit from recruiting a much larger number of clusters (e.g., 20+ clusters).

Findings from Paper 1 indicated that PA levels of preschoolers' in this investigation significantly declined from fall to winter. The decrease in time spent outdoors appears to have played a significant role in the observed daily MVPA reduction. Besides the observed seasonal reduction in MVPA, daily MVPA accumulation across the two time periods was less than optimal. Overall, preschoolers in this sample averaged 48.8 min of MVPA per every 8 waking hours in childcare, which is well below the desirable threshold of 60 min of MVPA per every 8 hr in childcare (Pate et al., 2004; Reilly, 2010). Results from Paper 2 indicated that the dance-based intervention evaluated during the study did not significantly change PA levels. However, the dance-sessions implemented during the study were rather active and characterized by high rates of MVPA accumulation relative to all other time spent indoors or outdoors. Future research may wish to make slight modifications to the intervention we evaluated (i.e., increase the number of dance sessions per day) and re-examine the effectiveness of the intervention using a much larger cluster randomized controlled trial.

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APPENDIX A. PARENT/GUARDIAN PERMISSION TO PARTICIPATE IN RESEARCH

Research Study

Your child/legal ward is invited to participate in a research study assessing his/her daily physical activity while at childcare for 1 week using an accelerometer on three separate occasions. An acceleromter is a small device (3.3 in X 1.4 in X 0.6 in) worn on the hip that detects and records physical activity. This study is being conducted by Dr. Gary Liguori and Mr. John Schuna, from the Department of Health, Nutrition, and Exercise Sciences at North Dakota State University (NDSU).

Basis for Participant Selection

Your child/legal ward has been selected because he or she attends one of the four childcare facilities agreeing to participate in this study and is between the ages of 3 and 5. The four centers are spread through Fargo and represent a variety of childcare facilities in Fargo. We are looking to assess approximately 15-30 children at each childcare facility.

Purpose of Study

There are two main purposes of this study: 1) to describe the physical activity of preschool aged children (3-5 year-olds) in the four Fargo-based childcare centers, while examining for seasonal differences in physical activity between Fall and Winter, and 2) to evaluate a new program for increasing physical activity levels and reducing sedentary behavior in preschool aged children in childcare. The program to be used in this study is called *Dance to Move* and consists of short dance breaks throughout the childcare day. The study will first measure physical activity of 3-5 year-old children at the four participating facilities during October/November 2011. Children at participating facilities will then have their physical activity measured again during mid-January 2012. Following this in mid-February 2012, physical activity at all four facilities will be measured again with two of the four facilities being randomly chosen to participate in a dance-based physical activity program called *Dance to Move*.

Explanation of Procedures

Physical Activity Assessments

- Your child will be asked to wear an accelerometer during the day while he/she is at childcare, for five straight days on three separate occasions (October/November 2011, January 2012, and February 2012).
    - Accelerometers are small devices which sense and record movement. The accelerometers cannot be broken down and do not have moving parts. Accelerometers are attached to an elastic waist-belt that is worn outside of any clothing, not on the child’s skin, which prevents rubbing or chaffing. Each accelerometer is protected in a soft plastic case connected to the elastic belt. The elastic belt attaches to itself with a small plastic buckle.

- To measure your child's physical activity on each occasion, your child will be asked to wear an acceleromter for their entire day at childcare, except during naptime, over a 5 day period (1 week). The total time your child will wear the accelerometer will vary depending upon when you drop-off and pick-up your child. This could range from only a few hours on a given day to 9+ hours on another day.
    - At the beginning of each day during the study, your child will be fit with an elastic belt and attached accelerometer when they arrive at the childcare facility. Your child will first be asked whether or not they want to participate in the study by wearing the elastic belt and attached accelerometer.
    - The elastic belts and attached accelerometer will be removed at naptime. Your child will be asked if they wish to continue participating in the study by wearing the elastic belt and attached accelerometer after their nap. Those children that wish to continue will be re-fit with the elastic belt and attached accelerometer.
    - If at any time your child indicates they do not want to wear the accelerometer or participate in the study, the elastic belt and attached accelerometer will be removed by one of the childcare center's teachers. At the end of the day, the elastic belt and attached accelerometer will be removed by a childcare center teacher. Any children leaving the center earlier than usual for the day will return their elastic belt and accelerometer directly to a teacher or leave it in their cubbie.

Dance to Move Program

- The *Dance to Move* program is a dance-based program consisting of 2 short 7.5-10 minute daily dance breaks. These breaks are spread across the childcare day. The program is designed to increase physical activity while at childcare.

- Only two of the four participating childcare facilities will receive the *Dance to Move* program beginning in February 2012, which coincides with the last physical activity measurement period.

- To make sure all participating facilities benefit, the two childcare facilities which do not receive the *Dance to Move* program in February 2012 will still receive the *Dance to Move* program materials, training, and instructions at the end of the study in March 2012.

*****If you decide to allow your child to participate in this study, you will first be asked to fill out a short parental information sheet (4 questions) asking for your child's name, date of birth, gender, and race/ethnicity.

Study Schedule

October/November 2011

- Your child will first be weighed and measured.
- Your child will then only be asked to wear an accelerometer during each day they attend childcare over a 5 day period (1 week).
- Children will participate in their normal daily activities

January 2012

- Your child will first be weighed and measured
- Your child will then only be asked to wear an accelerometer during each day they attend childcare over a 5 day period (1 week).
- Children will participate in their normal daily activities.

February 2012

- Your child will only be asked to wear an accelerometer during each day they attend childcare over a 5 day period (1 week).
- Children from two of the participating childcare facilities will be exposed to a dance-based program (*Dance to Move*) consisting of 2 short 7.5-10 minute dance breaks
- Children at the two facilities not participating in the *Dance to Move* program will participate in their normal daily activities

Potential Risks and Discomforts

The accelerometer provides minimal discomfort, if any, while being worn. There is no known health or injury risks associated with wearing the accelerometer besides falling directly onto the device. Such a fall may cause localized swelling, bruising, or discomfort. However, the risk of such an injury from falling directly on top of the accelerometer is no greater than the risk of falling while wearing a similar-sized device on the waist (e.g., cellular phone, beeper, etc.). There are no physical risks for your child while they are being weighed and measured. All measurements will be conducted individually and their results will be kept confidential by the research team. There is the potential for physical injury during the dance breaks incorporated in the *Dance to Move* program. However, the dance breaks pose no greater risk of injury than your child already encounters while participating in regular physical activity while at childcare.

In addition, as a parent/guardian of a participating child, you do not need to worry about your child damaging the accelerometer used during this research. The accelerometers can only be removed from the elastic belt by cutting the elastic belt. Any damage to the device will most likely be due to a direct fall on top of it. However, such damage is unlikely as the device is made of a strong and resilient material; in addition, it will be contained within its own protective case made of durable plastic. If an accelerometer is damaged by a participant, you and your child will not be held liable for that damage and will not be expected to pay for any costs associated with repairing or replacing the device.

Potential Benefits

If you choose to allow your child to participate in this study, you and your child will benefit by being provided an objective assessment of your child's physical activity during the Fall and Winter months while at childcare. In addition, if your child is enrolled at one of the sites which receives the intervention in February 2012, they will have the opportunity to accumulate additional physical activity during the childcare day. Again, even those childcare facilities which do not receive the *Dance to Move* program in February 2012, will be given the same program, materials, and training at the completion of the study (March 2012). Results from this study may have the potential to benefit society in general by identifying effective strategies to increase physical activity of children while in childcare.

Assurance of Confidentiality

Your child will ***not*** be identified by name or any other identifying characteristics in any publication referring to this study. All data will be kept strictly confidential by the research team. The researchers will remove any information that identifies your child once all data is collected. Only aggregate data will be used for reporting purposes.

Data and records created by this project are owned by North Dakota State University and the investigator. You may view information collected from your child/legal ward by making a written request to the principal investigator. You may view only information collected from your child/legal ward, and not information collected about others participating in the project.

Voluntary Participation and Withdrawal From the Study

Your child/legal ward's participation is voluntary and he/she can quit at any time. Your decision whether or not to allow your child/legal ward to participate will not affect you or your child/legal ward's ability to attend the childcare center or any other benefits to which they are otherwise entitled. If you decide to allow your child/legal ward to participate, you are free to withdraw your permission and to discontinue their participation at any time. Furthermore, if you decide to allow your legal child/legal ward to participate, your legal child/legal ward still has the final say as to whether or not they want to participate. Your child will be asked whether they want to participate in the study at the beginning of each day. In addition, your child will be asked several times throughout the day to indicate whether or not they want to continue participating. If at any time your child indicates that they do not want to wear the accelerometer or participate in the study, the elastic belt and attached accelerometer will be removed by one of the childcare center teachers. Similarly, your child/legal ward's decision whether or not to participate will not affect you or your child/legal ward's ability to attend the childcare center or any other benefits to which they are otherwise entitled.

Offer to Answer Questions

You and your child/legal ward should feel free to ask questions now or at any time during the study. If you or your child/legal ward has questions about this study, you can contact Dr. Gary Liguori at gary.liguori@ndsu.edu or 701-231-8682 or Mr. John Schuna at John.Schunajr@ndsu.edu or 701-231-8513. If you have questions about the rights of human research participants, or wish to report a research-related problem or injury, contact the NDSU IRB Office at (701) 231-8908 or ndsu.irb@ndsu.edu.

Consent Statement

By signing this form, you are stating that you have read and understand this form and the research project, and are freely agreeing to allow your child/legal ward to be a part of this study. If there are things you do not understand about the study, please ask the researchers before you sign the form. You will be given a copy of this form to keep.

____

Parent/Guardian Signature Printed Name Date

____

Parent/Guardian Signature Printed Name Date

____

Relation to Participant Name of Child/Legal Ward

____

Researcher obtaining permission:
Signature Printed Name Date

APPENDIX B. PARENT/GUARDIAN SURVEY

Please do not complete this survey until you have read and signed the attached informed consent form.

To assist us in describing the physical activity patterns of your child, please answer the questions below. Your responses will be used for research purposes only and all information provided here will be kept strictly confidential.

Thank you.

1. What is your child's name? ______________________
2. What is your child's date-of-birth _____/_____/________ (Month/Day/Year)
3. What is your child's gender? Male Female (Circle One)
4. What is your child's race/ethnicity? (Circle One)
   a. White/Caucasian
   b. Black/African-American
   c. Hispanic or Latino
   d. Asian or Pacific Islander
   e. Native American
   f. Other. Please specify __________________

APPENDIX C. INSTITUTIONAL REVIEW BOARD APPROVAL FORM

NDSU NORTH DAKOTA STATE UNIVERSITY

Institutional Review Board

Office of the Vice President for Research, Creative Activities and Technology Transfer
NDSU Dept. 4000
1735 NDSU Research Park Drive
Research 1, P.O. Box 6050
Fargo, ND 58108-6050

701.231.8995
Fax 701.231.8098

Federalwide Assurance #FWA00002439

October 21, 2011

Gary Liguori
Department of Health, Nutrition & Exercise Science
EML 351

IRB Approval of Protocol **#HE12064**, "**Physical Activity During Childcare - Longitudinal Assessment and Physical Activity Intervention**"
Co-investigator(s) and research team: **John Schuna, Sarah Hilgers, Anita Gust, Nick Redenius, Jared Tucker**

Approval period: 10/19/2011 to 10/18/2012 **Continuing Review Report Due: 9/1/2012**

Research site(s): **Atonement Children's Weekday Ministries, The Learning Patch Child Care Center, Nokomis 1 Child Care Center, Nokomis 2 Child Care Center** Funding agency: **n/a**
Review Type: ☒ Expedited category # 4, 7 ☐ Full Board
IRB approval is based on original submission, with revised: protocol, permission form, and assent script (received 10/19/2011).

Additional approval is required:

- prior to implementation of any proposed changes to the protocol (*Protocol Amendment Request Form*).
- for continuation of the project beyond the approval period (*Continuing Review/Completion Report Form).* A reminder is typically sent two months prior to the expiration date; timely submission of the report is your responsibility. To avoid a lapse in approval, suspension of recruitment, and/or data collection, a report must be received, and the protocol reviewed and approved prior to the expiration date.

A report is required for:

- any research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others within 72 hours of known occurrence (*Report of Unanticipated Problem or Serious Adverse Event Form*).
- any significant new findings that may affect risks to participants.
- closure of the project (*Continuing Review/Completion Report Form*).

Research records are subject to random or directed audits at any time to verify compliance with IRB regulations and NDSU policies.

Thank you for cooperating with NDSU IRB procedures, and best wishes for a successful study.

Sincerely,

Kristy Shirley

Kristy Shirley, CIP
Research Compliance Administrator

Last printed 10/21/2011 2:35:00 PM

NDSU is an EO/AA university.

APPENDIX D. OUTDOOR TIME AND NAPTIME RECORDING FORM

For each date, please record the start and stop time for times spent outdoors and naptime.

Monday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Naptime
Start Time:			
Stop Time:			

Tuesday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Naptime
Start Time:			
Stop Time:			

Wednesday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Naptime
Start Time:			
Stop Time:			

Thursday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Naptime
Start Time:			
Stop Time:			

Friday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Naptime
Start Time:			
Stop Time:			

APPENDIX E. ACCELEROMETER DATA REDUCTION PROGRAM

All syntax below written in the R statistical programming language

```
library(PhysicalActivity)

totals <- function(Inout.sub)
{
Mondayprenap.sub <- subset(Inout.sub, days==1 & "YYYY-MM-DD HH:MM:SS" > Time)
Mondaypostnap.sub <- subset(Inout.sub, days==1 & "YYYY-MM-DD HH:MM:SS" < Time)

 Monday.sub <- rbind(Mondayprenap.sub, Mondaypostnap.sub)
  Monsed <- (sum(0<= Monday.sub$counts & Monday.sub$counts < 125)/12)
  Monlght <- (sum(125 <= Monday.sub$counts & Monday.sub$counts < 195)/12)
  Monmod  <- (sum(195 <= Monday.sub$counts & Monday.sub$counts < 294)/12)
  Monvig <- (sum(294 <= Monday.sub$counts & Monday.sub$counts < 1667)/12)
  Monmv  <- (sum(195 <= Monday.sub$counts & Monday.sub$counts < 1667)/12)
  Monmalf <- (sum(Monday.sub$counts >= 1667)/12)
  Monwear <- (sum(Monday.sub$wearing=="w")/12)
  Moncts <- sum(Monday.sub$counts)
  Monctspermin <- Moncts/Monwear

 Mondayout1.sub <- subset(Monday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                          "YYYY-MM-DD HH:MM:SS" >= Time)
 Mondayout2.sub <- subset(Monday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                          "YYYY-MM-DD HH:MM:SS" >= Time)
 Mondayout.sub <- rbind(Mondayout1.sub, Mondayout2.sub)
  Monsedout <- (sum(0<= Mondayout.sub$counts & Mondayout.sub$counts < 125)/12)
  Monlghtout <- (sum(125 <= Mondayout.sub$counts & Mondayout.sub$counts < 195)/12)
  Monmodout  <- (sum(195 <= Mondayout.sub$counts & Mondayout.sub$counts < 294)/12)
  Monvigout <- (sum(294 <= Mondayout.sub$counts & Mondayout.sub$counts < 1667)/12)
  Monmvout  <- (sum(195 <= Mondayout.sub$counts & Mondayout.sub$counts < 1667)/12)
  Monmalfout <- (sum(Mondayout.sub$counts >= 1667)/12)
  Monwearout <- (sum(Mondayout.sub$wearing=="w")/12)
  Monctsout <- sum(Mondayout.sub$counts)
  Monctsperminout <- Monctsout/Monwearout

  Monsedin <- Monsed-Monsedout
  Monlghtin <- Monlght-Monlghtout
  Monmodin <- Monmod-Monmodout
  Monvigin <- Monvig-Monvigout
  Monmvin <- Monmv-Monmvout
  Monmalfin <- Monmalf-Monmalfout
  Monwearin <- Monwear-Monwearout
  Monctsin <- Moncts-Monctsout
  Monctsperminin <- Monctsin/Monwearin
```

```
Tuesdayprenap.sub <- subset(Inout.sub, days==2 & "YYYY-MM-DD HH:MM:SS" > Time)
Tuesdaypostnap.sub <- subset(Inout.sub, days==2 & "YYYY-MM-DD HH:MM:SS" < Time)

 Tuesday.sub <- rbind(Tuesdayprenap.sub, Tuesdaypostnap.sub)
  Tuessed <- (sum(0<= Tuesday.sub$counts & Tuesday.sub$counts < 125)/12)
  Tueslght <- (sum(125 <= Tuesday.sub$counts & Tuesday.sub$counts < 195)/12)
  Tuesmod  <- (sum(195 <= Tuesday.sub$counts & Tuesday.sub$counts < 294)/12)
  Tuesvig <- (sum(294 <= Tuesday.sub$counts & Tuesday.sub$counts < 1667)/12)
  Tuesmv  <- (sum(195 <= Tuesday.sub$counts & Tuesday.sub$counts < 1667)/12)
  Tuesmalf <- (sum(Tuesday.sub$counts >= 1667)/12)
  Tueswear <- (sum(Tuesday.sub$wearing=="w")/12)
  Tuescts <- sum(Tuesday.sub$counts)
  Tuesctspermin <- Tuescts/Tueswear


 Tuesdayout1.sub <- subset(Tuesday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                              "YYYY-MM-DD HH:MM:SS" >= Time)
 Tuesdayout2.sub <- subset(Tuesday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                              "YYYY-MM-DD HH:MM:SS" >= Time)
 Tuesdayout.sub <- rbind(Tuesdayout1.sub, Tuesdayout2.sub)
  Tuessedout <- (sum(0<= Tuesdayout.sub$counts & Tuesdayout.sub$counts < 125)/12)
  Tueslghtout <- (sum(125 <= Tuesdayout.sub$counts & Tuesdayout.sub$counts < 195)/12)
  Tuesmodout  <- (sum(195 <= Tuesdayout.sub$counts & Tuesdayout.sub$counts < 294)/12)
  Tuesvigout <- (sum(294 <= Tuesdayout.sub$counts & Tuesdayout.sub$counts < 1667)/12)
  Tuesmvout  <- (sum(195 <= Tuesdayout.sub$counts & Tuesdayout.sub$counts < 1667)/12)
  Tuesmalfout <- (sum(Tuesdayout.sub$counts >= 1667)/12)
  Tueswearout <- (sum(Tuesdayout.sub$wearing=="w")/12)
  Tuesctsout <- sum(Tuesdayout.sub$counts)
  Tuesctsperminout <- Tuesctsout/Tueswearout

  Tuessedin <- Tuessed-Tuessedout
  Tueslghtin <- Tueslght-Tueslghtout
  Tuesmodin <- Tuesmod-Tuesmodout
  Tuesvigin <- Tuesvig-Tuesvigout
  Tuesmvin <- Tuesmv-Tuesmvout
  Tuesmalfin <- Tuesmalf-Tuesmalfout
  Tueswearin <- Tueswear-Tueswearout
  Tuesctsin <- Tuescts-Tuesctsout
  Tuesctsperminin <- Tuesctsin/Tueswearin

Wednesdayprenap.sub <- subset(Inout.sub, days==3 & "YYYY-MM-DD HH:MM:SS" >
                                        Time)
Wednesdaypostnap.sub <- subset(Inout.sub, days==3 & "YYYY-MM-DD HH:MM:SS" <
                                         Time)
```

```
Wednesday.sub <- rbind(Wednesdayprenap.sub, Wednesdaypostnap.sub)
 Wedsed <- (sum(0<= Wednesday.sub$counts & Wednesday.sub$counts < 125)/12)
 Wedlght <- (sum(125 <= Wednesday.sub$counts & Wednesday.sub$counts < 195)/12)
 Wedmod  <- (sum(195 <= Wednesday.sub$counts & Wednesday.sub$counts < 294)/12)
 Wedvig <- (sum(294 <= Wednesday.sub$counts & Wednesday.sub$counts < 1667)/12)
 Wedmv  <- (sum(195 <= Wednesday.sub$counts & Wednesday.sub$counts < 1667)/12)
 Wedmalf <- (sum(Wednesday.sub$counts >= 1667)/12)
 Wedwear <- (sum(Wednesday.sub$wearing=="w")/12)
 Wedcts <- sum(Wednesday.sub$counts)
 Wedctspermin <- Wedcts/Wedwear

Wednesdayout1.sub <- subset(Wednesday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                            "YYYY-MM-DD HH:MM:SS" >= Time)
Wednesdayout2.sub <- subset(Wednesday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                            "YYYY-MM-DD HH:MM:SS" >= Time)
Wednesdayout.sub <- rbind(Wednesdayout1.sub, Wednesdayout2.sub)
 Wedsedout <- (sum(0<= Wednesdayout.sub$counts & Wednesdayout.sub$counts < 125)/12)
 Wedlghtout <- (sum(125 <= Wednesdayout.sub$counts & Wednesdayout.sub$counts <
                195)/12)
 Wedmodout  <- (sum(195 <= Wednesdayout.sub$counts & Wednesdayout.sub$counts <
                 294)/12)
 Wedvigout <- (sum(294 <= Wednesdayout.sub$counts & Wednesdayout.sub$counts <
                1667)/12)
 Wedmvout  <- (sum(195 <= Wednesdayout.sub$counts & Wednesdayout.sub$counts <
                1667)/12)
 Wedmalfout <- (sum(Wednesdayout.sub$counts >= 1667)/12)
 Wedwearout <- (sum(Wednesdayout.sub$wearing=="w")/12)
 Wedctsout <- sum(Wednesdayout.sub$counts)
 Wedctsperminout <- Wedctsout/Wedwearout

 Wedsedin <- Wedsed-Wedsedout
 Wedlghtin <- Wedlght-Wedlghtout
 Wedmodin <- Wedmod-Wedmodout
 Wedvigin <- Wedvig-Wedvigout
 Wedmvin <- Wedmv-Wedmvout
 Wedmalfin <- Wedmalf-Wedmalfout
 Wedwearin <- Wedwear-Wedwearout
 Wedctsin <- Wedcts-Wedctsout
 Wedctsperminin <- Wedctsin/Wedwearin

Thursdayprenap.sub <- subset(Inout.sub, days==4 & "YYYY-MM-DD HH:MM:SS" > Time)
Thursdaypostnap.sub <- subset(Inout.sub, days==4 & "YYYY-MM-DD HH:MM:SS" <
                              Time)

Thursday.sub <- rbind(Thursdayprenap.sub, Thursdaypostnap.sub)
 Thurssed <- (sum(0<= Thursday.sub$counts & Thursday.sub$counts < 125)/12)
```

```
 Thurslght <- (sum(125 <= Thursday.sub$counts & Thursday.sub$counts < 195)/12)
 Thursmod  <- (sum(195 <= Thursday.sub$counts & Thursday.sub$counts < 294)/12)
 Thursvig <- (sum(294 <= Thursday.sub$counts & Thursday.sub$counts < 1667)/12)
 Thursmv  <- (sum(195 <= Thursday.sub$counts & Thursday.sub$counts < 1667)/12)
 Thursmalf <- (sum(Thursday.sub$counts >= 1667)/12)
 Thurswear <- (sum(Thursday.sub$wearing=="w")/12)
 Thurscts <- sum(Thursday.sub$counts)
 Thursctspermin <- Thurscts/Thurswear

Thursdayout1.sub <- subset(Thursday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                          "YYYY-MM-DD HH:MM:SS"    >= Time)
 Thursdayout2.sub <- subset(Thursday.sub, "YYYY-MM-DD HH:MM:SS" <= Time &
                          "YYYY-MM-DD HH:MM:SS" >= Time)
Thursdayout.sub <- rbind(Thursdayout1.sub, Thursdayout2.sub)
 Thurssedout <- (sum(0<= Thursdayout.sub$counts & Thursdayout.sub$counts < 125)/12)
 Thurslghtout <- (sum(125 <= Thursdayout.sub$counts & Thursdayout.sub$counts <
                    195)/12)
 Thursmodout  <- (sum(195 <= Thursdayout.sub$counts & Thursdayout.sub$counts <
                      294)/12)
 Thursvigout <- (sum(294 <= Thursdayout.sub$counts & Thursdayout.sub$counts <
                    1667)/12)
 Thursmvout  <- (sum(195 <= Thursdayout.sub$counts & Thursdayout.sub$counts <
                    1667)/12)
 Thursmalfout <- (sum(Thursdayout.sub$counts >= 1667)/12)
 Thurswearout <- (sum(Thursdayout.sub$wearing=="w")/12)
 Thursctsout <- sum(Thursdayout.sub$counts)
 Thursctsperminout <- Thursctsout/Thurswearout

 Thurssedin <- Thurssed-Thurssedout
 Thurslghtin <- Thurslght-Thurslghtout
 Thursmodin <- Thursmod-Thursmodout
 Thursvigin <- Thursvig-Thursvigout
 Thursmvin <- Thursmv-Thursmvout
 Thursmalfin <- Thursmalf-Thursmalfout
 Thurswearin <- Thurswear-Thurswearout
 Thursctsin <- Thurscts-Thursctsout
 Thursctsperminin <- Thursctsin/Thurswearin

Fridayprenap.sub <- subset(Inout.sub, days==5 & "YYYY-MM-DD HH:MM:SS" > Time)
Fridaypostnap.sub <- subset(Inout.sub, days==5 & "YYYY-MM-DD HH:MM:SS" < Time)

Friday.sub <- rbind(Fridayprenap.sub, Fridaypostnap.sub)
 Frised <- (sum(0<= Friday.sub$counts & Friday.sub$counts < 125)/12)
 Frilght <- (sum(125 <= Friday.sub$counts & Friday.sub$counts < 195)/12)
 Frimod  <- (sum(195 <= Friday.sub$counts & Friday.sub$counts < 294)/12)
 Frivig <- (sum(294 <= Friday.sub$counts & Friday.sub$counts < 1667)/12)
```

```
  Frimv  <- (sum(195 <= Friday.sub$counts & Friday.sub$counts < 1667)/12)
  Frimalf <- (sum(Friday.sub$counts >= 1667)/12)
  Friwear <- (sum(Friday.sub$wearing=="w")/12)
  Fricts <- sum(Friday.sub$counts)
  Frictspermin <- Fricts/Friwear

  Fridayout1.sub <- subset(Friday.sub, "YYYY-MM-DD HH:MM:SS" <= Time & "YYYY-
                              MM-DD HH:MM:SS" >=    Time)
  Fridayout2.sub <- subset(Friday.sub, "YYYY-MM-DD HH:MM:SS" <= Time & "YYYY-
                              MM-DD HH:MM:SS" >= Time)
 Fridayout.sub <- rbind(Fridayout1.sub, Fridayout2.sub)
  Frisedout <- (sum(0<= Fridayout.sub$counts & Fridayout.sub$counts < 125)/12)
  Frilghtout <- (sum(125 <= Fridayout.sub$counts & Fridayout.sub$counts < 195)/12)
  Frimodout  <- (sum(195 <= Fridayout.sub$counts & Fridayout.sub$counts < 294)/12)
  Frivigout <- (sum(294 <= Fridayout.sub$counts & Fridayout.sub$counts < 1667)/12)
  Frimvout  <- (sum(195 <= Fridayout.sub$counts & Fridayout.sub$counts < 1667)/12)
  Frimalfout <- (sum(Fridayout.sub$counts >= 1667)/12)
  Friwearout <- (sum(Fridayout.sub$wearing=="w")/12)
  Frictsout <- sum(Fridayout.sub$counts)
  Frictsperminout <- Frictsout/Friwearout

  Frisedin <- Frised-Frisedout
  Frilghtin <- Frilght-Frilghtout
  Frimodin <- Frimod-Frimodout
  Frivigin <- Frivig-Frivigout
  Frimvin <- Frimv-Frimvout
  Frimalfin <- Frimalf-Frimalfout
  Friwearin <- Friwear-Friwearout
  Frictsin <- Fricts-Frictsout
  Frictsperminin <- Frictsin/Friwearin

############
############

Weekdata <- cbind(Id, Wave, Facility, Room, Monsed, Monsedout, Monsedin, Tuessed,
Tuessedout, Tuessedin, Wedsed, Wedsedout, Wedsedin, Thurssed, Thurssedout, Thurssedin,
Frised, Frisedout, Frisedin, Monlght, Monlghtout, Monlghtin, Tueslght, Tueslghtout,
Tueslghtin, Wedlght, Wedlghtout, Wedlghtin, Thurslght, Thurslghtout, Thurslghtin, Frilght,
Frilghtout, Frilghtin, Monmod, Monmodout, Monmodin, Tuesmod, Tuesmodout, Tuesmodin,
Wedmod, Wedmodout, Wedmodin, Thursmod, Thursmodout, Thursmodin, Frimod,
Frimodout, Frimodin, Monvig, Monvigout, Monvigin, Tuesvig, Tuesvigout, Tuesvigin,
Wedvig, Wedvigout, Wedvigin, Thursvig, Thursvigout, Thursvigin, Frivig, Frivigout,
Frivigin, Monmv, Monmvout, Monmvin, Tuesmv, Tuesmvout, Tuesmvin, Wedmv,
Wedmvout, Wedmvin, Thursmv, Thursmvout, Thursmvin, Frimv, Frimvout, Frimvin,
Monmalf, Monmalfout, Monmalfin, Tuesmalf, Tuesmalfout, Tuesmalfin, Wedmalf,
Wedmalfout, Wedmalfin, Thursmalf, Thursmalfout, Thursmalfin, Frimalf, Frimalfout,
```

```
Frimalfin, Monwear, Monwearout, Monwearin, Tueswear, Tueswearout, Tueswearin,
Wedwear, Wedwearout, Wedwearin, Thurswear, Thurswearout, Thurswearin, Friwear,
Friwearout, Friwearin, Moncts, Monctsout, Monctsin, Tuescts, Tuesctsout, Tuesctsin,Wedcts,
Wedctsout, Wedctsin, Thurscts, Thursctsout, Thursctsin, Fricts, Frictsout, Frictsin,
Monctspermin, Monctsperminout, Monctsperminin, Tuesctspermin, Tuesctsperminout,
Tuesctsperminin, Wedctspermin,Wedctsperminout, Wedctsperminin, Thursctspermin,
Thursctsperminout, Thursctsperminin, Frictspermin, Frictsperminout, Frictsperminin)

write.table(Weekdata, file="C:/Dir/Aggregrate.csv", sep = ",", col.names=F, row.names=F,
quote=F, append=T)
}

three <- readCountsData("C:/Dir/Acc_file.csv", ctPerSec = 1/5)
mydata1m <- three

Id <- "Id number"
Wave <- "Wave number"
Facility <- "Facility number"
Room <- "Room number"

data1m = wearingMarking(dataset = mydata1m,
frame = 10,
perMinuteCts = 12,
TS = "TimeStamp",
cts = "counts",
streamFrame = 0,
allowanceFrame= 0,
newcolname = "wearing")

Time <- as.POSIXct(data1m$TimeStamp)
data2m <- cbind(data1m, Time)

    Mondayinout.sub <- subset(data2m, wearing=="w" & days==1 & "YYYY-MM-DD
                           HH:MM:SS" <= Time & "YYYY-MM-DD HH:MM:SS" >= Time)

    Tuesdayinout.sub <- subset(data2m, wearing=="w" & days==2 & "YYYY-MM-DD
                           HH:MM:SS" <= Time & "YYYY-MM-DD HH:MM:SS" >= Time)

    Wednesdayinout.sub <- subset(data2m, wearing=="w" & days==3 & "YYYY-MM-DD
                              HH:MM:SS" <= Time & "YYYY-MM-DD HH:MM:SS" >=
                              Time)

    Thursdayinout.sub <- subset(data2m, wearing=="w" & days==4 & "YYYY-MM-DD
                            HH:MM:SS" <= Time & "YYYY-MM-DD HH:MM:SS" >= Time)
```

```
    Fridayinout.sub <- subset(data2m, wearing=="w" & days==5 & "YYYY-MM-DD
                              HH:MM:SS" <= Time & "YYYY-MM-DD HH:MM:SS" >= Time)

Inout.sub <- rbind(Mondayinout.sub, Tuesdayinout.sub, Wednesdayinout.sub,
                   Thursdayinout.sub, Fridayinout.sub)

totals(Inout.sub)
```

APPENDIX F. DANCE PROGRAM INSTRUCTIONS

The dance program you are being asked to implement from February X through February X has been designed to allow you flexibility in its usage. Below is a list of bullet points outlining the program:

- You will supplement each day (Monday through Friday) with **2** dance sessions involving music from the supplied Ipod.
  - The dance sessions should be short and last **7.5-10 minutes** each (3 -5 songs depending on song length).
  - The timing of the dance sessions is left to your discretion. However, it may work best to incorporate 1 dance session earlier in the day (i.e., before lunch) and 1 dance session later in the day (i.e., after naptime).
  - The choice of songs/music used during each dance session is left to your discretion.
- The dance breaks are intended to be a supplement (addition) to your day, so please do not use the breaks as a replacement for any other physical activities you had planned.
- Model/lead the dance sessions just as you would normally lead a dance session in your classroom.
- Please record the starting and ending time of each dance session on the supplied time recording form.

If you have any questions please let me know. I will be stopping by the facility rather frequently to see how things are going. In case you need to contact me my information is below. Thank you again for all your help and assistance.

John Schuna
Email – John.Schunajr@my.ndsu.edu
Office Phone – (701)-231-8513
Cell Phone – (715)-781-4174

APPENDIX G. OUTDOOR TIME, NAPTIME, AND INTERVENTION TIME RECORDING FORM

For each date, please record the start and stop time for times spent outdoors, dance time, and naptime.

Monday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Dance Time 1	Dance Time 2	Naptime
Start Time:					
Stop Time:					

Tuesday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Dance Time 1	Dance Time 2	Naptime
Start Time:					
Stop Time:					

Wednesday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Dance Time 1	Dance Time 2	Naptime
Start Time:					
Stop Time:					

Thursday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Dance Time 1	Dance Time 2	Naptime
Start Time:					
Stop Time:					

Friday, XX-XX-XXXX

	Outdoor Time 1	Outdoor Time 2	Dance Time 1	Dance Time 2	Naptime
Start Time:					
Stop Time:					