SEDENTARY BEHAVIOR INTERVENTION:
APPLICATION OF CONTEXTUAL INFORMATION OF SEDENTARY BEHAVIOR

by

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For her endless love, sacrifice, and support,

I dedicate this dissertation to my wife, Sujin Kim.

Sujin has constantly motivated and encouraged me

to dream bigger dreams than I ever thought possible.

I could not have made this journey without her love and support.

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ABSTRACT

The objective of this dissertation is twofold. First, it aims to validate a self-report, sedentary behavior measure—known as the Sedentary Behavior Record (SBR)—that measures the contextual information of sedentary behavior. Second, it aims to evaluate the feasibility of using the contextual information of sedentary behavior to reduce sedentary behavior time. Regarding the first study, the goal is to validate the SBR against a criterion measure that uses a proxy for direct observation; the proxy here is an Autographer wearable camera. To establish evidence of validity (i.e., classification accuracy), the investigator compared images obtained from the camera with patient-reported sedentary behavior status and activity classification. Researchers calculated the contingency (C) coefficients between the SBR and the Autographer. C coefficients were also compared across domains, types, time of day, and type of day. The findings show that the overall C coefficient between SBR and the Autographer was acceptable (C = .70).

The purpose of the second study is to evaluate the feasibility and effectiveness of the tailored domain-specific sedentary behavior intervention. The evaluation, which is done using contextual information of sedentary behavior, is intended to reduce sedentary behavior time among adults. Participants' sedentary behavior time was measured by accelerometers, and contextual information of their sedentary behavior was obtained from the SBR. The finding highlighted that the tailored domain-specific sedentary behavior intervention decreased sedentary behavior time for the 2-week intervention

period. The observed decrease of 74 minutes a day in objectively measured sitting time represented a medium effect size (0.56).

Together, these two studies yield insights into the usefulness of contextual information of an individual's sedentary behavior; they also helped justify the use of contextual information in health research and to come up with interventions to reduce sedentary behavior in physical activity.

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DISSERTATION INTRODUCTION

The physical, economic, and social environments of people living in modern society have been changing rapidly. These changes in transportation, workplace, and domestic-entertainment technologies have been associated with significantly-reduced demands for physical activity (Owen, Health, Matthews, & Dunstan, 2010). These reductions in the demands for physical activity have resulted in an increase of another class of health-related behaviors—sedentary behavior (Owen et al., 2010).

Sedentary behaviors include sitting during commuting and leisure time, and in the workplace and the domestic environment. Sedentary behavior is defined as all waking time behavior in a prolonged sitting/lying posture such as watching TV, working on a computer, or driving a car for which energy expenditure is low [<1.5 metabolic equivalent units (METs); Sedentary Behavior Research Network, 2012)]. Sedentary behavior can lead to poor health outcomes and is a risk factor for chronic diseases such as metabolic syndrome (Dunstan et al., 2005; Healy et al., 2008) and cardiovascular disease (Hamilton, Hamilton, & Zderic, 2007; Katzmarzyk, Church, Craig, & Bouchard, 2009). To prevent chronic disease therefore, public health officials have made reducing sedentary behavior time an important public health strategy.

Accurate measurements of sedentary behavior are critical to establishing the relationship between sedentary behavior and health outcomes and to making effective interventions (Kang & Rowe, 2015). A variety of measures are available for sedentary behavior documentation including objective (e.g., energy expenditure and postural classification devices) and self-report measures (e.g., questionnaires; Kang & Rowe, 2015). Objective measures are effective for estimating sedentary behavior time in the free-living environment (Atkins et al., 2012). These measures, however, are relatively expensive (approximately $300 per unit), not appropriate for studies requiring large sample sizes, and fail to provide contextual information about the nature of sedentary behavior (Wijndaele et al., 2014).

Also, to assess sedentary behavior, researchers have developed self-report measures (i.e., questionnaires). Some of these questionnaires, such as IPAQ, provide total sedentary behaviors time using a single item. Other questionnaires have focused on more questions, but have a limited set of questions to cover only certain activities (e.g., TV viewing; Clark et al., 2009) or a particular domain (e.g., workplace sitting; Chau, Van der Ploeg, Dunn, Kurko, & Bauman, 2012; Clark et al., 2011). Some measures assess contextual information about sedentary behaviors through delayed recall (i.e., usual or last 7-day's sedentary behavior; Marshall, Miller, Burton, & Brown, 2010; Rosenberg et al., 2010). Self-report measures of sedentary behavior, however, are limited to participants recalling their sedentary behavior accurately in the free-living environment because sedentary behavior is often not as structured and purposive as physical activity (Healy et al., 2011; Owen et al., 2010).

An alternative solution for minimizing recall-based errors and capturing contextual information can be the self-report diary—one of the criterion measures for assessing physical activity (Kohl, Fulton, & Caspersen, 2000; Sirard & Pate, 2001). A self-report diary documents daily sedentary behavior, employing a retrospective coverage strategy (Shiffman, Stone, & Hufford, 2008). This type of reporting method decreases the period that the participant must recall and thus limits potential recall bias. Compared to other self-report measures then, the diary-type measurement tool is able to not only measure sedentary behavior time accurately but also capture contextual information of sedentary behaviors.

A recently developed diary-type sedentary behavior measure is the Sedentary Behavior Record (SBR). The SBR, which addresses the lack of contextual information in sedentary behavior, is used to document the amount and types of sedentary behavior in which a participant engages (Kang, Kim, Farnsworth, & Ragan, 2015). Health providers can use the added contextual information to develop individualized intervention strategies to reduce sedentary behaviors. Researchers (Kang et al., 2015; Kim, Farnsworth, Ryu, & Kang, 2015) have produced evidence of convergent validity with SBR using accelerometer data (Contingency coefficient [C] = .74 [meaningful range: .5 to 1 (Safrit & Wood, 1995)]). Researchers, however, have yet to address the accuracy of the classification of contextual information (i.e., agreement of domains and types of sedentary behavior between SBR and direct observation). Once researchers are able to capture the contextual information of sedentary behavior with a sedentary behavior measurement tool, they will be better able to plan a sedentary behavior intervention by targeting specific times or activities related to high sedentary behavior.

Researchers have begun building several types of these interventions. Previous studies and reviews have highlighted the need of tailored sedentary behavior intervention using contextual information of sedentary behavior (Kang et al., 2015; Lakerveld et al., 2013; Owen et al., 2011; Teychenne, Ball, & Salmon, 2012). Only a small number of intervention studies, though, have included consultation with the use of contextual information of sedentary behavior. In addition, many interventions have not applied theoretical models despite evidence suggesting that interventions based on theory can be more effective (Gourlan et al., 2014; Ivers et al., 2012). In other words, interventions that did not use contextual information or that were not based on theory did not guarantee effectiveness of reducing sedentary behavior. Therefore, it is necessary to develop new tailored interventions that make use of contextual information and that are based on theory such as social cognitive theory (Bandura, 1986) or behavioral choice theory (Rachlin, 1989).

Statement of Purpose

The overall goal of this project is twofold. First, it is to determine whether the Sedentary Behavior Record (SBR) instrument can be used to accurately capture contextual information of sedentary behavior. Second, it is to demonstrate that, by using contextual information of sedentary behavior obtained from the SBR instrument, one can create a tailored domain-specific sedentary behavior intervention. The purpose of the first study is to validate the SBR instrument—a diary-type sedentary behavior measure—against a criterion measure through a proxy of direct observation. In this study, a criterion measure of the proxy for direct observation will be an Autographer wearable camera. To establish evidence of validity (i.e., classification accuracy), researchers will compare images obtained from the camera with patient-reported sedentary behavior status and activity classification. Researchers will then calculate the degree of agreement between the SBR and the Autographer—the proxy for direct observation. Agreement will also be compared across domains, types, and time of day.

The purpose of the second study is to examine the degree to which sedentary behavior time is reduced as the result of a tailored intervention for domain-specific sedentary behavior, with the intervention being based on the contextual information of sedentary behavior. We hypothesize that the intervention will decrease total sedentary behavior time in free-living.

Together, these two studies will yield a better understanding of the usefulness of contextual information of an individual's sedentary behavior; they will also help justify the use of contextual information in health research and to come up with interventions to reduce sedentary behavior in physical activity.

Significance of Studies

The SBR can be used to capture contextual information of sedentary behavior, identifying when, where, and how sedentary behavior occurs. After establishing evidence of the validity of the SBR instrument, researchers utilizing contextual information will identify the effect of the sedentary behavior intervention. If found to be feasible and effective, this intervention could be implemented to help reduce sedentary behavior time.

CHAPTER II

REVIEW OF LITERATURE

Independent of being physically inactive, sedentary behavior is a major health risk. It is, in other words, an independent risk factor for poor health (Tramblay, Colley, Suanders, Health, & Owen, 2010). Excessive sedentary behavior levels can lead to poor health outcomes and are a risk factor for chronic diseases such as metabolic syndrome (Dunstan et al., 2005; Healy et al., 2008), cardiovascular disease (Hamilton et al., 2007; Katzmarzyk et al., 2009; Thorp et al., 2010; Warren et al., 2010), type 2 diabetes (Proper, Singh, Van Mechelen, & Chinapaw, 2011; Thorp, Owen, Neuhaus, & Dunstan, 2011), hypertension (Beunza et al., 2007), and obesity (Mitchell et al., 2009). Therefore, an important public health strategy to prevent chronic disease is that of reducing sedentary behavior time. This chapter covers the definition of sedentary behavior, sedentary behavior measurements, issues/challenges in self-report measures of sedentary behavior, and intervention to reduce sedentary behavior.

Sedentary Behavior Defined

In the past 10 years, researchers have considerably changed the definition of sedentary behavior. The term "sedentary" comes from the Latin *sedere*, meaning "to sit." In early physical activity recommendations and physical activity epidemiology research, the term "sedentary" was synonymous with "inactive or low active" (Paffenbarger, Hyde, Wing, & Hsieh, 1986) or "inactive or irregularly active" (Centers for Disease Control and Prevention, 1993). It is insufficient, however, to consider sedentary behavior to be a lack of higher intensities of physical activity, as its attributes are distinct from physical activity (Owen et al., 2010).

Owen (2010) defined sedentariness as “too much sitting as distinct from too little exercise.” More specifically, this newer definition has been characterized as prolonged sitting, requiring low levels of energy expenditure (1.0 – 1.5 METs). The Sedentary Behavior Research Network (2012) defined sedentary behavior as “any waking behavior characterized by energy expenditure ≤ 1.5 METs while in a sitting or reclining posture.” This updated definition involves both a postural aspect (sitting, reclining, or lying) and low levels of energy expenditure, while excluding light activity (e.g., quiet standing).

Measures of Sedentary Behavior

To continue the advancement of sedentary behavior research, it is critical to be able to accurately measure sedentary behavior, as doing so 1) establishes a relationship between sedentary behavior and health outcomes, 2) enables the planning of effective interventions to reduce sedentary behavior, and 3) informs public health messages related to sedentary behavior (Kang & Rowe, 2015). As human life expectancy increases and interest in health and well-being increases, it is crucial to extend current knowledge on the appropriate measurement of sedentary behavior in health outcome research (Rosenberger, 2012).

Various measures are available for documentation of sedentary behavior, including objective (e.g., energy expenditure and postural classification devices) and self-report measures (e.g., questionnaires). This literature review covers only self-report measures’ advantages, disadvantages, and issues. Previous literature reviews (Atkin et al., 2012; Kang & Rowe, 2015) have already described well such objective measures as energy expenditure devices (e.g., accelerometers) and posture classification devices (e.g., activPAL).

Self-report measures (e.g., questionnaire) are practical for large-sample observational studies because of low administration cost and low participant burden (Sallis & Saelens, 2000). A number of self-report questionnaires have been developed to assess sedentary behavior. Some questionnaires such as IPAQ document sedentary behavior time using a single item. The use of a single-item questionnaire prohibits the collection of contextual information. Other questionnaires use a variety of questions; these are limited, though, to specific activities such as television viewing (Clark et al., 2009) or a single domain (e.g., workplace sitting; Chau et al., 2012; Clark et al., 2011). Table 1 shows a summary of self-report measures of sedentary behavior questionnaires, including recall period, measuring domain, results of validity and reliability test, and criterion measure for validation.

Issues/Challenges in Self-Report Measures of Sedentary Behavior

In health research of the past, a sitting activity was less noticeable and less important than a physical one. While physical activity was measured in multiple ways by type, frequency, intensity, and duration, sedentary behavior was briefly assessed by a single question (e.g., Global Physical Activity Questionnaire [GPAQ], International Physical Activity Questionnaire [IPAQ]). In other words, a common approach to assess sedentary behavior was to ask a simple question (e.g., time spent sitting), one that was already included in a physical activity questionnaire. With a single question, the IPAQ and GPAQ assess time spent sitting while at work, at home, while doing course work, and during leisure time on weekdays and weekend days. In time-constrained clinical practices, health providers used a brief assessment tool called Rapid Assessment Disuse Index (RADI; Shuval et al., 2014). It consists of three questions aimed at measuring sitting time as well as general moving about and stair-climbing behaviors. Specific to the workplace environment, the Occupational Sitting and Physical Activity Questionnaire (OSPAQ; Chau et al., 2012) asks participants to report how many hours they worked in the previous 7 days and the number of days they were at work. It subsequently asks for percent of time spent at work sitting, standing, and in physical activity.

Because this approach provides only general information regarding the sitting time of an individual, it may not be a complete representation of sedentary behavior. Therefore, it can be challenging for researchers or health professionals to develop, based on this type of evidence, targeted behavior-change interventions to reduce sedentary behaviors. In other words, the tools that ask for overall sedentary behavior time provide insufficient data to inform intervention strategies for a complex set of behaviors.

Measuring Contextual Information of Sedentary Behavior

Researchers have recently developed measurement tools that assess sedentary behavior in terms of types (e.g., TV viewing, screen time, socializing) and domains (e.g., sitting at work/home, transportation). Such tools included the following: Sedentary Behavior Questionnaire (SBQ; Rosenberg et al., 2010), Marshall Sitting Questionnaire (Marshall, Miller, Burton, & Brown, 2010), SIT-Q (Lynch et al., 2014), and Longitudinal Aging Study Amsterdam (LASA) sedentary behavior questionnaire (Visser & Koster, 2013). The domains and types that these measurement tools measure are described in Table 1. Because the tools describe patterns of sedentary behavior, individualized and targeted interventions can more effectively target time spent in sedentary behavior. Although the aforementioned tools measure contextual information regarding sedentary behavior, these measures do not provide information on when specific sedentary behaviors occur. If we know more about the time that sedentary behaviors occur, we can develop more effective intervention by targeting specific times related to high levels of sedentary behavior.

Criterion Measures as Validation Tools

Measurement tools assessing contextual information of sedentary behavior may not have been validated by appropriate methods. Tools for measuring contextual information should be validated against the criterion measure that can assess contextual information. Nonetheless, most tools were verified by comparing them with tools that cannot measure contextual information (e.g., accelerometer, ActivPAL; Clark et al., 2012; Gardiner et al., 2016; Rosenberg et al., 2010; Visser & Koster, 2013) except for the PDR (Kozey-Keadle et al., 2014) (i.e., they used direct observation). Therefore, it is important to validate a measurement tool that assesses the contextual information of sedentary behavior against an appropriate criterion measure that is capable of assessing contextual information.

Recall Period

Most sedentary behavior measurement tools ask for information concerning a respondent’s usual or last seven days of sedentary behavior (Chau et al., 2012; Gardiner et al., 2011; Marshall et al., 2010; Shuval et al., 2014; Visser & Koster, 2013). However, sedentary behavior is not commonly structured and purposive like physical activity; rather, it occurs persistently throughout the day. This may negatively impact participants' ability to recall accurately the amount of time spent in sedentary behaviors in free-living environments (Healy et al., 2011; Owen et al., 2010). To overcome this issue, researchers (Clark et al., 2013; Metthews et al., 2013) developed tools to measure the sedentary time of the previous day rather than a participant's usual or last week of sedentary behavior. By using past-day recall of sedentary behavior time, the Past-day Adults' Sedentary Time (PAST) questionnaire (Clark et al., 2013) measures sedentary behavior time through seven items—work, transport, TV, computer, electronic device, reading, hobby, and other. Similar to the PAST, the Previous-Day Recall (PDR; Kozey-Keadle et al., 2014) minimizes recall-based errors by decreasing the period that the participant must recall. In PDR, items to measure sedentary behavior are divided by location and purpose of sedentary behavior.

Table1.

Summary of self-report measures of sedentary behavior questionnaire

Questionnaire	Recall period	Measuring domains	Results of validity test	Criterion measure for validation	Results of reliability test
GPAQ	- Usual	- Total sitting time	- ρ = .06 - .35	- Accelerometer - Pedometer - Questionnaire	- ICC = .67-.81
IPAQ	- 7 days (Last week) - Usual	- Total sitting time	- ρ = .30	- Accelerometer - Questionnaire	- ρ = .18-.95
LASA	- Usual	- Nap - Reading - Listening - Music - TV - Hobby - Talking - Computer - Sitting activity - Transportation - Church or Theater	- r = .35	- Accelerometer	- ICC = .71
Marshall Sitting Questionnaire	- Usual	- Travelling - Work - TV - Computer - Leisure	- r = .20 - .74 (women) - r = .13 - .74 (men)	- Accelerometer - Log	- ICC = .78 - .84 (weekday) - ICC = .23 - .74 (weekend)

Table1.

Summary of self-report measures of sedentary behavior questionnaire (cont.)

Questionnaire	**Recall period**	**Measuring domains**	**Results of validity test**	**Criterion measure for validation**	**Results of reliability test**
Most	- 7 days (Last week)	- TV or video/DVDs - Computer/Internet - Reading - Socializing - Driving or transportation - Hobby - Other	- ρ = .30	- Accelerometer	- ρ = .04 - .79
OSPAQ	- 7 days (Last week)	- Sitting including driving	- ρ = .65	- Accelerometer	- ICC = .89
PAST	- 1 day (Yesterday)	- Work - Transport - TV - Computer, electronic device - Reading - Hobby - Other	- r = .33 - .58	- ActivPal - Accelerometer	- ICC = .22 - .64
PDR	- 1 day (Yesterday)	- Home - Work/School - Community - Household activity - Work - Education - Transportation - Leisure	- r = .60 - .81	- Direct observation	- N/A

Table1.

Summary of self-report measures of sedentary behavior questionnaire (cont.)

Questionnaire	Recall period	Measuring domains	Results of validity test	Criterion measure for validation	Results of reliability test
RADI	- Usual	- Total sitting time	- ρ = .19 - .29	- Accelerometer	- ICC = .56-.60
SBQ	- Usual	- TV - Computer or video game - Listening music - Phone - Paperwork or computer work - Reading a book - Playing a musical instrument - Doing artwork or crafts - Transportation	- partial r = .00 - .04 (men) - partial r = .01 - .26 (women)	- Accelerometer - IPAQ	- ICC = .51 - .93
SITBRQ	- Usual	- Sitting for work - Breaks in sitting time	- ρ = .05 - .24	- Accelerometer	- ρ = .59 - .71

Table1.

Summary of self-report measures of sedentary behavior questionnaire (cont.)

Questionnaire	Recall period	Measuring domains	Results of validity test	Criterion measure for validation	Results of reliability test
SIT-Q	- Usual	- Sleeping and napping - Meals - Transportation - Work, study, and volunteering - Childcare and elder care - Leisure and relaxing (TV, computer, reading) - Others	- ρ = .19 - .76	- Activity diary	- ICC = .25 - .84
SIT-Q-7d	- 7 days	- Sleeping and napping - Meals - Transportation - Work, study, and volunteering - Screen time and other activities (TV, computer, video game)	- ρ = .21 - .76	- ActivPal - Log	- ICC = .03 - .77

Interventions to Reduce Sedentary Behavior Time

In an attempt to reduce sedentary behavior, researchers have begun to build several types of interventions. These include the following: counseling (Aittasalo et al., 2012; Gardiner et al., 2011; Lakerveld et al., 2013; Lewis et al., 2016), workplace-based intervention (Alkhajah et al., 2012; Chau et al., 2016; Gao et al., 2016; Hall et al., 2015; Pronk et al., 2012), incentive-based intervention (Ball et al., 2017), phone-based intervention (Kendzor et al., 2016; Urda et al., 2016), and pedometer (De Greef et al., 2010; Kozey-Keadle et al., 2011). Of these various types of interventions, researchers have developed many interventions based on counselling that require no installation of equipment or use of tools (Table 2). This type of intervention is based on theory, including social cognitive theory (Bandura, 1986), behavioral choice theory (Rachlin, 1989), ecological model of sedentary behavior (Owen et al., 2011).

Counselling-type intervention not using contextual information of sedentary behavior. To reduce sedentary behavior time in older adults, Gardiner and colleagues (2011) used goal-setting, self-monitoring, and feedback strategies based on social cognitive theory (Bandura, 1986) and behavioral choice theory (Rachlin, 1989). In their study, participants decreased their sedentary time by 3.2%. To reduce TV watching, Raynor et al. (2013) applied similar strategies (e.g., self-monitoring and goal-setting). In their study, Raynor and colleagues instructed participants to gradually reduce TV watching time to 10 hours per week. They found that there was a significant condition-by-time interaction, in which treatment group significantly reduced TV watching time by 2.3 hours.

In contrast to such findings, Lakerveld et al. (2013) and Verweij et al. (2012) found no significant intervention effect for total sedentary behavior time. Lakerveld et al. (2013) used motivational interviewing and problem-solving treatment to reduce leisure-time sedentary behavior in adults at risk of cardiovascular disease. They found that both treatment and control groups significantly reduced their sedentary behavior after 12 months by 27 min/day and 19 min/day, respectively. Lakerveld and colleagues speculated that one of the reasons their research was ineffective might have been due to not using contextual information based on individual, social, or environmental factors. Verweij et al. (2012) developed an occupational health guideline aimed at preventing weight gain and reducing sedentary behavior. Based on the heath guideline, they offered behavioral change counselling with motivational interviewing. No significant intervention effect was found for total level of sedentary behavior and sedentary behavior in leisure time. Verweij and colleagues said this result may have been caused by the use of self-report measure and invalidated sedentary behavior questionnaire. In conclusion, the reduction of sedentary behavior was not always guaranteed by counseling-type interventions that made no use of contextual information of sedentary behavior.

Counseling-type intervention using contextual information of sedentary behavior. Aittasalo et al. (2017) examined the effect of the Moving To Business (MTB) program on reducing sedentary behavior using goal-setting, education through workshop and meeting, and individualized consultation. In their study, participants measured their sedentary behavior time using the Workforce Sitting Questionnaire (items: travelling, work, watching TV, using a computer at home, and other leisure activities) at baseline.

Participants received individual consultation with this baseline information of sedentary behavior. The results showed that the time spent in sedentary behavior decreased by 16%.

Lewis et al. (2016) investigated the effectiveness and feasibility of their “Small Steps” intervention including an incremental goal setting to reduce sitting time. They also used strategies of review of participants’ sitting time, normative feedback on sitting time other than incremental goal setting. Participants received individualized consultation through a review of assessed sedentary time obtained from Multimedia Activity Recall for Children and Adults (MARCA; Ridley, Olds, & Hill, 2006). Lewis and colleagues concluded that objectively measured total sitting time was significantly reduced by 51.5 minutes. In addition, participants self-reported spending 96 minutes less per day sitting and 32 minutes less per day watching television.

Maher et al. (2017) examined the feasibility of sedentary behavior intervention including education via video, review of sedentary behavior, and goal setting. Participants reported the time spent sitting or lying down while engaging in each of the nine sedentary activities on an average weekday and average weekend day over the past week. Participants in the intervention group also reported an average decrease in weekday sedentary behavior of 132.6 min/weekday in the week following the delivery of group content.

Table 2

Counselling-type interventions to reduce sedentary behavior

Study	Theory /Model	Tailored	Contextual information	Component	Period	Outcome measures (finding)
Adams et al. (2013)	- SCT	- Yes	- No	- Email message - Feedback - Goal setting - Self-monitoring	- 6 wk.	- Accelerometer (NS.) - Questionnaire (↓ 12 mins/day)
Aittasalo et al. (2017)	- SCT	- Yes	- Yes	- Education - Goal setting	- 11 mo.	- Accelerometer (↓ 7.6%) - Questionnaire (↓ 16%)
Fitzsimons et al. (2013)	- SEM - BCT	- Yes	- No	- Education - Goal setting	- 2 wk.	- ActivPAL (↓ 24 mins/day) - Questionnaire - (↓ 1 hr/week)
Gardiner et al. (2011)	- SCT - BCT	- Yes	- No	- Feedback - Goal setting - Review of sedentary time - Self-monitoring	- 1 wk.	- Accelerometer (↓ 3.2%)
Lakerveld et al. (2013)	- TSR - TPB	- Yes	- No	- Motivational interview - Problem solving treatment	- 24 wk.	- Questionnaire (NS.)

Note. SCT = social cognitive theory; SEM = social ecological model; BCT = behavior change theory; TSR = theory of self-regulation; TPB = theory of planned behavior; SDT = self-determination theory; DPM = dual-process model; OMM = occupational medicine and intervention map

Table 2.

Counselling-type interventions to reduce sedentary behavior (cont.)

Study	Theory /Model	Tailored	Contextual information	Component	Period	Outcome measures (finding)
Lewis et al. (2016)	- SDT	- Yes	- Yes	- Feedback - Goal setting - Review of sedentary time	- 6 wk.	- ActivPAL (↓ 51 mins/day) - Questionnaire (↓ 96 mins /day)
Maher et al. (2017)	- DPM	- Yes	- Yes	- Education - Goal setting	- 2 wk.	- Questionnaire (↓ 837.8 min/week)
Raynor et al. (2013)	- N/A	- No	- No	- Goal setting - Problem solving - Self-monitoring	- 8 wk.	- TV Allowance equipment (↓ 2.3 hrs/day)
Verweij et al. (2012)	- OMM	- No	- No	- Occupational health guideline	- 6 mo.	- Questionnaire (NS.)

Note. SCT = social cognitive theory; SEM = social ecological model; BCT = behavior change theory; TSR = theory of self-regulation; TPB = theory of planned behavior; SDT = self-determination theory; DPM = dual-process model; OMM = occupational medicine and intervention map

Conclusion

Previous studies and reviews have highlighted the need of a tailored sedentary behavior intervention using contextual information of sedentary behavior (Kang et al., 2015; Lakerveld et al., 2013; Owen et al., 2011; Teychenne, Ball, & Salmon, 2012). However, a limited number of intervention studies incorporated consultation with use of contextual information of sedentary behavior. Also, use of contextual information of sedentary behaviors was just one component in interventions, and these researchers did not evaluate the sole effect of contextual information on reducing sedentary behavior time. Lastly, even if the contextual information was utilized as part of an intervention to reduce sedentary behavior, most of that information was obtained from measurement tools that were validated through inappropriate methods. In other words, the tools for measuring contextual information needed to be validated against a criterion measure capable of assessing contextual information, yet most of these tools were verified by comparing them with tools incapable of measuring contextual information (e.g., accelerometer, ActivPAL). Therefore, it is necessary to develop a well-validated tool to measure contextual information of sedentary behavior. In addition, researchers need to examine how the reduction of sedentary behavior is affected by using contextual information of sedentary behavior.

CHAPTER III

VALIDATION OF SEDENTARY BEHAVIOR RECORD INSTRUMENT AS A MEASURE OF CONTEXTUAL INFORMATION OF SEDENTARY BEHAVIOR

Introduction

Sedentary behavior has been defined as “any waking behavior characterized by energy expenditure ≤ 1.5 METs while in a sitting or reclining posture,” (Sedentary Behavior Research Network, 2012). It is a risk factor for such chronic diseases as metabolic syndrome (Dunstan et al., 2005; Healy et al., 2008), cardiovascular disease (Hamilton et al., 2007; Katzmarzyk et al., 2009; Thorp et al., 2010; Warren et al., 2010), type 2 diabetes (Proper, Singh, Van Mechelen, & Chinapaw, 2011; Thorp, Owen, Neuhaus, & Dunstan, 2011), hypertension (Beunza et al., 2007), and obesity (Mitchell et al., 2009).

Accurate measurement of sedentary behavior is important 1) to establishing the relationship between sedentary behavior and health outcomes, 2) to planning effective interventions to reduce sedentary behavior, and 3) to informing public health messages related to sedentary behavior (Kang & Rowe, 2015). As human life expectancy increases and interest in health and well-being increases, it is crucial to extend the current knowledge on the appropriate measurement of sedentary behavior in health outcome research (Rosenberger, 2012).

Sedentary behavior can be documented through various measures, including objective ones (e.g., energy expenditure and postural classification devices) and self-report ones (e.g., questionnaires). Objective measures of sedentary behavior are popular because of the relatively high reliability and validity of sedentary behavior estimates in the free-living setting compared with self-report measures (Atkin et al., 2012; Healy et al., 2011). These measures, however, are expensive, not practical for use with studies requiring large sample sizes, and they fail to provide contextual information about the nature of sedentary behaviors being performed (Wijndaele et al., 2014). Self-report measures are practical for large-sample observational studies because of low administration cost and low participant burden (Sallis & Saelens, 2000). A number of self-report questionnaires have been developed to assess sedentary behavior. Some questionnaires such as IPAQ use a single item to document sedentary behavior time. The use of a single-item questionnaire prohibits the collection of contextual information.

Other questionnaires use a variety of questions, though these are limited to specific activities such as television viewing (Clark et al., 2009) or a single domain (e.g., workplace sitting; Chau et al., 2012; Clark et al., 2011).

When developing new tools to measure sedentary behavior, it is important to understand the personal, social, and environmental factors that influence sedentary behaviors based on an ecological model of sedentary behavior (Owen et al., 2011). Interventions can be enhanced when contextual information (i.e., how, when, and where sedentary behavior occurs) is identified. Such information targets specific times or activities related to high sedentary behavior. A self-report measure assesses contextual information about sedentary behaviors through delayed recall (i.e., usual or last 7-day's sedentary behavior; Marshall, Miller, Burton, & Brown, 2010; Rosenberg et al., 2010).

Recall-based measures of sedentary behavior are limited, however, as participants may not be able to accurately recall their sedentary behavior in the free-living environment. This is because sedentary behavior is often not as structured and purposive as physical activity (Healy et al., 2011; Owen et al., 2010).

An alternative solution for minimizing recall-based errors and capturing contextual information may be the self-report diary, one of the criterion measures for assessing physical activity (Kohl et al., 2000; Sirard & Pate, 2001). Self-report diary documents sedentary behavior daily, employing a retrospective coverage strategy (Shiffman, Stone, & Hufford, 2008). This type of reporting method decreases the period that the participant must recall and thus limits potential recall bias. Therefore, to design more-effective personalized interventions, researchers need a diary-type measurement tool that captures the contextual information of sedentary behavior.

To address the lack of contextual information in sedentary behavior, Kang, Kim, Farnsworth, and Ragan (2015) came up with the Sedentary Behavior Record (SBR) instrument. SBR is a diary-type sedentary behavior measure used to document the amount and types of sedentary behavior in which a participant engages. Evidence of convergent validity has been previously documented with SBR using accelerometer data (Kang et al., 2015; Kim, Farnsworth, Ryu, & Kang, 2015). What still needs to be examined is the accuracy of the classification of contextual information (i.e., agreement of domains and types of sedentary behavior between SBR and direct observation). Therefore, the purpose of this study is to establish evidence of validity (i.e., classification of accuracy) for the SBR instrument using a criterion measure through a proxy for direct observation. In addition, classification of accuracy will be compared by participant characteristics (e.g., gender, BMI, work type, meeting physical activity guidelines).

Method

Participants

To identify the minimum number of participants required to achieve sufficient power, the investigator conducted a priori power analysis for Goodness-of-fit tests with contingency tables. It is recommended to use a medium effect size of 0.30 (Maxwell & Delaney, 2004) with an alpha of 0.05 and a power of 0.80 (Tabachnick & Fidell, 2013). Based upon results of the power analysis, a minimum of 333 cases was suggested. In this study, a total of 4300 cells (cases) were computed, and the number of cases were enough to achieve sufficient power.

Participating in this study were 27 adults (age ≥ 18; 15 male/12 female) with no physical or medical disabilities that could have hampered them from engaging in normal daily activities. All participants met with an investigator to review and sign the informed consent that was approved by a University's Institutional Review Board.

Instruments

The Sedentary Behavior Record (SBR), developed by Kang et al. (2015), was an adaptation of the 3-day Physical Activity Record (Bouchard et al., 1983) for quantifying sedentary behavior time, and identifying contextual information of sedentary behavior in 15-minute blocks. The SBR includes three modified domains—work-related sitting, non-work related sitting and transport—and a choice of different activities under each domain. These activities include 1) non-work related sitting (watching TV, computer/mobile/electronic device use, other), 2) work-related sitting (screen based [i.e., computer/electronic device use] and non-screen based), and transport (screen based [i.e., computer/electronic device use] and non-screen based). The modified domains and types in the SBR were adapted from the ecological model of sedentary behavior (Owen et al., 2011) as well as other previous studies (Clark et al., 2013; Rosenberg et al., 2010; Visser & Koster, 2013). The SBR can measure all the components of sedentary behavior suggested by Tremblay, Colley, Saunders, Healy, and Owen (2010)—frequency, interruptions, total time, and type. As evidence of convergent validity with SBR, Kang and colleagues (2015) used accelerometer data (Contingency coefficient [C] = .74 [meaningful range: .5 to 1]; Safrit & Wood, 1995).

Drawing on the recommendations proposed by Kim, Welk, Braun, and Kang (2015), this study revised the original SBR to capture sedentary behavior in a minimum of 10-minute blocks. The modified online-version SBR is illustrated in Figure 1.

Sedentary Behavior Record (SBR)

Name: ____________________________

Day: 1 2 3 4 (Circle one) **Date:** ________/________/________
month day year

Directions: Using the numbers below, fill in each cell in the table that best describes the activity that was performed during the majority of each 10-minute period. If the cell corresponds with an activity not related to sitting or lying down, cross-out the cell(s).

No.	Sedentary Behavior
1	Sleep
	Non-work Related
2	Watching TV
3	Computer/mobile/electronic device use
4	Other: eating, reading, socializing, etc.
	Work Related
5	Screen based
6	Non-screen based
	Transport
7	Screen based
8	Non-screen based

Hour	Minutes					
	0-10	10-20	20-30	30-40	40-50	50-60
00:00-1:00						
1:00-2:00						
2:00-3:00						
3:00-4:00						
4:00-5:00						
5:00-6:00						
6:00-7:00						
7:00-8:00						
8:00-9:00						
9:00-10:00						
10:00-11:00						
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20:00-21:00						
21:00-21:00						
21:00-22:00						
22:00-23:00						
23:00-24:00						

Figure 1. Sedentary Behavior Record (SBR) instrument

Criterion measure of sedentary behavior: Autographer. The Autographer (Oxford Metrics Group, plc., Oxford, UK) is a new type of camera which provides hands-free image capturing. A small portable device (58g; 3.74 × 9.55 × 2.29cm), the Autographer incorporates five sensors (tri-axial accelerometer, magnetometer, ambient temperature, light level, and passive infrared) to determine the best moment to automatically capture the images without any user intervention. The camera may be worn around the neck using a lanyard provided by the manufacturer. The Autographer captures images using its five-megapixel wide angel (136° field of view) precision-optics lens. The battery life of the camera is dependent upon the image capture rate, which can capture up to 360 images per hour. Figure 2 offers samples of photos taken from the device. Validation of the Autographer as a criterion measure suggests that the absolute mean differences between starting and ending time of sedentary events between the Autographer and direct observation was 1.91 seconds (SD = 1.51) with a maximum bias range of ± 5 seconds during a 1-hour period (Kim et al., 2015). Therefore, in this study, the Autographer was considered a criterion measure of direct observation proxy.

Figure 2. Sample image of sedentary behavior from the Autographer. Reprinted from "Using the SenseCam to improve classifications of sedentary behavior in free-living settings," by Kerr et al., 2013, *American Journal of Preventive Medicine*, *44*(3), 290-296.

Procedure

Participants were recruited from the U.S. Southeast via word of mouth and flyers posted on Middle Tennessee State University. Participants had an initial meeting with the investigators where they read and signed an informed consent that was approved by the University's Institutional Review Board. Demographic information that was collected included age, sex, occupation, race, education, income, and self-reported height (cm) and body weight (kg).

During the initial meeting with research investigators, participants were instructed on how to record their sedentary behavior through the SBR and on to assess their sedentary behavior time for four consecutive days including two weekdays and two weekend days for reliable data collection (Kang, Farnsworth & Kim, 2014). Throughout the measurement period, participants recorded their sedentary behavior using the SBR instrument every night.

During the four-day data collection period, participants also wore an Autographer wearable camera as a proxy for direct observation. The Autographer camera was worn around the neck with a lanyard provided by the manufacturer. To maximize battery life, the image capture rate was set on the low setting, providing two images per minute (i.e., one every thirty seconds). This allowed for approximately 12 hours of data collection (2 images x 60 minutes x 12 hours) resulting in approximately 1,440 images per day during waking hours. Participants were responsible for charging the camera each night using the USB cable provided.

Throughout the measurement period, participants were instructed to perform normal daily activities without any behavior modification, such as reducing sedentary behavior or increasing physical activity during the measurement period. To improve participant compliance with the study protocol, the investigator sent a daily reminder using their preferred method of contact (i.e., phone call, text message, or email). At the end of the four-day period, participants met with the investigator to turn in the Autographer wearable camera.

Analysis

Time-stamped images obtained from the Autographer were analyzed using the manufacturer's software following the standardized coding protocol developed by Kerr et al. (2013). To classify sedentary behavior status in each image, the researcher considered visual cues in each image, cues that included limb positions, camera angles, and associated environments. Autographer data was aggregated into 10-minute intervals to be consistent with the SBR, where sedentary behavior classification was determined from the majority of activity that occurred within the 10-minute bout. Two independent observers classified each image. Discrepancies between the two observers were, when necessary, resolved by a third observer. Classification accuracy was calculated on the basis of the photographs provided from the participants; thus excluded from the analysis were the 10-miute cells when photographs were not provided.

To establish evidence of decision validity (i.e., classification accuracy) through criterion-reference approach for the SBR, contingency (C) coefficients were calculated between the SBR and a proxy of direct observation (i.e., the Autographer). For C coefficients, agreement (agree or no agree) was assessed between two measurements. A total of 4300 10-minute cells were compared based on identifiable images from the Autographer. In other words, cells without image data were excluded from the analysis. The C coefficients were also compared across domains, types, and time of day. A desirable C coefficient is .8 (Safrit & Wood, 1995). Additionally, independent sample t-tests were used to compare C coefficients among participant characteristics (e.g., gender, BMI, work type, meeting physical activity guidelines). Alpha level was set at .0125 using the Bonferroni adjustment technique to account for multiple comparisons.

Results

A total of 30 adults with no physical or medical disabilities provided written informed consent. With the exception of three participants who felt uncomfortable wearing the Autographer due to privacy issue during the measurement period, 27 participants completed this study. Table 1 presents the demographic characteristics of 27 participants.

Participants ranged in age from young to old (range: 20 to 64 years). The majority of participants were Asian/Pacific Islander, university-educated, office workers, and met the physical activity guidelines.

Table 1
Demographic information of participants

	Male (n = 15)	Female (n = 12)	Total (n = 27)
Age (years)	34.5 ± 11.5	31.7 ± 11.6	33.3 ± 11.4
Height (cm)	178.3 ± 5.0	163.0 ± 4.6	171.5 ± 9.1
Weight (kg)	82.6 ± 14.3	62.3 ± 11.5	73.6 ± 16.5
BMI (kg/m^2)	26.1 ± 5.2	23.4 ± 3.9	24.9 ± 4.8
Race			
Asian/Pacific Islander	11	3	14
Black/African-American	2	2	4
White/Caucasian	3	6	9
Education			
High school	2	1	3
College	6	9	15
Graduate school	7	2	9
Office worker			
Yes	12	7	19
No	3	5	8
Meeting PAG			
Yes	10	7	17
No	5	5	10

Note. PAG = physical activity guidelines.

Overall, C coefficient between SBR and criterion measures were acceptable (C = .70). C coefficients were computed for each domain (e.g., non-work related, work related, transportation) and each activity (e.g., watching TV, computer/mobile/electronic device use, screen based, non-screen based, etc.) under domains. Among all the domains, the highest C coefficient was reported for work-related sitting (C = .87). Lower C coefficient was reported for non-work related (C = .67) and transport (C = .69; Figure 3). Also, C coefficients ranged from .49-.91 among activities with the highest accuracy in work-related, screen-based sitting, yet the lowest accuracy was found in non-work related computer/mobile/electronic device use (Figure 4).

In addition, C coefficients were computed for time of a day (e.g., morning, afternoon, evening), and type of day (e.g., weekday, weekend day). C coefficients for morning, afternoon, and evening were .71, .69, and .72, respectively (Figure 5). C coefficients for each time of a day were similar. C coefficients for weekday and weekend were .74 and .63, respectively (Figure 6). C coefficient was higher for weekday than for weekend.

The independent t-tests were used to examine whether the C coefficients differed by characteristics (e.g., gender, BMI, work type, meeting physical activity guidelines). Alpha level was set at .0125. The results indicated that there are no differences in C coefficients by gender, $t(25) = .070$, $p = .945$, BMI, $t(25) = .840$, $p = .409$, work type, $t(25) = .874$, $p = .390$, and meeting physical activity guide lines, $t(25) = .1.193$, $p = .244$.

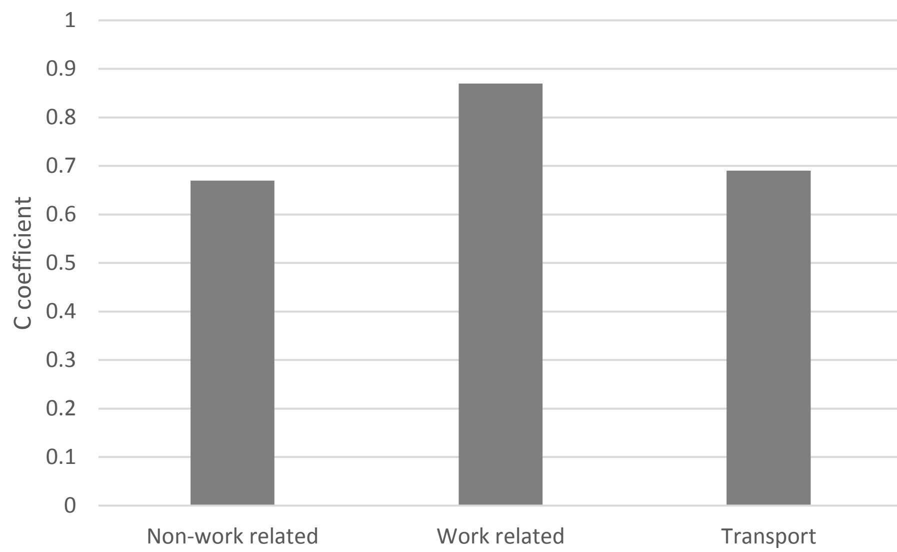

Figure 3. Comparison of C coefficient between sedentary behavior domains.

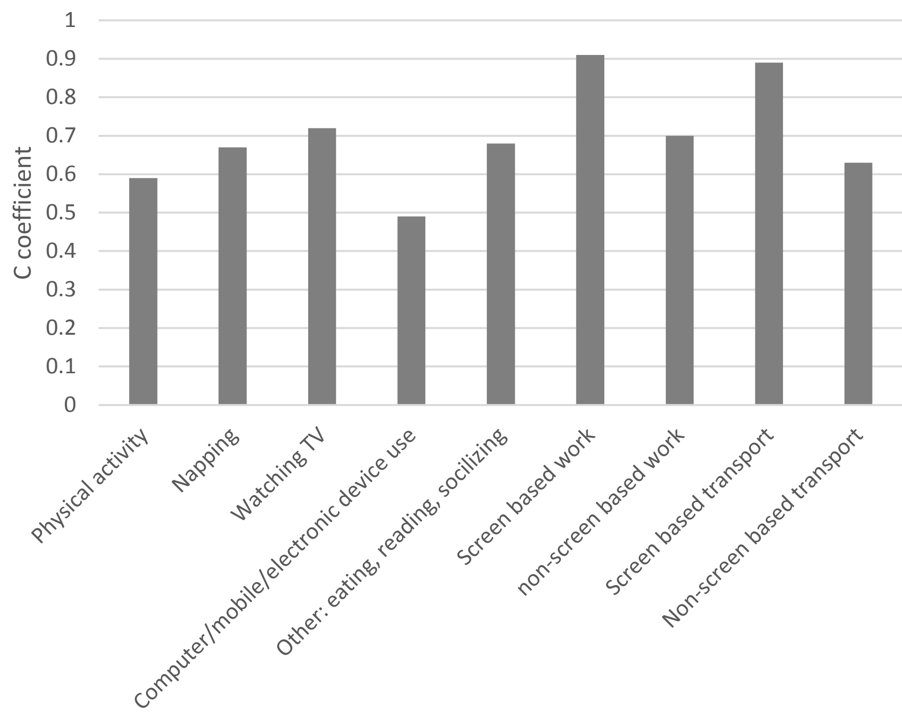

Figure 4. Comparison of C coefficient among activities under sedentary behavior domains

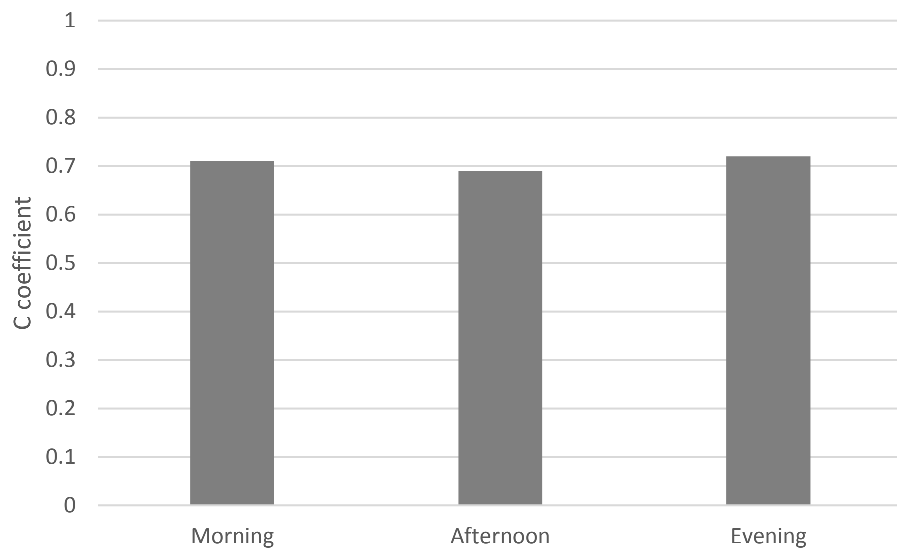

Figure 5. Comparison of C coefficient between morning, afternoon, and evening hours.

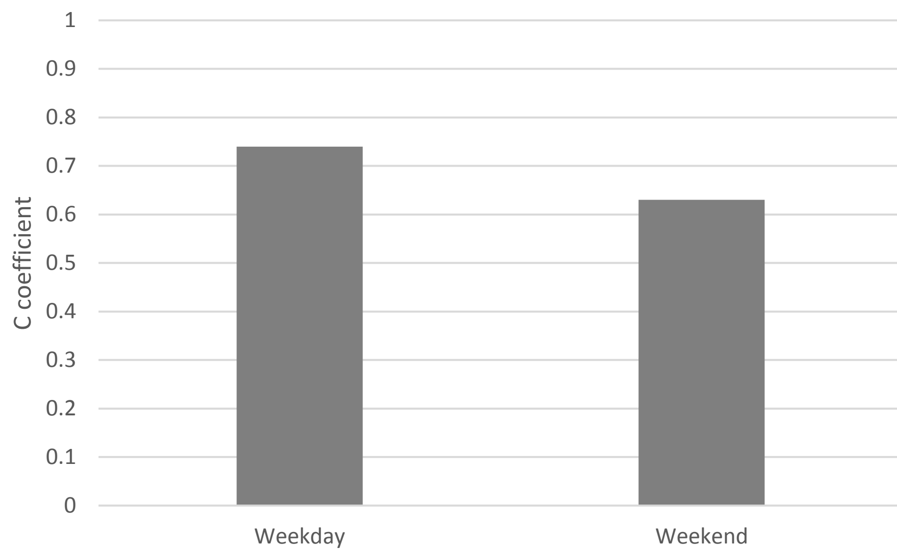

Figure 6. Comparison of C coefficient between weekdays and weekend days

Discussion

The purpose of this study was to establish evidence of validity (i.e., classification of accuracy) for the diary-type SBR instrument designed to assess contextual information of sedentary behavior using criterion measure through a proxy of direct observation. Overall, the C coefficient between the SBR and criterion measure (i.e., Autographer wearable camera) was acceptable (C = .70). The highest C coefficient was reported for work-related sitting (C = .87). The time (i.e., morning, afternoon, evening) did not influence C coefficient. C coefficient was higher for weekday (C = .74) than for weekend (C = .63). Neither were C coefficients affected by participant characteristics such as gender, race, education level, BMI, work type, meeting physical activity guidelines.

C coefficient for work-related sitting was higher (C = .87) than non-work related sitting (C = .67) and transportation (C = .69), probably reflective of constant working hours during a day. It is consistent with the pattern of validity characteristics for a work day and a nonwork day seen in the Workforce Sitting Questionnaire (WSQ; Chau et al., 2011). Among activities under domains, the highest C coefficient was for screen-based sitting under work-related sitting, and the lowest was C coefficient for computer/mobile/electronic use under non-work related sitting. The accuracy also seemed to change depending on whether the activities occurred intermittently or structurally. For screen-based working, office workers participated in this study could record their work-related, screen-based sitting time accurately because their sitting was relatively structured. On the other hand, non-work related computer/mobile/electronic use occurs intermittently during a day, and thus participants might not be able to recall the time.

Consistent with previous studies (Chau et al., 2011; Clemes et al., 2012; Marshall et al., 2009), classification accuracy (i.e., C coefficient) was lower for weekend days than for weekdays. In these previous studies, validity estimates on weekend were not acceptable or lower than on weekdays. The potential explanation of low validity estimates on weekends is that the nature of activities performed on weekends are variable and unstructured.

Results of the independent t-tests indicated participants' characteristics such gender, BMI, work type, and meeting physical activity guidelines did not influence classification accuracy. These results support that the SBR instrument measures the construct in the same way across groups, and thus, measurement invariance. In other words, the SBR can capture the contextual information of sedentary behavior well regardless of gender, BMI, work type, and meeting physical activity.

There have been some previous efforts to identify the purpose of sedentary behaviors. Among them, some questionnaires ask contextual information of sedentary behavior to acquire information about where and how sedentary behaviors occur (Friedenreich et al., 2006; Marshall et al., 2010). These questionnaires typically ask how much time a participant spends in domains of sedentary behavior (e.g., workplace, home, leisure, transport). As noted above, however, these domain-specific questionnaires have not been validated properly (Helmerhorst et al., 2012; Shephard et al., 2003) due to lack of strong criterion measures that can measure contextual information of sedentary behavior. The gold standard for a criterion measure is direct observation, but this time-consuming approach can be a burden on observers. An important strength of this study then is the use of a proxy for direct observation (i.e., Autographer wearable camera) as a criterion measure. Capability of the Autographer capturing sedentary behaviors has already been validated by Kim et al. (2015). They demonstrated that absolute mean differences between starting and ending points of sedentary events between the Autographer and direct observation was only 1.91 seconds (SD = 1.51) with a maximum bias range of ± 5 seconds during a 1-hour period. They found only a few differences between Autographer and direct observation. Therefore, as a proxy for direct observation, the Autographer can be considered as a strong criterion measure. In addition, the study participants completed a four-day measurement period including 2 weekdays and 2 weekend days. Therefore, the SBR can reflect participants' normal routine life, and real use of the tool.

There are some limitations of this study that should be considered. Participants of the current study were relatively young (33.3 ± 11.4 years). There were also only two participants over 60. Thus, the generalizability of this SBR instrument for use in older adults may be limited. To compensate for this issue, further research for old adults is needed. In addition, the SBR was diary-type instrument decreasing the period that the participants must recall and limiting potential recall bias. Even though we tried to minimize recall-based errors by using a diary-type instrument, an approximately 12-hour period might not be sufficiently brief to recall daily sedentary behavior time, as sedentary behaviors occur intermittently. In the future, it may be helpful to have online versions of the instrument or a mobile app with which people can record their sedentary behavior in real time.

In conclusion, this study's results support the claim that the SBR has been validated in an appropriate approach to provide important contextual information of sedentary behavior. We suggest that the SBR measures total and domain-specific sedentary behavior time. This information can be used in studies that need to measure work-related sitting, screen-based sitting, or sitting time on transport for studies of the relationship between each sedentary behavior domain and health outcomes, and finally for intervention studies using contextual information of sedentary behavior.

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Appendix for Study I

Appendix A – Informed Consent

Middle Tennessee State University Institutional Review Board
Informed Consent Document for Research

Principal Investigator: Heontae Kim
Study Title: "Validation of Sedentary Behavior Record Instrument as a Measure of Contextual Information of Sedentary Behavior"
Institution: Middle Tennessee State University

Name of participant: ____ Age: __________

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

1. **Purpose of the study:**
   You are being asked to participate in a research study because there is a need to validate a self-report measurement tool of sedentary behavior. Your participation will help determine if the self-report measurement tool can capture contextual information of sedentary behavior.

2. **Description of procedures to be followed and approximate duration of the study:**
   You must be ambulatory with no physical/medical disabilities. You will be asked to complete a questionnaire, provide height and weight measurements, and to wear a wearable camera such as an Autographer on four consecutive days including two days on a weekday and two days on a weekend. On the day of our initial meeting, you will be asked to visit our laboratory to get the devices initialized for you to wear during the data collection. Further, height/weight measurements will be conducted and you will be asked to complete a questionnaire. Devices must be returned to the to one of the researchers once monitoring is complete.

   Measuring device:
   The Autographer (Oxford Metrics Group, plc., Oxford, UK) is a new type of camera which provides hands-free image capturing. The Autographer, a small portable device (58g; 3.74 × 9.55 × 2.29cm), incorporates five sensors (tri-axial accelerometer, magnetometer, ambient temperature, light level, and passive infrared) to determine the best moment to automatically capture the images without any user-intervention. The camera will be worn around the neck using the lanyard provided by the manufacturer

3. **Expected costs:**
   N/A

4. **Description of the discomforts, inconveniences, and/or risks that can be reasonably expected as a result of participation in this study:**
   The images captured by the Autographer wearable camera may be unwanted or unflattering.
   - A maximum 3 images will be captured in a minute during the monitoring day and will depict where you go, what you do, and for how long.
   - Participants can forget they are wearing the device and record unwanted and unflattering images (e.g., bathroom visits, online banking).

1

- Data of illegal activities may not be protected by confidentiality and may be passed to law enforcement depending on the nature of the activity.
- Images of Third Parties may be captured which could subject the participant to liability for invasion of privacy or similar claims.
- Participants will not get copies of their images.
- Participants may also experience physical discomfort from wearing the devices.

Although the participant may not have as much control for the automatically capture images during the measurement sessions, following components will be secured in order to protect your privacy and confidentiality.

- No individual will be identifiable in any research dissemination.
- The images will be stored in the USB flash drive. The password protection to access the USB flash drive will be secured. The USB flash drive will be kept in a locked file cabinet or cupboard along with other documents.
- Participants will review (and delete if necessary) their images in privacy.
- Participants are able to remove the device or temporarily pause image capture whenever they wish.
- Only a team of specifically trained researchers will have access to the image data.
- A reference card will be provided for you to carry around while wearing the device.

5. **Compensation in case of study-related injury:**
MTSU will not provide compensation in the case of study related injury.

6. **Anticipated benefits from this study:**
a) The potential benefits to science and humankind that may result from this study is ability to capture contextual information of sedentary behavior leading to future study focused on effective sedentary behavior intervention.
b) The potential benefits to you from this study are learning about sedentary behaviors and obtaining your individual sedentary behavior time.

7. **Alternative treatments available:**
There is no alternative treatment available.

8. **Compensation for participation:**
There is no monetary compensation for participating in this study.

9. **Circumstances under which the Principal Investigator may withdraw you from study participation:**
If conditions prior to arriving to the lab are not met, the principal investigator may withdraw you from participation.

10. **What happens if you choose to withdraw from study participation:**
There are no consequences for withdrawing from the study.

11. **Contact Information.** If you should have any questions about this research study or possible injury, please feel free to contact Heontae Kim at 512-775-4546 or my Faculty Advisor, Dr. Weatherby at 615-898-5241.

12. **Confidentiality.** All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, if you or someone else is in danger or if we are required to do so by law.

Information Card

This card illustrates the answers if someone inquires about the Autographer device.

"I am participating in a study on sedentary behaviors which has been approved by the MTSU IRB. This is a digital camera that automatically captures low-resolution still images throughout the day, which will later be used to describe my behaviors. It does not record audio or full-motion video. Any images captured will not be made public in any fashion and will only be seen by the trained researchers. If you would prefer, I can turn off or temporarily deactivate the camera, and/or make a note the images just taken deleted without anyone seeing them. I can also provide contact information for the researchers."

List of the places that you should NOT use the camera

- Any restroom
- Any changing room, locker room (e.g., house, gym), etc.
- Doctor's office/Hospital/Medical Center
- Banks/ATM
- Schools/Government Buildings
- Whenever/Wherever you would prefer for images not to be captured
- Whenever/Wherever anyone requests deactivating or removing

<u>Contact Information</u>

Heontae Kim
Department of Health and Human Performance
Phone: 512-775-4546
Email: hk3m@mtmail.mtsu.edu

Dr. Norman Weatherby
Department of Health and Human Performance
Phone: 615-898-5241
Email: norman.weatherby@mtsu.edu

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13. **<u>STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY</u>**
I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I freely and voluntarily choose to participate in this study.

________________ ________________________________
Date Signature of patient/volunteer

Consent obtained by:

________________ ________________________________
Date Signature

____
Printed Name and Title

Appendix B – IRB Letter of Approval

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Wednesday, January 03, 2018

Principal Investigator	**Heontae Kim** (Student)
Faculty Advisor	Norman Weatherby
Co-Investigators	Minsoo Kang (University of Missisippi) and Garvita Thareja
Investigator Email(s)	*jk3m@mtmail.mtsu.edu; norman.weatherby@mtsu.edu; kang@olemiss.edu; gt2g@mtmail.mtsu.edu*
Department	Health and Human Performance
Protocol Title	***Validation of sedentary behavior record instrument as a measure of contextual information of sedentary behavior***
Protocol ID	**18-2119**
Funding	*NONE*

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the categories: *(4) Collection of data through noninvasive procedures* (PRIMARY) and *(7) Research on individual or group characteristics or behavior* (SECONDARY). A summary of the IRB action and other particulars in regard to this protocol application are tabulated below:

IRB Action	APPROVED for one year
Date of expiration	12/31/2020
Participant Size	50 (FIFTY)
Participant Pool	General adult (!8 years or older)
Exceptions	1. Collection of identifying information and life-style demographics is permitted with restrictions. 2. Photoimaging is permitted. 3. Approved to monitor the participants for daily sedentary behavior.
Restrictions	**1. Mandatory signed informed consent; the PI must provide a copy of the informed consent signed by the PI/FA to each participant. 2. Video/audio data must be destroyed after data processing as described in the protocol. 3. Identifiable information must be destroyed upon data processing. 4. The participants must wear the disclosure sign all the time when the camera is on. The PI must explicitly disclose to the subjects that the signage display is mandatory before enrollment.**
Comments	NONE

This protocol can be continued for up to THREE years (12/31/2020) by obtaining a continuation approval prior to 12/31/2018. Refer to the following schedule to plan your annual project reports and be aware that you may not receive a separate reminder to complete your continuing reviews. Failure in obtaining an approval for continuation will automatically result in cancellation of this protocol. Moreover, the completion of this study MUST be notified to the Office of Compliance by filing a final report in order to close-out the protocol.

Continuing Review Schedule:

Reporting Period	Requisition Deadline	IRB Comments
First year report	11/30/2018	NOT ELIGIBLE
Second year report	11/30/2019	NOT ELIGIBLE
Final report	11/30/2020	NOT ELIGIBLE

Post-approval Protocol Amendments:

Date	**Amendment(s)**	**IRB Comments**
NONE	NONE	NONE

The investigator(s) indicated in this notification should read and abide by all of the post-approval conditions imposed with this approval. Refer to the post-approval guidelines posted in the MTSU IRB's website. Any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918 within 48 hours of the incident. Amendments to this protocol must be approved by the IRB. Inclusion of new researchers must also be approved by the Office of Compliance before they begin to work on the project.

All of the research-related records, which include signed consent forms, investigator information and other documents related to the study, must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data storage must be maintained for at least three (3) years after study completion. Subsequently, the researcher may destroy the data in a manner that maintains confidentiality and anonymity. IRB reserves the right to modify, change or cancel the terms of this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

Click here for a detailed list of the post-approval responsibilities.
More information on expedited procedures can be found here.

CHAPTER IV

THE FEASIBILITY OF TAILORED DOMAIN-SPECIFIC INTERVENTION USING CONTEXTUAL INFORMATION OF SEDENTARY BEHAVIOR ON REDUCING SEDENTARY TIME

Introduction

Sedentary behavior is defined as all waking time behavior spent in a prolonged sitting/lying posture for which energy expenditure is low (<1.5 METs). Such behavior includes watching TV, working on a computer, or driving a car (Sedentary Behaviour Research Network , 2012). Sedentary behavior may be conceptualized as being at the low end of the physical activity continuum above sleep (Tremblay et al., 2010). During the day, U.S. civilians spend on average approximately 55% of their time in sedentary behavior (Matthews et al., 2008). This is equivalent to approximately 7.7 hours per day. Many studies have demonstrated that sedentary behavior is a major health risk, independent of being physically inactive. Excessive sedentary behavior levels can lead to poor health outcomes and are a risk factor for chronic diseases such as metabolic syndrome (Dunstan et al., 2005; Healy et al., 2008) and cardiovascular disease (Hamilton et al., 2007; Katzmarzyk et al., 2009). Therefore, an important public health strategy to prevent chronic disease is to reduce sedentary behavior time.

In an attempt to reduce sedentary behavior, researchers have begun to build several type of interventions. These include the following: counseling (Aittasalo et al., 2012; Gardiner et al., 2011; Lakerveld et al., 2013; Lewis et al., 2016), web-based interventions (Marshall, Leslie, Bauman, Marcus, & Owen, 2003; Plotnikoff, McCargar, Wilson, & Loucaides, 2005), incentive-based intervention (Ball et al., 2017), portable pedal exercise machines (Carr, Walaska, & Marcus, 2011), face-to-face and phone-based coaching (Opdenacker & Boen, 2008), standing interventions (Gilson, Suppini, Ryde, Brown, & Brown, 2012; Speck, 2011; Speck & Schmitz, 2009), "walk-and-work" stations (Levine & Miller, 2007; Thompson, Foster, Eide, & Levine, 2007), and portable stepping devices (McAlpine, Manohar, McCrady, Hensrud, & Levine 2007).

According to a systematic review (Gourlan et al., 2016), examining efficacy of theory-based physical activity intervention among adults, interventions based on theory can be more effective (d = 0.31, 95% CI [0.24, 0.37]). Drawing on particular theoretical models for behavioral change, constructs from Social Cognitive Theory (Bandura, 1986) and Behavioral Choice Theory (Rachlin, 1989) can be used to guide the development of interventions. From Social Cognitive Theory (Bandura, 1986), the self-efficacy construct suggests the use of self-monitoring (which could be done using a simple daily sitting time record book) and setting realistic and measurable goals to ensure initial success (e.g., aiming to limit screen time outside of work to no more than 2 hours/day; standing during each TV advertisement break). In addition, the outcome expectancies construct would suggest highlighting the benefits of reducing sedentary time (e.g., reduced muscle stiffness). From Behavioral Choice Theory, one could use providing reinforcement (rewards for goal attainment) and identifying enjoyable non-sedentary activities (e.g., dancing while listening to music, or standing up to paint or draw at an easel instead of sitting down).

In addition to applying theoretical background, understanding the correlates of sedentary behavior taking place in a specific domain is important to develop more effective interventions. Understanding specific domains (e.g., times or activities) related to high sedentary behavior time also requires research attention. This could be helpful to target interventions for high-risk subgroups, and knowing specific sedentary behaviors of the subgroups could help tailor interventions (Owen, 2011). Therefore, it is necessary to reflect the information obtained from identifying individual's or particular group's contextual information (i.e., where, when, and how sedentary behaviors occur) and the time spent in sedentary behavior in order to design the effective sedentary behavior intervention.

To continue the advancement of sedentary behavior intervention, it is important for researchers to use theoretical background and contextual information of sedentary behavior. Therefore, the purpose of this study is to identify the feasibility of tailored domain-specific sedentary behavior intervention and its effect on reducing sedentary behavior time using contextual information of sedentary behavior.

Methods

Study Design

In this study, we implemented a randomized controlled trial (RCT) examining the effect of tailored domain-specific intervention using contextual information of sedentary behavior on reducing sedentary behavior. Because there were variables that needed to be controlled and participants were enrolled continually during the current study, covariate adaptive randomization was used. In the covariate adaptive randomization, a new participant was sequentially assigned to a particular group by taking into account the specific covariates (i.e., gender and BMI) and previous assignments of participants; this was to minimize imbalance of sample size among several covariates (Kang, Ragan, & Park, 2008). The design employed three intervention arms: (1) a tailored domain-specific sedentary behavior intervention using individual contextual information, (2) a standard sedentary behavior intervention only, and (3) a control group. Data collection of sedentary behavior time took place at 3 time-points over the course of three weeks—the baseline, 1st intervention week, and 2nd intervention week.

Participants

To identify the minimum number of participants required to achieve sufficient power, the investigator conducted a priori power analysis for repeated measures ANOVA with within-between interaction. It is recommended to use a medium effect size of 0.25 (Maxwell & Delaney, 2004) with an alpha of 0.05 and a power of 0.80 (Tabachnick & Fidell, 2013) without theory dictating and expected effect size. Based upon results of the power analysis, a minimum sample of 36 participants was suggested. Oversampling of 10% was used to account for participant attrition resulting in a sample size of 40.

As a result, participants in this study comprised 40 adults (age $\geq$ 18) with no physical or medical disabilities that would reduce engagement in normal daily activities. All participants met with an investigator to review and sign the informed consent approved by the University's Institutional Review Board.

Procedure

Participants were recruited from the U.S. Southeast via word of mouth and posted flyers. Figure 1 illustrates the timeline of intervention, intervention components, and measures.

Visit 1. After signing the informed consent form, the investigator obtained anthropometric measurements including age, sex, race, education, income, occupation, and self-reported height (cm) and body weight (kg). During the initial meeting with research investigators, participants were instructed on how to record their sedentary behavior through online-based, diary-type questionnaire using Google Sheets. This was done so their sedentary behavior time could be assessed and the contextual information of sedentary behavior for 7-day baseline measurement period could be identified. To measure their sedentary behavior objectively, the investigator had participants wear an accelerometer. Written and verbal instructions were provided for wearing the device correctly. Throughout the baseline measurement period, participants wore the activity monitor and recorded their sedentary behavior daily using an online-based questionnaire. Participants were instructed to perform normal daily activities without any behavior modification, such as reducing sedentary behavior or increasing physical activity during the measurement period. To improve participant compliance with the study protocol, the investigator sent a daily reminder using their preferred method of contact (i.e., phone call, text message, or email).

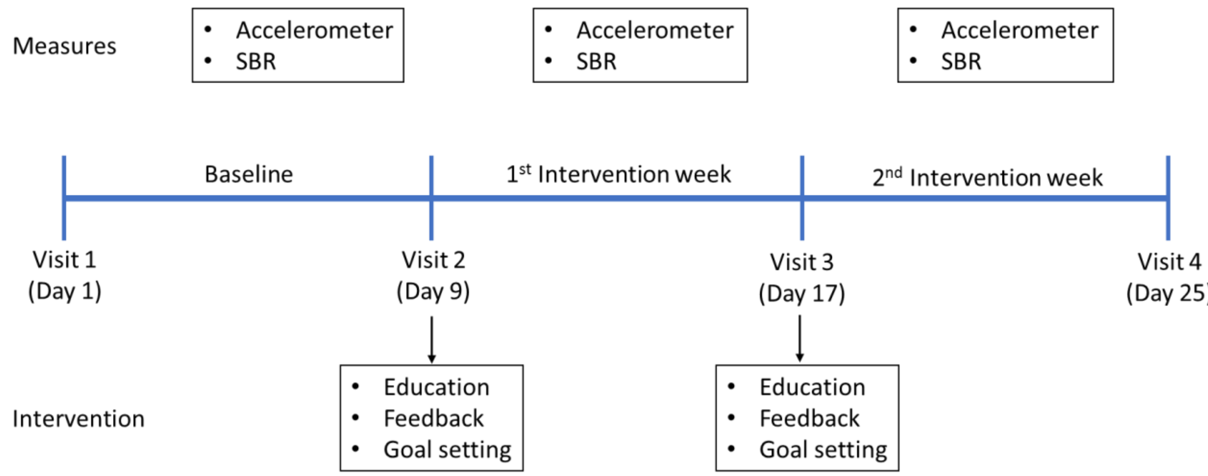

Figure 1. Study procedure

Visit 2. Following completion of the 7-day baseline measurement, participants met with the investigator to review their sedentary behavior obtained from sedentary behavior questionnaire and turned in the activity monitors. The participants in the intervention groups began to receive interventions. Each participant received an activity monitor again to measure sedentary behavior time during first intervention week. Also, they recorded their sedentary behavior using online-based questionnaire every day. During the first intervention week, they were instructed to implement the behavioral strategies discussed with the investigator.

Visit 3. After the 1st intervention week, participants returned the activity monitors and participants in the intervention groups received the intervention again for the 2nd intervention week. Participants' sedentary behavior was measured by the online questionnaire and activity monitor for second intervention week.

Visit 4. At the end of the 2nd intervention period, participants met with the investigator to turn in the activity monitors on visit 4.

Intervention

The primary aim of a 2-week tailored sedentary behavior intervention is to reduce sedentary behavior time using individuals' contextual information of sedentary behavior. Basically, behavioral strategies to reduce sedentary behavior included educational meeting and materials, goal setting and feedback, and self-monitoring based on Social Cognitive Theory (Bandura, 1986) and Behavioral Choice Theory (Rachlin, 1989). Table 1 describes the intervention elements.

Tailored domain-specific intervention group. In the initial education session (visit 2), the investigator educated participants about definition and prevalence of sedentary behavior, health benefits of reduced sedentary behavior, and suggestions to reduce sedentary behavior. On visits 2 and 3, for the tailored goal setting, each participant in this group was instructed to reduce specific sedentary behavior time targeting relatively frequent activities (e.g., TV viewing, sitting on desk) that individual's sedentary behaviors occur.

Individual contextual information of sedentary behavior (obtained from online-based questionnaires) was used to guide the goal setting and suggest behavior (e.g., stand while talking on the phone, stand during commercials, stand at bus stops, take a 5-minute walk/stand break each hour, etc.). Self-monitoring was implemented by completing diary-type sedentary behavior questionnaire every day.

Table 1

Elements of tailored sedentary behavior intervention

Intervention Segment	**Description of intervention element**
Initial Education	• Definition of sedentary behavior • Prevalence of sedentary behavior • Health benefits of reduced sedentary behavior
Goal Setting	• Establishing realistic goal based on assessed contextual information of sedentary behavior • Incremental goal setting during intervention period (reduce their sedentary behavior time by 30 and 60 minutes at first and second intervention week, respectively)
Feedback	• Providing information on when, where, and how individual sedentary behavior occur frequently • Give motivation base on individual sedentary behavior patterns assessed
Self-monitoring	• Record individual sedentary behavior using SBR instrument

Standard intervention group. Basically, the standard intervention group received the same intervention as the tailored intervention group (e.g., education, goal setting, feedback, and self-monitoring) without the tailored goal setting and feedback based on individual contextual information of sedentary behavior. In other words, for goal setting, the investigator gave participants general advice only, not individualized advice.

Control group. Participants in the control group were asked to perform normal daily activities without any behavior modification, such as reducing sedentary behavior or increasing physical activity during the intervention period.

Aside from the key components of the intervention, the basic frame of these interventions was derived from the recommendations of previous studies, including three recent systemic reviews of sedentary behavior interventions (Martin et al., 2015; Gardiner et al., 2016; Prince et al., 2014). In these reviews, the authors have recommended use of interventions primarily aimed to reduce sedentary behavior only. Also, Lewis et al., (2016) demonstrated that use of incremental goal setting in interventions can reduce sedentary behavior time effectively. The 2-week period of the intervention was selected based on recommendation of relatively shorter intervention duration (e.g., ≤ 3 months; Martin et al., 2015) and the success of previous short-term sedentary behavior interventions (Evans et al., 2012; Fitzsimons et al., 2013; Gardiner et al., 2011; Maher et al., 2017; Urda et al., 2016).

Measure

Sedentary Behavior Record (SBR). The SBR, developed by Kang et al. (2015), was an adaptation of the 3-day Physical Activity Record (Bouchard et al., 1983) for quantifying sedentary behavior time, and identifying contextual information of sedentary behavior in 15-minute blocks. The SBR includes three modified domains (work-related sitting, non-work related sitting and transport) and a choice of different activities under each domain—1) non-work related sitting (e.g., watching TV, computer/mobile/electronic device use, other), 2) work-related sitting (e.g., screen based i.e., computer/electronic device use] and non-screen based), and transport (e.g., screen based [i.e., electronic device use] and non-screen based). The modified domains and types in the SBR were adapted from ecological model of sedentary behavior (Owen et al., 2011) as well as other previous studies (Clark et al., 2013; Rosenberg et al., 2010; Visser & Koster, 2013). All the components of sedentary behavior suggested by Tremblay, Colley, Saunders, Healy & Owen (2010)—frequency, interruptions, total time, and type—can be measured by the SBR. As evidence of convergent validity with SBR, Kang and colleagues (2015) used accelerometer data (Contingency coefficient [C] = .74 [meaningful range: .5 to 1]; Safrit & Wood, 1995). In addition, for this study, the original SBR was revised to capture sedentary behavior in a minimum of 10-minute blocks, based upon the recommendations proposed by Kim, Welk, Braun, and Kang (2015). The modified SBR is illustrated in Figure 2.

TIME	0-10	10-20	20-30	30-40	40-50	50-60
00:00-01:00						
01:00-02:00						
02:00-03:00						
03:00-04:00						
04:00-05:00						
05:00-06:00						
06:00-07:00						
07:00-08:00						
08:00-09:00						
09:00-10:00						
10:00-11:00						
11:00-12:00						
12:00-13:00						
13:00-14:00						
14:00-15:00						
15:00-16:00						
16:00-17:00						
17:00-18:00						
18:00-19:00						
19:00-20:00						
20:00-21:00						
21:00-22:00						
22:00-23:00						
23:00-24:00						

Directions: Using the numbers below, fill in each cell in the table that best describes the activity that was performed during the majority of each 10-minute period. If the cell corresponds with an activity not related to sitting or lying down, cross-out the cell(s).

No.	Sedentary Behavior	Time (minutes)
1	Sleep	0
	Non-work Related	
2	Watching TV	0
3	Coumputer/mobile/electronic device use	0
4	Other: eating, reading, socializing, etc.	0
	Work Related	
5	Screen based	0
6	Non-screen based	0
	Transport	
7	Screen based	0
8	Non-screen based	0
	Total	0

Figure 2. Online version of SBR

Actigraph. To assess sedentary behavior time, this study used the Actigraph GT3X accelerometer, which is a light and small (27 g; 3.8 × 3.7 × 1.8 cm) triaxial accelerometer. The Actigraph GT3X accelerometer provides valid and reliable estimates of sedentary behavior time in a free-living environment (Atkins et al., 2012; Healy et al., 2011). A cutoff of < 100 counts/minute was chosen to categorize sedentary behavior time. Non-wear time was defined as intervals of at least 60 consecutive minutes of zero counts. To be considered valid, days of data collection required at least 10 hours of wear time (Toriano et al., 2008). Participants were instructed to secure the accelerometer to the right hip at the waistline. Also, participants wore the accelerometer during all waking time and removed it during water-based activities (e.g., bathing, swimming).

Analysis

All data management and analyzes were conducted using SAS version 9.4 and SPSS version 23. Descriptive statistics were expressed as frequencies with percentage and means ± standard deviations to summarize characteristics about participants and the dependent variables. Statistical significance was set at .05. Comparison among the three groups was conducted for changes in total time spent in sedentary behavior time using two-way (Group × Time) repeated measures analysis of variance (ANOVA). The effects of group (tailored sedentary behavior intervention vs standard intervention vs control), time (baseline, 1st intervention week, 2nd intervention week), and their interactions were tested. A significant Group × Time interaction was hypothesized with the intervention group decreasing sedentary behavior time over time. The data was split by groups and simple effects repeated measures ANOVAs were analyzed to assess the effect of each intervention. In order to correct for violating the assumption of sphericity, Greenhouse-Geisser corrected statistics (G-G *p*) were reported.

Results

A total of 43 adults with no physical or medical disabilities provided written informed consent. This study included only 36 participants who wore the Actigraph during at least 10 hours per day for at least four days (3 weekdays and 1 weekend day). Table 2 presents the demographic characteristics of 36 participants who completed this study. Participants ranged in age from young to middle-aged (19 to 58 years). The majority of participants were White/Caucasian, university-educated, non-office workers, and met physical activity guidelines.

In the tailored domain-specific intervention group, the investigator consulted with each participant based on his/her contextual information of sedentary behavior obtained from the SBR. Participants were instructed to reduce different types of sedentary behavior time: reducing work-related screen based sitting (n = 20), TV viewing (n = 8), computer/mobile/electronic use (n = 7), and other sitting (e.g., reading, eating, socializing) (n = 3).

Shown in Table 3 are descriptive statistics for the sedentary behavior time of each group at all measurement points. To compare the sedentary behavior time throughout measurement period among groups, the investigator used a two-way repeated measures ANOVA with group (standard intervention, tailored domain-specific intervention, control) as a between-subject factor and measurement point (baseline, 1st intervention week, 2nd intervention week) as a within-subject factor. A family-wise alpha of .05 was used. There was a significant interaction between group and measurement time point, *F* (3.9, 63.6) = 3.94, *MSE* = 2079.74, G-G $p = .007$, $\eta^2_p = .193$. Also, there was significant main effect for measurement time, *F* (1.9, 63.6) = 5.03, *MSE* = 2079.74, G-G $p = .010$, $\eta^2_p = .132$, while there was no significant main effect for group, *F* (2, 33) = 0.10, *MSE* = 10238.20, G-G $p = .902$, $\eta^2_p = .006$.

One-way ANOVAs (α = .0167) and Tukey pairwise comparisons (see Table 4) were used to compare the mean sedentary behavior time between groups for each time point. Sedentary behavior time did not differ among groups at the baseline measurement, *F* (2, 33) = 2.02, *MSE* = 3457.57, $p = .149$, $\eta^2_p = .109$; at the 1st intervention week, *F* (2, 33) = 0.79, *MSE* = 5073.76, $p = .464$, $\eta^2_p = .045$; and at the 2nd intervention week, *F* (2, 32) = 1.03, *MSE* = 5717.40, $p = .367$, $\eta^2_p = .059$.

One-way repeated measures ANOVAs (α = .0167) and Sidak pairwise comparisons (see Table 5) were used to compare the sedentary behavior time between time points within each group. Sedentary behavior time at baseline, 1st intervention week, and 2nd intervention week were similar for the control group, *F* (1.7, 18.9) = 0.48, *MSE* = 3069.37, G-G $p = .597$, $\eta^2_p = .042$. Also, the sedentary behavior time of the standard intervention group at each week was similar, *F* (1.8, 20.1) = 1.76, *MSE* = 2033.56, G-G $p = .198$, $\eta^2_p = .138$. On the other hand, the sedentary behavior time differed by time for tailored domain-specific intervention group, *F* (1.7, 18.8) = 14.00, *MSE* = 1783.64, G-G $p < .001$, $\eta^2_p = .560$. For the tailored domain-specific intervention group, the sedentary behavior time at the 1st and 2nd intervention weeks were less than sedentary behavior time at baseline (see Figure 3).

Table 2

Demographic characteristics of participants in baseline

	Control (n = 12)	Standard (n = 12)	Tailored (n = 12)	Total (n = 36)
Gender				
Male	7	7	7	21
Female	5	5	5	15
Age (year)	29.2 ± 12.8	29.6 ± 10.4	30.3 ± 6.7	29.7 ± 10.0
Height (cm)	171.0 ± 8.6	174.2 ± 8.4	170.2 ± 8.6	171.8 ± 8.5
Weight (kg)	74.0 ± 16.1	76.7 ± 12.9	69.4 ± 12.1	73.4 ± 13.8
BMI (kg/m^2)	25.2 ± 4.8	25.1 ± 3.2	23.8 ± 2.8	24.7 ± 3.6
Race				
Asian/Pacific Islander	2	2	2	6
Black/African-American	3	4	2	9
Latino/Latina	1	0	0	1
White/Caucasian	6	6	8	20
Education				
High School	2	1	0	3
College	7	9	9	25
Graduate School	2	2	3	7
Other	1	0	0	1
Office worker				
Yes	4	4	7	15
No	8	8	5	21
Income				
Between $5,000 to $34,999	2	2	3	7
Between $35,000 to $49,999	4	3	1	8
Between $50,000 to $74,999	2	4	3	9
$75,000 and greater	2	1	5	8
Don't know	2	2		4
Marital status				
Yes (married)	3	4	8	15
No (not married)	9	8	4	21
Meeting PAG				
Yes	9	11	8	28
No	3	1	4	8

Note. BMI = body mass index, PAG = physical activity guidelines

Table 3

Descriptive Statistics for sedentary behavior time of each group at 3 time-point

Group	Time	Mean	95% CI	
			Lower	Upper
Control	Baseline	503.13	466.46	539.80
	1st	515.48	471.11	559.86
	2nd	525.26	478.13	572.39
Standard intervention	Baseline	527.07	491.97	562.19
	1st	497.66	455.18	540.15
	2nd	499.27	454.14	544.39
Tailored domain-specific intervention	Baseline	551.54	516.43	586.66
	1st	477.41	434.93	519.90
	2nd	479.60	434.48	524.72

Note. CI = confidence interval.

Table 4

Comparisons for sedentary behavior time among intervention groups

			95% CI	
I	J	Mean diff	lower	Upper
Baseline				
Control	Standard	-23.94	-96.93	49.04
Control	Tailored	-48.41	-121.40	24.57
Standard	Tailored	-24.47	-95.85	46.91
1st intervention week				
Control	Standard	17.82	-70.50	106.13
Control	Tailored	38.07	-50.24	126.38
Standard	Tailored	20.25	-66.12	106.63
2nd intervention week				
Control	Standard	25.99	-67.80	119.79
Control	Tailored	45.66	-48.14	139.45
Standard	Tailored	19.66	-72.07	111.40

Note. CI = confidence interval

Table 5

Comparisons for sedentary behavior time among time points

I	J	Mean diff	95% CI lower	95% CI Upper
Control				
Baseline	1st intervention week	-12.348	-107.144	82.447
Baseline	2nd intervention week	-22.127	-89.514	45.259
1st intervention week	2nd intervention week	-9.779	-86.408	66.850
Standard intervention				
Baseline	1st intervention week	29.41	-21.16	79.98
Baseline	2nd intervention week	27.81	-35.62	91.24
1st intervention week	2nd intervention week	-1.60	-67.77	64.57
Tailored domain-specific intervention				
Baseline	1st intervention week	74.13*	9.13	139.14
Baseline	2nd intervention week	71.94*	22.51	121.38
1st intervention week	2nd intervention week	-2.19	-50.25	45.87

Note. CI = confidence interval; *$p < .0167$

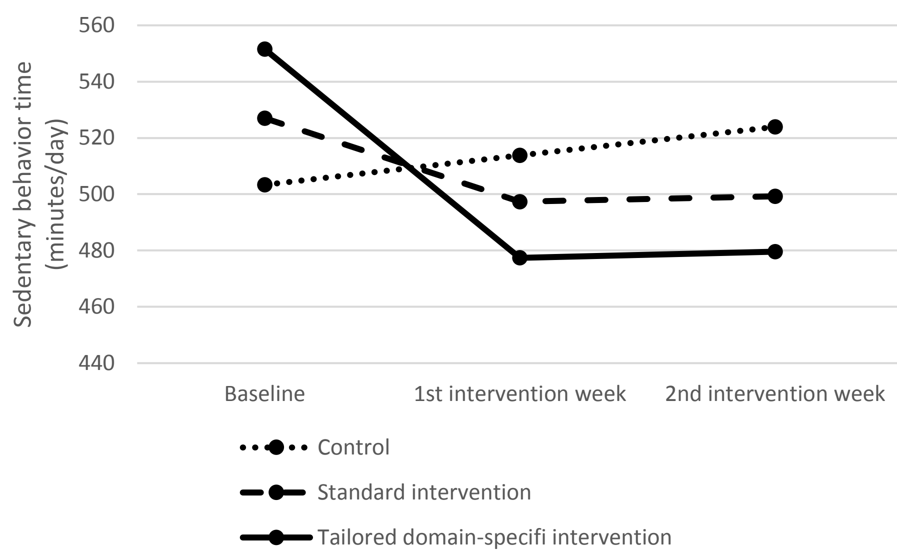

Figure 3. Sedentary behavior time for control group at 3 time-points.

Discussion

The purpose of this study was to evaluate the feasibility and effectiveness of the tailored domain-specific sedentary behavior intervention using contextual information of sedentary behavior, so as to reduce such behavior time among adults. The results indicate the tailored domain-specific sedentary behavior intervention decreased sedentary behavior time. The observed decrease of 74 minutes a day in objectively measured sitting time represented a medium effect size (0.56). In contrast, the standard sedentary behavior intervention showed no statistically significant effect.

Reduction in sedentary behavior time from tailored domain-specific intervention may be attributable to the customized approach that allowed the participants to effectively understand information about their sedentary behavior. In other words, participants were able to effectively reduce their sedentary behavior time when they received information about when, where, and how their sedentary behaviors occurred. Previous studies and reviews have highlighted the need of tailored sedentary behavior intervention using contextual information of sedentary behavior (Kang et al., 2015; Lakerveld et al., 2013; Owen et al., 2011; Teychenne, Ball, & Salmon, 2012). The findings presented here offer support to the suggestions of previous studies and reviews.

There was no statistically significant reduction in sedentary behavior time in the standard intervention group even though sedentary behavior time tended to decrease during the three-week measurement period (28 minutes/day). This result was not consistent with previous studies using interventions involving the same components (e.g., education, goal setting, feedback, self-monitoring) used in the current study. Adams et al.

(2013) demonstrated their 6-week intervention reduced sedentary behavior time by 12 minutes/day. Raynor et al. (2013) showed their 8-week intervention decreased sedentary behavior time by 2.3 hours/day. These inconsistent results may be due to differences of intervention length. The current study had a relatively short 2-week intervention period that might have resulted in a nonsignificant effect of the sedentary behavior intervention. We used a 2-week intervention based on the previous successful 2-week intervention developed by Gardiner et al. (2011). In the current study, however, participants' characteristics differed from those Gardiner and colleagues' study. In the current study, participants were relatively young participants (29.7 ± 10.0 years), ranging in age from 19 to 58, and their average BMI (24.7 ± 3.6) fell within the normal range. On the other hand, Gardiner et al., (2011) reported their participants were older adults (> 60 years). Participants in Raynor et al., (2013) study were sedentary adults (watch ≥16 hours of TV per week, and engage in ≤100 minutes of MVPA per week) who ranged from overweight to obese ($25\ kg/m^2 < BMI < 40\ kg/m^2$). Also, Adams et al. (2013) reported their participants were from 35 to 85 years old with a BMI > 25. Differences among participants' age and BMI may influence study results as these demographic characteristics are known correlates of sedentary behavior time (Dikerson et al., 2011; Matthews et al., 2008).

Some researchers have demonstrated that interventions using contextual information of sedentary behavior were effective at reducing sedentary behavior (Aittasalso et al., 2017; Lewis et al., 2016; Maher et al., 2017). In their studies, however, the use of contextual information of sedentary behaviors was just one component in interventions, and the authors did not evaluate the effect of contextual information alone on reducing sedentary behavior time. The current study has demonstrated the sole effect of contextual information of sedentary behavior by comparing it with a standard intervention.

There are some limitations to this study that should be considered. Participants were relatively young (29.7 ± 10.0 years), the oldest being 58. Thus, the generalizability of this SBR instrument for use in older adults may be limited. Further research with old adults and other population is needed. In addition, the intervention period of the current study was relatively short (i.e., two weeks) because this study was intended to examine the feasibility of a tailored domain-specific intervention. Therefore, it was not possible to evaluate the long-term effect of the intervention. In the future, to assess the sustainability of the intervention effect, we need to investigate its effectiveness with follow-up measures.

In conclusion, we found the tailored domain-specific sedentary behavior intervention using contextual information of sedentary behavior was feasible and acceptable to adults. While we still do not know the long-term effectiveness of the tailored domain-specific intervention, there is potential to reduce sedentary behavior by using contextual information regarding it. The promotion of verified effective strategies to reduce sedentary behavior time may lead to sustainable improvements in health benefits.

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Appendix for Study II

Appendix A

Intervention Brochure

Stop Sitting & Stand Up!!

Facts About Sedentary Behavior

- Too much sitting may lead to low back pain
- A 10% increase in sedentary time can lead to a 3.1cm increase in waist circumference
- Being sedentary can lead to fat gain from over eating
- Obese individuals who sit for ¾ of the day, have double the risk of all-cause mortality than obese individuals who sit ½ of the day.
- Some evidence suggests sitting is associated with an increased risk of ovarian cancer, breast cancer, and colorectal cancer.

What is sedentary behavior time?
Sedentary behavior time is when you are lying or sitting

Do I sit too much?
National data shows U.S. people spend 7.7 hours/day in sedentary behavior. Compare it with your sitting time.

Can sitting too much affect my health?
YES!! Current researches have shown sedentary behavior is associated with an increased risk of mortality, diabetes, obesity, hypertension, heart disease, and cancers.

What if I exercise?
Even if you exercise, it is still important to decrease your sedentary behavior. If you exercise regularly, but are sedentary the rest of the day, you are known as an “active couch potato” and are still at high risk of poor health.

How can you reduce your sedentary behavior?

Suggestions

At Home:
- Stand up whenever you talk with someone
- Stand up to talk on the phone
- Use a restroom located a little further away
- Do dishes by hand instead of using the dishwasher
- Stand up during commercials
- Walk up and down stairs a couple times a day
- Mow your lawn

At Work:
- Stand up whenever you talk with someone
- Stand up to talk on the phone
- Set an hourly timer to remind you to take a break
- Hand-deliver a message to a coworker instead of emailing
- Take the stairs
- Use a restroom located a little further away

Recreation and Transportation:
- Choose active recreation instead of going to a movie (e.g., bowling, pool, and darts)
- Take a bus or other public transportation
- Go for a hike or a picnic instead of going for a scenic drive

Appendix B

Informed Consent

Middle Tennessee State University Institutional Review Board
Informed Consent Document for Research

Principal Investigator: Heontae Kim
Study Title: "Feasibility of tailored domain-specific intervention using contextual information of sedentary behavior on reducing sedentary behavior"
Institution: Middle Tennessee State University

Name of participant: ______________________________ Age: ________

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

1. **Purpose of the study:**
   You are being asked to participate in a research study because there is a need to examine the feasibility of intervention using contextual information of sedentary behavior on reducing sedentary behavior.

2. **Description of procedures to be followed and approximate duration of the study:**
   (Visit 1) You will be met in the Kinesmetrics laboratory where your height, weight, and age will be measured. Also, at this time, you will be asked to complete a simple questionnaire. During the initial meeting with research investigator, you will be instructed how to record their sedentary behavior through online based diary-type questionnaire using Google Sheets to assess your sedentary behavior time for 7-day baseline measurement period. In addition, you will be assigned an accelerometer to measure your sedentary behavior objectively. Written and verbal instructions will be provided for wearing the device. Throughout the baseline measurement period, you will be instructed to perform normal daily activities without any behavior modification, such as reducing sedentary behavior or increasing physical activity during the baseline measurement period.
   (Visit 2) Following completion of the baseline measurement, you will meet with the investigator to turn in the activity monitors. Participants in the intervention groups will begin to receive interventions and keep recording the online-based sedentary behavior questionnaire. You will be asked to wear an activity monitor during 1st intervention week. Also, you will implement the behavioral strategies discussed with investigator during 1st intervention week.
   (Visit 3) After 1st intervention week, you will return the activity monitors, and participants in the intervention groups will receive the intervention again for 2nd intervention week. You will be asked to wear the activity monitor for 2nd intervention week again.
   (Visit 4) At the end of 2nd intervention period, you will meet with the investigator to turn in the activity monitor.

3. **Expected costs:**
   N/A

4. **Description of the discomforts, inconveniences, and/or risks that can be reasonably expected as a result of participation in this study:**
   While there are no apparent risks for participating, you may experience some discomfort or inconveniences from recording your sedentary behavior and wearing the activity monitor.

5. **Compensation in case of study-related injury:**
MTSU will not provide compensation in the case of study related injury.

6. **Anticipated benefits from this study:**
a) The potential benefits to science and humankind that may result from this study are the ability to objectively assess the feasibility of sedentary behavior intervention and lead to future research designed for intervention.
b) The potential benefits to you from this study are learning about sedentary behavior domains and acquiring their sedentary behavior information.

7. **Alternative treatments available:**
There is no alternative treatment available.

8. **Compensation for participation:**
There is no monetary compensation for participating in this study.

9. **Circumstances under which the Principal Investigator may withdraw you from study participation:**
If activity monitor wear time is inadequate, the principal investigator may withdraw you from study participation.

10. **What happens if you choose to withdraw from study participation:**
There are no consequences for withdrawing from the study.

11. **Contact Information.** If you should have any questions about this research study or possible injury, please feel free to contact Heontae Kim at 512-775-4546 or my Faculty Advisor, Dr. Weatherby at 615-898-5241.

12. **Confidentiality.** All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, if you or someone else is in danger or if we are required to do so by law.

13. **STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY**
I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I freely and voluntarily choose to participate in this study.

______________________ ______________________________________
Date Signature of patient/volunteer

Consent obtained by:

______________________ ______________________________________
Date Signature

____
Printed Name and Title

Appendix C

IRB Letter of Approval

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram Building,
2269 Middle Tennessee Blvd
Murfreesboro, TN 37129

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Thursday, January 04, 2018

Principal Investigator	**Heontae Kim** (Student)
Faculty Advisor	Norman Weatherby
Co-Investigators	Minsoo Kang (University of Missisippi) and Garvita Thareja
Investigator Email(s)	*jk3m@mtmail.mtsu.edu; norman.weatherby@mtsu.edu; kang@olemiss.edu; gt2g@mtmail.mtsu.edu*
Department	Health and Human Performance
Protocol Title	***Feasibility of tailored domain-specific intervention using contextual information of sedentary behavior on reducing sedentary behavior***
Protocol ID	**18-2120**
Funding	*NONE*

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110 within the category*(7) Research on individual or group characteristics or behavior.* A summary of the IRB action and other particulars in regard to this protocol application are tabulated below:

IRB Action	APPROVED for one year from the date of this notification
Date of expiration	**1/31/2021**
Participant Size	50 (FIFTY)
Participant Pool	General adult (!8 years or older)
Exceptions	Collection of identifying information and life-style demographics is permitted with restrictions.
Restrictions	**1. Mandatory signed informed consent; the PI must provide a copy of the informed consent signed by the PI/FA to each participant.** **2. Identifiable information must be destroyed upon data processing.**
Comments	NONE

This protocol can be continued for up to THREE years (**1/31/2021**) by obtaining a continuation approval prior to **1/31/2019**. Refer to the following schedule to plan your annual project reports and be aware that you may not receive a separate reminder to complete your continuing reviews. Failure in obtaining an approval for continuation will automatically result in cancellation of this protocol. Moreover, the completion of this study MUST be notified to the Office of Compliance by filing a final report in order to close-out the protocol.

Continuing Review Schedule:

Reporting Period	Requisition Deadline	IRB Comments
First year report	12/31/2018	NOT ELIGIBLE
Second year report	12/31/2019	NOT ELIGIBLE
Final report	12/31/2020	NOT ELIGIBLE

Post-approval Protocol Amendments:

Date	Amendment(s)	IRB Comments
NONE	NONE	NONE

The investigator(s) indicated in this notification should read and abide by all of the post-approval conditions imposed with this approval. Refer to the post-approval guidelines posted in the MTSU IRB's website. Any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918 within 48 hours of the incident. Amendments to this protocol must be approved by the IRB. Inclusion of new researchers must also be approved by the Office of Compliance before they begin to work on the project.

All of the research-related records, which include signed consent forms, investigator information and other documents related to the study, must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data storage must be maintained for at least three (3) years after study completion. Subsequently, the researcher may destroy the data in a manner that maintains confidentiality and anonymity. IRB reserves the right to modify, change or cancel the terms of this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

Click here for a detailed list of the post-approval responsibilities.
More information on expedited procedures can be found here.

CHAPTER V

OVERALL CONCLUSION

Sedentary behaviors include sitting during commutes and leisure time, in the workplace, and in domestic environments. Sedentary behavior is defined as all waking time behavior in a prolonged sitting/lying posture such as watching TV, working on a computer, or driving a car for which energy expenditure is low (<1.5 metabolic equivalent units [METs]; Sedentary Behavior Research Network, 2012). Sedentary behavior can lead to poor health outcomes and is a risk factor for chronic diseases such as metabolic syndrome (Dunstan et al., 2005; Healy et al., 2008) and cardiovascular disease (Hamilton, Hamilton, & Zderic, 2007; Katzmarzyk, Church, Craig, & Bouchard, 2009). To prevent chronic disease therefore, public health officials have made it an important public health strategy to reduce sedentary behavior time.

Accurate measurement of sedentary behavior is important 1) to establishing the relationship between sedentary behavior and health outcomes, 2) to planning effective interventions to reduce sedentary behavior, and 3) to informing public health messages related to sedentary behavior (Kang & Rowe, 2015). As human life expectancy increases and interest in health and well-being increases, it is crucial in health outcome research to extend the current knowledge on appropriate measurements of sedentary behavior (Rosenberger, 2012).

The first study was entitled “Validation of sedentary behavior record instrument as a measure of contextual information of sedentary behavior.” It established evidence of validity (i.e., classification of accuracy) for the SBR instrument using a criterion measure captured through a proxy for direct observation. Interventions to reduce sedentary behavior time can be enhanced when health providers can identify contextual information (i.e., how, when, and where sedentary behavior occurs). Such information targets specific times or activities related to high sedentary behavior. A self-report measure assesses contextual information about sedentary behaviors through delayed recall (i.e., usual or last 7-day's sedentary behavior; Marshall, Miller, Burton, & Brown, 2010; Rosenberg et al., 2010). An alternative solution for minimizing recall-based errors and capturing contextual information may be the self-report diary, one of the criterion measures for assessing physical activity (Kohl et al., 2000; Sirard & Pate, 2001). Self-report diary documents sedentary behavior daily, employing a retrospective coverage strategy (Shiffman, Stone, & Hufford, 2008). This type of reporting method decreases the period that the participant must recall and thus limits potential recall bias.

To address the lack of contextual information in sedentary behavior and potential recall bias, Kang, Kim, Farnsworth, and Ragan (2015) created the Sedentary Behavior Record (SBR) instrument. SBR is a diary-type sedentary behavior measure used to document the amount and types of sedentary behavior in which a participant engages. Evidence of convergent validity has been previously documented with SBR using accelerometer data (Kang et al., 2015; Kim, Farnsworth, Ryu, & Kang, 2015). What still needed to be examined prior to this study was the accuracy of the classification of contextual information (i.e., agreement of domains and types of sedentary behavior between SBR and direct observation). Therefore, in the first study, we established evidence of validity (i.e., classification of accuracy) for the SBR instrument using a criterion measure through a proxy for direct observation.

Overall, the C coefficient between the SBR and criterion measure (i.e., Autographer wearable camera) was acceptable (C = .70). This study's results support the claim that the SBR has been validated appropriately as a means of providing important contextual information of sedentary behavior. We suggest that the SBR measures total and domain-specific sedentary behavior time. This information can be used in studies that need to measure work-related sitting, screen-based sitting, or sitting time on transport; in studies of the relationship between each sedentary behavior domain and health outcomes; and finally for intervention studies using contextual information of sedentary behavior.

The second study was entitled "The feasibility of tailored domain-specific intervention using contextual information of sedentary behavior on reducing sedentary time." It examined the feasibility and effectiveness of the tailored domain-specific sedentary behavior intervention using contextual information of sedentary behavior, so as to reduce such behavior time among adults. In an attempt to reduce sedentary behavior, researchers have begun to build several types of interventions. These include the following: counseling (Aittasalo et al., 2012; Gardiner et al., 2011; Lakerveld et al., 2013; Lewis et al., 2016), web-based interventions (Marshall, Leslie, Bauman, Marcus, & Owen, 2003; Plotnikoff, McCargar, Wilson, & Loucaides, 2005), incentive-based intervention (Ball et al., 2017), portable pedal exercise machines (Carr, Walaska, & Marcus, 2011), face-to-face and phone-based coaching (Opdenacker & Boen, 2008), standing interventions (Gilson, Suppini, Ryde, Brown, & Brown, 2012; Speck, 2011; Speck & Schmitz, 2009), "walk-and-work" stations (Levine & Miller, 2007; Thompson, Foster, Eide, & Levine, 2007), and portable stepping devices (McAlpine, Manohar, McCrady, Hensrud, & Levine 2007).

Understanding specific domains (e.g., times or activities) related to high sedentary behavior time also requires research attention. This could be helpful to target interventions for high-risk subgroups; moreover, knowing specific sedentary behaviors of the subgroups could help tailor interventions (Owen, 2011). Therefore, it is necessary to reflect the information obtained from identifying an individual's or a particular group's contextual information (i.e., where, when, and how sedentary behaviors occur) and the time spent in sedentary behavior in order to design the effective sedentary behavior intervention.

The second study's results indicated the tailored domain-specific sedentary behavior intervention decreased sedentary behavior time. The observed decrease of 74 minutes a day in objectively measured sitting time represented a medium effect size (0.56). In contrast, the standard sedentary behavior intervention showed no statistically significant effect. Reduction in sedentary behavior time from tailored domain-specific intervention may be attributable to the customized approach that allowed the participants to effectively understand information about their sedentary behavior. In other words, participants were able to effectively reduce their sedentary behavior time when they received information about when, where, and how their sedentary behaviors occurred. Previous studies and reviews have highlighted the need of tailored sedentary behavior intervention using contextual information of sedentary behavior (Kang et al., 2015; Lakerveld et al., 2013; Owen et al., 2011; Teychenne, Ball, & Salmon, 2012). The findings presented here offer support to the suggestions of previous studies and reviews.

Some researchers have demonstrated that interventions using contextual information of sedentary behavior are effective at reducing sedentary behavior (Aittasalso et al., 2017; Lewis et al., 2016; Maher et al., 2017). In the interventions studies, however, the use of contextual information of sedentary behaviors was just one component, and the authors did not evaluate the effect of contextual information alone on reducing sedentary behavior time. The current study has demonstrated the sole effect of contextual information of sedentary behavior by comparing it with a standard intervention. We found the tailored, domain-specific sedentary behavior intervention using contextual information of sedentary behavior was feasible for and acceptable to adults. While we still do not know the long-term effectiveness of the tailored domain-specific intervention, there is potential to reduce sedentary behavior by using contextual information regarding it. The promotion of verified effective strategies to reduce sedentary behavior time may lead to sustainable improvements in health benefits.

In conclusion, the studies contained in this dissertation are the results of efforts to improve the self-report measures for sedentary behavior and the intervention to reduce sedentary behavior time. We do not believe that this project is the first to address the sedentary behavior measurement tool measuring the contextual information of sedentary behavior and the intervention using the contextual information to reduce sedentary behavior time. However, our diary-type instrument was well-validated by a proxy for direct observation, and the sole effect of using contextual information on reducing sedentary behavior time appears to be a useful resource when measuring work-related sitting, screen-based sitting, or sitting time on transport for studies of the relationship between each sedentary behavior domain and health outcomes, and finally for intervention studies using contextual information of sedentary behavior.

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