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Levels of sedentary behavior increase across the lifespan, making older adults the most sedentary segment of the population. Sedentary behavior is associated with many chronic health conditions including diabetes, cardiovascular disease, and all-cause mortality. Though attempts have been made to reduce or limit sedentary behavior through intervention, little is known about the motivational processes that may be contributing to sedentary time in older adults. It is important to recognize that although physical activity motivation has been extensively researched, physical activity and sedentary behavior are considered independent health behaviors and the same motivational processes that contribute to the upregulation of physical activity may not adequately explain the downregulation (i.e., limiting or reducing) of sedentary behavior. Therefore, the purpose of this thesis is to capture behavioral regulations (specified within Self-Determination Theory) to engage in physical activity and limiting sedentary behavior and examine associations between these behavioral regulations and average daily sedentary time in older adults. Older adults, age 60+ years, completed a baseline questionnaire indicating their behavioral regulations to limit sedentary behavior and to engage in physical activity, then wore an activity monitor for the following two weeks to collect their average daily sedentary time. Results regarding behavioral regulations to limit sedentary behavior indicated that only integrated (β = -.203, p = .006) and intrinsic regulations (β = -.185, p = .012) significantly and negatively predicted average daily sedentary time. When all behavioral regulations to limit sedentary behavior were included in the same model, no behavioral regulation significantly predicted average daily sedentary time. Results regarding behavioral regulations to engage in physical activity revealed that only integrated regulation significantly and negatively predicted average daily sedentary time (β = -.205, *p* = .007). This negative association remained significant when all behavioral regulations to engage in physical activity were included in the same model (β = -.240, *p* = .032). This is one of the first studies to assess associations between behavioral regulations to limit sedentary behavior and to engage in physical activity and test their associations with average daily sedentary time among older adults. Results indicate distinct differences between behavioral regulations for limiting sedentary behavior and engaging in physical activity in predicting subsequent average daily sedentary time. Though across both sets of behavioral regulations more autonomous, self-determined behavioral regulations appeared to be associated with average daily behavior compared to more controlling behavioral regulations. Ultimately, this study fills an important knowledge gap by exploring associations between behavioral regulations to limit sedentary behavior and engage in physical activity and subsequent average daily device-based sedentary time. This work is an essential first step in developing effective interventions designed to limit or reduce sedentary behavior among older adults.

ASSOCIATIONS BETWEEN BEHAVIORAL REGULATIONS AND SEDENTARY BEHAVIOR AMONG OLDER ADULTS

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CHAPTER I: INTRODUCTION

Sedentary behavior is defined as "any waking behavior characterized by an energy expenditure of ≤1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" (Tremblay et al., 2017). Recent device-based estimates suggest that older adults are sedentary around 62% of their waking hours (Schlaff et al., 2017). Similarly, a systematic review based on self-reported data suggests that 67% of older adults are sedentary for more than 8.5 waking hours per day (Harvey et al., 2015). This level of sedentary behavior is problematic because excessive sedentary behavior (i.e., more than 8 hours per day of sitting) can increase the risk for diabetes, cardiovascular disease, cancer-related mortality, and all-cause mortality in middle-aged and older adults (Gilchrist et al., 2020; Rezende et al., 2014). Accumulating evidence also suggests a dose-response relationship, where higher levels of sedentary behavior are associated with greater risk of all-cause mortality in older adults (Katzmarzyk et al., 2009; Pavey et al., 2015). As a result, the World Health Organization and the 2018 US Physical Activity Guidelines have noted the importance of sitting less and moving more across the lifespan (Bull et al., 2020; Piercy et al., 2018).

Despite the need to limit or reduce sedentary behavior, little is known about what motivates individuals to sit less compared to the understanding of motivational processes driving engagement in physical activity. The motivational determinants of physical activity have been extensively researched across the lifespan. For example, a literature review among older adults found self-efficacy to be a strong predictor of physical activity initiation and maintenance (van Stralen et al., 2009). Further intentions and perceived benefits of engaging in physical activity have also been shown to be positively associated with physical activity behavior (Amireault et al., 2013; van Stralen et al., 2009). Additionally, motivation that is more intrinsically driven has been found to be positively associated with physical activity behavior (Teixeira et al., 2012).

Though much research has focused on motivational determinants of physical activity, this may not shed light on the motivational processes underlying efforts to limit sedentary behavior. Physical activity and sedentary behavior are distinct health behaviors (Biddle, 2011; Katzmarzyk et al., 2009). In other words, as one considers longer time scales (e.g., days, weeks, months) the opportunities to accumulate both high levels of physical activity and high levels of sedentary behavior increase. For instance, there is a phenomenon known as the "active couch potato" that occurs when an individual meets physical activity guidelines but still spends extensive amounts of time during the day engaged in sedentary behavior (Freene et al., 2016). This likely indicates that although individuals have the motivation to engage in physical activity, they can still struggle to have the motivation necessary to limit their sedentary behavior. Ultimately, research suggests that physical activity and sedentary behavior are independent health behaviors, and the motivational processes for these behaviors should be empirically evaluated as such (Dogra & Stathokostas, 2012; Katzmarzyk, 2010; Quartiroli & Maeda, 2014; Thivel et al., 2018).

There are many theories of motivation that attempt to explain why individuals choose to engage in health behaviors or not. Theories such as the Theory of Planned Behavior (Ajzen, 1991) and Social Cognitive Theory (Bandura, 1998) are popular approaches for predicting and explaining health behaviors despite limited experimental evidence that these theoretical frameworks can change behavior (Sniehotta et al., 2014). One reason for the limited evidence surrounding these theoretical frameworks is that these theories focus on the quantity of motivation for a behavior (Brooks et al., 2017; Hagger et al., 2020; Jekauc et al., 2015). They focus solely on the motive, a desired state, and leave out the conditions surrounding the reasons for the motive. For example, the Theory of Planned Behavior posits intentions as the proximal predictor of behavior (Brooks et al., 2017), and Social Cognitive Theory emphasizes the direct role that self-efficacy and outcome expectations can have on behavior (Jekauc et al., 2015). However, neither theory examines the extent to which the quality of motivation (e.g., the different sources and types of motivation that contribute to an individual's whole motivation towards a behavior) predicts behavior in specific contexts (Brooks et al., 2017; Hagger & Chatzisarantis, 2009). The source and type of motivation influencing behavior are just as important to consider as the level of the motivation.

Self-Determination Theory (Deci & Ryan, 2012; Ryan et al., 2009) overcomes some of the noted limitations of social cognitive frameworks by focusing on the underlying reasons behind one's motivation for a behavior and the quality of the motivation as opposed to just the quantity of it (Hagger et al., 2020; Roth, 2019). Self-Determination Theory posits that humans have an innate drive to grow, develop, and form a unified sense of self in the context of the larger social structure (Hagger et al., 2020). There are three basic psychological needs in the theory: (1) relatedness (i.e., making meaningful connections with others), (2) autonomy (i.e., having control over one's choice and behavior), and (3) competence (i.e., feeling accomplished when completing a task; Rhodes et al., 2019; Ryan et al., 2009; Ryan & Deci, 2017). The extent to which those basic psychological needs are satisfied determines the motives that regulate engagement in behaviors and the extent to which those behaviors are internalized.

In the context of Self-Determination Theory, motivation is viewed as a behavioral regulation continuum ranging from amotivation (i.e., no intention of the behavior, apathy) to extrinsic motivation (i.e., motivation from external rewards to the behavior aligning with your values) to intrinsic motivation (i.e., engaging in the behavior due to enjoyment, interest, and values; Gill et al., 2017; Ryan & Deci, 2000; Zamarripa et al., 2018). As individuals fulfill the three basic psychological needs, they progress along the motivation continuum towards intrinsic motivation (Geller et al., 2018; Hagger et al., 2020). Further, greater fulfillment of one's basic psychological needs and progression towards more autonomously regulated, intrinsic motivation for a behavior is associated with behavioral engagement. For example, Self-Determination Theory posits that behavior is more likely to be engaged in and subsequently maintained when an individual's basic psychological needs are satisfied, meaning that the individual is likely to experience intrinsic motivation (Hagger & Chatzisarantis, 2009). This is because the individual can cultivate social relationships, exert their own free will, have enjoyment in the activity, and feel challenged and accomplished during and after the behavioral engagement (Hagger et al., 2020). Alternatively, when those needs are not met or thwarted, the individual experiences more controlled forms of motivation and, in terms of the continuum, is likely to experience external regulation and even possibly amotivation, making the behavior harder to enjoy, integrate into oneself, and maintain engagement (Hagger et al., 2020; Ryan & Deci, 2017).

There is strong evidence to support the tenants of Self-Determination Theory in predicting and explaining physical activity behavior, in both observational and experimental literature (Teixeira et al., 2012). For instance, in adults, greater fulfillment of one's basic psychological needs had a significant positive correlation with self-reported physical activity (Brunet & Sabiston, 2011). Similarly, in older adults, an observational study found that those experiencing higher levels of intrinsic motivation engaged in greater levels of physical activity (Ferrand et al., 2012). In another observational study of older adults, those who engaged in exercise had higher levels of intrinsic motivation compared to non-exercisers (Kirkland et al., 2011). A review of three randomized controlled trials of adults (i.e., the Canadian Physical

Activity Counseling Trial, the Empower trial from the UK, and the Portuguese PESO), all showed support for Self-Determination Theory in that basic psychological needs are universal and the need for more autonomous motivation in individuals to increase their physical activity levels (Fortier et al., 2012). Overall, evidence suggests that Self-Determination Theory is useful in understanding the underlying motives of physical activity as well as other health behaviors (Ng et al., 2012a). However, motivation related to the upregulation of a health-protective behavior (i.e., engaging in physical activity) may not be the same motivation related to the downregulation of a health risk behavior (i.e., limiting sedentary behavior; Lavigne et al., 2009). Therefore, the field of behavioral medicine would likely benefit from understanding the underlying motives to limit sedentary behavior and their relationship with sedentary behavior.

Despite the potential to use Self-Determination Theory to explain and predict health behaviors, studies have not been seen to have applied this theoretical framework to limiting sedentary behavior. Previous research employing Self-Determination Theory to understand sedentary behavior has tended to focus on engaging in sedentary behavior as the behavioral target (Gaston et al., 2016; Quartiroli & Maeda, 2014; Rhodes et al., 2019). However, the target within interventions would likely be focused on limiting or reducing sedentary behavior as opposed to engaging in sedentary behavior. Therefore, there is a need to understand how Self-Determination Theory may help explain one's motivation to limit or reduce sedentary behavior as best to the author's knowledge, no research has seen to focused on this behavioral target specifically.

Additionally, much of this research on behavioral regulations for engaging in sedentary behavior has focused on children, college students, and adults (Gaston et al., 2016; Quartiroli & Maeda, 2014). Older adults may be less constrained by daily activities that require sedentary behavior (e.g., sitting during class or work) and therefore motivational differences may exist between older adults and populations previously studied. Further, as older adults age, they tend to prioritize positive emotional experiences and activities that create these positive experiences (Carstensen et al., 2020; Catalino et al., 2014; Steltenpohl et al., 2019). Engagement in sedentary behavior may be associated with positive experiences (e.g., relaxation; Palmer et al., 2019). Therefore, understanding how motivation contributes to limiting sedentary behavior in older adults is necessary due to older adults being a high-risk population and their motivation potentially differing from other populations.

Finally, the research that has investigated the extent to which Self-Determination Theory can explain sedentary behavior has assessed engagement in sedentary behavior using self-reported measures. While self-reported measures of sedentary behavior can provide valuable information, they are limited in that some measures focus on specific domains of sedentary behavior (e.g., tv viewing) which may not capture the full range of sedentary activities (Gomersall et al., 2015). Further, self-reported measures of sedentary behavior may be limited in that they use retrospective reports that ask participants to reflect on typical engagement in behavior which may not accurately capture behavior on a given day or week. Due to the high volume of sedentary behavior in daily life, it may be difficult for individuals to accurately recall the average daily volume of sedentary behavior as opposed to other health behaviors that are less infrequent, more discreet behaviors (e.g., leisure-time physical activity; Gomersall et al., 2015). Finally, individuals may also report less sedentary behavior than they actually do to present themselves as healthier individuals (i.e., social desirability bias; Mortel, 2008). Given the limitations of self-reported assessments of sedentary behavior, it is important to understand how behavioral regulations to limit sedentary behavior predict device-based sedentary behavior among older adults.

Purpose

Given the posited independence of physical activity and sedentary behavior as well as the aforementioned limitations of previous work applying Self-Determination Theory to investigate associations between behavioral regulations and sedentary behavior, the purpose of this thesis is to capture behavioral regulations to engage in physical activity and behavioral regulations to limit sedentary behavior and examine associations between these behavioral regulations and average daily sedentary time in older adults. To accomplish this, data from the initial burst of a measurement burst design study among older adults with three measurement bursts over one year was used. Each burst consisted of a baseline assessment of behavioral regulations to engage in physical activity and to limit sedentary behavior, followed by 14 days of device-based monitoring. A regression analysis was conducted to test the relationships between different behavioral regulations to engage in physical activity and to limit sedentary behavior and average daily sedentary time.

The current proposal holds theoretical and practical implications. From a theoretical perspective, it will be one of the first studies to assess the relationship between behavioral regulations posited within Self-Determination Theory to limit sedentary behavior and average daily sedentary time in older adults. Further, it will describe possible differential associations between behavioral regulations to engage in physical activity and to limit sedentary behavior with subsequent average daily sedentary time. From a practical perspective, this work is needed to determine the appropriate behavioral targets in movement-related interventions using Self-Determination Theory as a theoretical basis among older adults. Ultimately, this work will contribute to the evidence base regarding the motivational processes that contribute to sedentary behavior. Understanding the ways in which behavioral regulations contribute to sedentary behavior can inform strategies to effectively enhance motivation and change behavior.

CHAPTER II: REVIEW OF THE LITERATURE

The literature review covers the principles of Self-Determination Theory, specifically reviewing the system of ideas regarding two main mini theories in Self-Determination Theory. This section will also cover literature in the field applying Self-Determination Theory to explain physical activity behavior and emerging evidence applying Self-Determination Theory to explain sedentary behavior. The literature review concludes by pointing out next steps needed to continue advancing knowledge within the field.

Self-Determination Theory

Self-Determination Theory aims to understand the underlying needs and conditions that contribute to an individual's motivation (Hagger et al., 2020; Ryan & Deci, 2000). The theory consists of six mini theories: basic psychological needs theory, organismic integration theory, cognitive evaluation theory, causality orientations theory, goal contents theory, and relationship motivation theory. However, two mini theories form the basis for our understanding of how our underlying needs and conditions impact motivation and subsequent behavior and have been the primary focus of research that looks to explain individual motivation and behavior: basic psychological needs theory and organismic integration theory (Hagger & Chatzisarantis, 2008; Hagger et al., 2020; Ryan & Deci, 2017). Collectively, these two theories posit a behavioral regulation continuum that is influenced by the fulfillment of the three basic psychological needs (Rhodes et al., 2019; Ryan et al., 2009; Ryan & Deci, 2017).

The first mini theory, Basic Psychological Needs Theory, posits that individuals have three basic psychological needs that need to be fulfilled (Hagger et al., 2020; Ryan & Deci, 2017). The first psychological need is relatedness or the need for individuals to be close or connected to others. This may include being cared for by others, caring for others, and/or having trust in others. The second psychological need is autonomy, or an individual having a sense of agency and choice in their behavior (Hagger et al., 2020; Ryan et al., 2009). This may include how much control an individual feels that they have over their choices, being able to engage in one's choices freely and willingly and being able to make decisions for themselves. The third basic psychological need is competence or having mastery over one's tasks and behaviors or feeling effective in those activities. This may include feeling successful, accomplished, and/or confident when completing a task and/or behavior (Deci & Ryan, 2012; Hagger et al., 2020).

When all three basic psychological needs are met, enhanced well-being and psychological functioning are likely to occur (Hagger et al., 2020). Conversely, the extent to which these basic psychological needs are not met or thwarted can result in poor outcomes. Further, if activities being completed by an individual are not meeting one's basic psychological needs, dissatisfaction and frustration with the activity can occur making it unenjoyable and potentially thwarting future engagement (Hagger et al., 2020). Each basic psychological need has its own individual and group influence on behavior, but all three need to be satisfied to have full benefits. For example, competence and autonomy play a critical role facilitating intrinsic motivation while autonomy and relatedness play a critical role in internalization within the external regulation continuum (Hagger & Chatzisarantis, 2008; Ryan & Deci, 2017).

The second main mini theory is the Organismic Integration Theory consisting of a behavioral regulation continuum that integrates the three basic psychological needs (Hagger et al., 2020). The behavioral regulation continuum encompasses amotivation, extrinsic motivation, and intrinsic motivation. As an individual's basic psychological needs are fulfilled to a greater extent, individuals progress along the continuum moving from amotivation to intrinsic motivation (Ryan & Deci, 2000).

On the lowest end of the continuum is amotivation. Amotivation occurs when an individual has no intention to act and are lacking regulation and self-determination (Deci & Ryan, 2008). An example may be an older adult who has no interest or concern in reducing their sedentary behavior.

Extrinsic motivation drives behavior when an individual engages in an activity to attain a particular outcome; however, depending on the reward contingencies, there may be different regulatory processes driving the behavior. These different processes are also on a continuum that becomes more self-determined/internalized (Ryan & Deci, 2000, 2017). The least self-determined form of extrinsic motivation is external regulation. External regulation occurs when a behavior is done due to external variables that the individual wants to obtain or avoid (e.g., rewards, punishments). An example would be an older adult limiting their sitting time during the day to avoid the stand-up notifications from their smartwatch. Continuing is introjected regulation, where behavior is done to avoid/reduce any guilt, anxiety, shame, and/or to improve ego, pride, and value. It is more internalized (e.g., more incorporated into an individual) than the external regulation (Hagger et al., 2020). An example would be an older adult who stands up and moves each half-hour to avoid the guilt of sitting for long periods of time.

The remaining types of regulation that fall under the umbrella of extrinsic motivation tend to be more self-determined and internalized behavioral regulations compared to external and introjected regulation (Deci & Ryan, 2008). The next type of regulation is identified regulation, where behavior is managed and has value to the individual to the point where it can become personally important. Compared to both external and introjected, identified regulation is more internalized (Hagger et al., 2020). An example of identified regulation is an older adult who knows that excessive levels and extended bouts of sitting can lead to health problems including heart disease or high blood pressure, and it is personally important to them to prevent those issues, therefore they make efforts to reduce or limit sedentary behavior.

Finally, there is integrated regulation, where behavior has been assimilated into a person's identity, values, needs, and beliefs. Integrated regulation is the most self-determined, internalized regulation within the extrinsic motivation (Hagger et al., 2020; Ryan & Deci, 2000). An example of integrated regulation would be if an older adult limits their sedentary time because they view themselves as an on-the-go individual. In this case, being an on-the-go individual is consistent with the older adult's identity and values which leads them to limit their sedentary behavior.

The final part of the behavioral regulation continuum is intrinsic motivation. When an individual is intrinsically motivated, they are motivated to do the behavior because it is challenging, interesting, and satisfying to them (Ryan & Deci, 2000). An example would be an older adult who regularly breaks up their sedentary behavior throughout the day because they find it challenging and satisfying to interrupt their sedentary behavior. By achieving intrinsic motivation, an individual's three basic psychological needs become more successfully met compared to those who are higher in extrinsic motivation (Geller et al., 2018).

Self-Determination Theory & Physical Activity

Self-Determination Theory is an approach that is used to help explain and predict health behaviors. The behavioral regulations posited by Self-Determination Theory have been documented in individuals' motivation for various health behaviors (Ng et al., 2012b; Ntoumanis et al., 2021), indicating the potential applicability of behavioral regulations to be used to explain sedentary behavior. Quantitative evidence regarding determinants of sedentary behavior suggests that Self-Determination Theory may be an applicable framework to apply to understand this behavioral phenomenon (Chastin et al., 2014; Sheeran et al., 2020). Self-Determination Theory has been extensively applied to physical activity behaviors (Ryan et al., 2009; Teixeira et al., 2012). Although, as previously stated, engagement in physical activity is independent of sedentary behavior. Despite this, understanding how Self-Determination Theory contributes to physical activity behavior may be useful for understanding how this theory may also apply to limiting or reducing sedentary behavior.

Amotivation & Physical Activity

Amotivation lacks self-determination and intention to act creating a negative association with physical activity. Across different study designs (e.g., cross-sectional, prospective, & experimental) among adults, amotivation was found to have a negative association with physical activity (Teixeira et al., 2012). Among adult women, amotivation was also found to have a negative association with physical activity (Markland, 2009). For older adult women, those with higher levels of amotivation had greater rates of dropout in physical activity programs compared to women with lower levels of amotivation (Stephan et al., 2010). Amotivation is the absence of intrinsic and extrinsic motivation and lack of self-determination, so it is less likely that an individual who has high levels of amotivation would be active. An individual may be amotivated because they do not feel that they would be successful at the behavior (e.g., physical activity) or lack value in the behavior (e.g., not seeing the value of being physically active; (Ryan & Deci, 2000).

Extrinsic Motivation & Physical Activity

External Regulation & Physical Activity. External regulation has low internalization and a negative association with physical activity. Across the lifespan, external regulation has a significant negative correlation with self-reported physical activity behavior for young adults

(18-24 years) but not significantly correlated among adults (25-44 years) and middle-aged adults (45-64 years; Brunet & Sabiston, 2011). In a systematic review of adults (45-64 years), in sixteen independent study samples, external regulation was found to have a negative association with exercise behavior (Teixeira et al., 2012). In another study, among adults 55 years or older, external regulation was also found to have a negative correlation with physical activity, though this correlation was weak (Huffman et al., 2022). Within older women, those with higher levels of external regulation had higher rates of dropout in physical activity programs (Stephan et al., 2010). External regulation is low on internalization and autonomy, and evidence suggests the external sources of motivation inherent in external regulation are likely a poor motivator.

Introjected Regulation & Physical Activity. Compared to amotivation and external regulation, introjected regulation is more internalized; however, findings are equivocal regarding the nature of the associations between introjected regulation and physical activity behavior. In a systematic review, Teixeira and colleagues (2012) found that most often introjected regulation had a null association with physical activity; but among a small proportion of studies, a positive association between introjected regulation and physical activity was found. Though it should be noted that among studies documenting positive associations between introjected regulation and behavior, the magnitude of the association was smaller than associations between more self-determined types of motivation (i.e., identified & integrated regulation) and physical activity (Teixeira et al., 2012). In a recent study among adults 55 years or older, introjected regulation had a weak positive association to physical activity (Huffman et al., 2022); however, similar to the systematic review by Teixeria and colleagues (2012), associations between introjected regulations and behavior were not as strong as associations between identified and integrated regulation and physical activity. Overall, discrepant findings make it difficult to draw firm conclusions about associations between introjected regulation and physical activity behavior. It is possible that introjected regulation (e.g., guilt-based motives) along with integrated regulation (e.g., the discrepancy with identity causes guilt) may help direct effort related to behavioral engagement in the short-term (Ryan & Deci, 2000).

Identified Regulation & Physical Activity. Identified regulation has high internalization and autonomy, resulting in a positive association with physical activity. Across the adult lifespan, identified regulation is positively correlated with physical activity behavior (Brunet & Sabiston, 2011). Identified regulation is a positive predictor of total exercise behaviors in adults (Edmunds et al., 2006). Within the Teixeira and colleagues (2012) systematic review, identified regulation had a positive association with exercise behavior in different types of studies (e.g., experimental, cross-sectional, & prospective). Further, results from this review suggested that identified regulation may be a stronger predictor of short-term exercise maintenance compared to more self-determined forms of motivation (e.g., intrinsic motivation). In adults 55 years or older, identified regulation had a significant positive association with physical activity (Huffman et al., 2022). The consistently positive association between identified regulation and physical activity behavior suggests that individuals who value a particular behavior tend to engage in higher levels of that behavior.

Integrated Regulation & Physical Activity. Integrated regulation has the highest internalization and autonomy in the extrinsic motivation continuum and a positive association with physical activity. In a longitudinal study of adults, integrated regulation was found to be the only regulation that was related to physical activity behavior consistency and maintenance (Miquelon & Castonguay, 2017). Integrated regulation also helped explain additional variance in physical activity behavior when controlling for the other behavioral regulations (Miquelon et al., 2017). In the systematic review conducted by Teixeira and colleagues (2012), eight studies examined associations between integrated regulation and exercise behavior, and more than two-thirds documented positive associations between integrated regulation and behavior. More recently among adults 55 years and older, integrated regulation was significantly and positively related to physical activity (Huffman et al., 2022). Ultimately, these findings suggest that when behavior is congruent with an individual's sense of self, individuals tend to engage in higher levels of that behavior.

Intrinsic Motivation and Physical Activity.

Intrinsic motivation is highly integrated and the most autonomous, self-determined form of motivation as an individual is satisfied, has enjoyment, and interest in the behavior. Overall, intrinsic motivation has a positive association with physical activity. Among young adults, adults, and middle-aged adults intrinsic motivation was positively correlated with physical activity behavior (Brunet & Sabiston, 2011). In adults, intrinsic motivation had a positive relationship with both strenuous and total exercise behavior (Edmunds et al., 2006). In their systematic review, Teixeira and colleagues (2012) found that intrinsic motivation had a positive association with exercise behavior and that intrinsic motivation was a strong predictor of long-term exercise maintenance. Further, no studies in the review reported a negative association between intrinsic motivation and behavior. Relatedly, in a sample of young adults, intrinsic motivation was the only motivation (compared to amotivation or the extrinsic regulations) to significantly predict aerobic fitness (Sibley et al., 2013). An intervention that focused on increasing enjoyment, challenge, and mastery for adults found that compared to the control group, intrinsic motivation became a stronger predictor of both moderate and vigorous-intensity exercise in the intervention group (Silva et al., 2010).

There is some evidence that intrinsic regulation by itself may not be enough for behavior maintenance (e.g., long-term engagement in physical activity; Mullan & Markland, 1997; Teixeira et al., 2012). This could be due to the longer engagement in a behavior relies more on the assimilation of the behavior into oneself and values (i.e., integrated regulation) versus enjoyment and interest in the behavior (i.e., intrinsic regulation). But, intrinsic regulation still plays a role in helping short-term engagement in physical activity and it is advised that for interventions, both identified and intrinsic regulations should be promoted (Teixeira et al., 2012).

Though there is some evidence that as adults get older, their intrinsic motivation decreases (Frederick-Recascino, 2002), intrinsic motivation still has a significant and positive association with physical activity levels in older adulthood. For instance, increases in intrinsic motivation among older adults are associated with an increase in physical activity behavior (Dacey et al., 2008). Specifically, changes in enjoyment in physical activity appeared to be driving the association between changes in intrinsic motivation and behavior (Dacey et al., 2008). A study examining differences between older adult exercisers and non-exercisers found that intrinsic motivation was higher among exercisers than non-exercisers (Kirkland et al., 2011). Both observational and experimental studies have shown that greater intrinsic motivation for a behavior is associated with higher levels of the behavior (Teixeira et al., 2012).

Self-Determination Theory & Sedentary Behavior

Though there is much evidence for Self-Determination Theory and behavioral regulations to explain physical activity behavior, little work has applied this theory to understand sedentary behavior, comparatively. To date, only a few studies have addressed the association between behavioral regulations and sedentary behavior.

Some initial qualitative work suggests that Self-Determination Theory may be an applicable framework for explaining sedentary behavior. For instance, Chastin and colleagues (2014) conducted focus groups among older women and found that guilt associated with sitting for a prolonged period was one factor that individuals reported as affecting their engagement in sedentary behavior (Chastin et al., 2014). Limiting engagement in sedentary behavior to avoid or reduce feelings of guilt closely aligns with the properties of introjected regulation (Hagger et al., 2020). Therefore, behavioral regulations associated with Self-Determination Theory may be useful for understanding and explaining motives to limit or reduce sedentary behavior.

Another qualitative study conducted semi-structured focus groups among older adults to determine if motivation for limiting sedentary behavior aligned with behavioral regulations outlined in Self-Determination Theory (Collins & Pope, 2021). Data from the focus groups were organized into six themes (i.e., amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, and intrinsic motivation). Results showed that each behavioral regulation was represented in some form by statements made by participants. For example, one participant commented on how they have been active all their life and if they were not, then they felt uncomfortable, which the authors argue is representative of integrated regulation. Further, across the entire sample no behavioral regulation was dominant over the other. Though participants expressed occasions of different behavioral regulations motivating them, behavioral regulation dominance varied for each participant. Specifically, one participant indicated feeling guilty for sitting (i.e., introjected regulation), "When you're sitting there you reach a point in time, over time, where you even feel guilty if you're sitting on your butt", while another participant indicated that limiting sedentary behavior and being active to be a part of their identity (i.e., integrated regulation), "I've always- I've been active all my life, so that's, I just feel like I want to continue to be." In summary, participants experienced different behavioral dominance and had different levels of internalization depending on the regulation.

Quantitative work will support more systematic conclusions regarding Self-Determination Theory as a viable framework for explaining limiting sedentary behavior by testing the extent to which behavioral regulations are associated with limiting sedentary behavior. Among studies that have examined quantitative associations between behavioral regulations and sedentary behavior, this work has focused on college student and adult populations (Gaston et al., 2016; Quartiroli & Maeda, 2014). Among college students, Quartiroli and Maeda (2014) examined associations between behavioral regulations for physical activity and self-reported physical activity and sedentary behavior. Results indicated that intrinsic regulation, identified regulation, autonomy, competence, and relatedness for physical activity were weakly and negatively correlated with sedentary behavior. Specifically, behavioral regulations and psychological needs for physical activity explained approximately 14% of physical activity behavior but only 3% of sedentary behavior, suggesting that capturing behavioral regulations for physical activity is likely insufficient to adequately explain sedentary behavior. Rather this finding suggests that capturing behavioral regulations for sedentary behavior (whether that be behavioral regulations for engaging in sedentary behavior or limiting sedentary behavior) may be necessary to explain and predict sedentary behavior engagement.

Among university students and staff, Gaston and colleagues (2016) found that external regulation for engaging in sedentary behavior was positively associated with self-reported weekend sedentary behavior affiliated with work and/or school activities (e.g., computer use) and introjected regulation for engaging in sedentary behavior was positively associated with self-reported weekday sedentary behavior affiliated with work and/or school activities. Results from this study also found that intrinsic motivation for engaging in sedentary behavior was positively associated with self-reported weekday and weekend day sedentary behavior affiliated with leisure activities (e.g., watching TV), whereas intrinsic motivation was negatively associated with self-reported weekend sedentary behavior affiliated with work and/or school activities. Though this study gives insight into the behavioral regulations for engaging in sedentary behavior, the focus of movement-related behavioral interventions is likely to focus on motivation, more broadly, or behavioral regulations, more specifically, to limit sedentary behavior. Therefore, understanding relations between behavioral regulations to limit sedentary behavior and subsequent behavior is necessary.

Limitations and Future Directions

There are current limitations (and as a result gaps) in the literature assessing behavioral regulations and their relationship with sedentary behavior that the proposed study can address. First, previous research that has focused on understanding motives for sedentary behavior from a Self-Determination Theory lens, has assessed behavioral regulations for engaging in sedentary behavior (Gaston et al., 2016; Quartiroli & Maeda, 2014); however, the focus of a movement-related behavioral intervention would likely be rooted in attempts to change motivation to engage in physical activity or limit sedentary behavior. Therefore, there is a current gap in the literature regarding the extent to which behavioral regulations to engage in physical activity and behavioral regulations to limit sedentary behavior impact subsequent sedentary behavior. The study assessed behavioral regulations to engage in physical activity and behavioral regulations to limit sedentary behavior and examined associations between those behavioral regulations and average daily sedentary time.

Second, although self-report measures of sedentary behavior used in previous studies are considered valid and reliable measures of behavior, they are still prone to recall bias and social desirability (Gomersall et al., 2015). Therefore, the proposed thesis will use a device-based measure of average daily sedentary behavior that can be worn continuously, even during water-based activities. Given that the device-based measure to be employed in this study is not susceptible to recall bias and the limited reasons for the device to be removed, the device-based measure is likely to more accurately capture average daily sedentary time compared to assessments used in previous research.

Third, there are noted limitations of the assessment of behavioral regulations in previous research. While Gaston and colleagues (2016) did use a modified version of the BREQ to assess behavioral regulations for sedentary behavior, the BREQ only measures external, introjected, identified, and intrinsic regulations. Amotivation and integrated regulation are not measured in the BREQ. Quartiroli and Maeda (2014) used the BREQ-2 which does assess amotivation, but does not include an integrated regulation subscale to help distinguish differences from identified and intrinsic regulation. Also, Quartiroli and Maeda (2014), used the BREQ-2 to measure behavioral regulations in exercise and did not focus on sedentary behavior as the behavioral target. This study will use the BREQ-3 modified to assess behavioral regulations for limiting sedentary behavior. The BREQ-3 assesses both amotivation and integrated regulation subscales. Capturing integrated regulation helps distinguish differences from identified regulation and intrinsic regulation empirically (Markland & Tobin, 2004; Wilson et al., 2006).

Fourth, the populations assessed in previous research focused on university/college students and adults (Gaston et al., 2016; Quartiroli & Maeda, 2014). Older adults are a vulnerable, at risk population due to their high levels of sedentary behavior (Harvey et al., 2015;

Schlaff et al., 2017). Older adults already have higher increased risk of chronic diseases (e.g., heart disease, stroke, cancer; *Older Adults | Healthy People 2020*, n.d.), and with higher levels of sedentary behavior compared to other age groups, the risk for those chronic diseases and all-cause mortality increases (Katzmarzyk et al., 2009; Pavey et al., 2015). Past literature has also indicated age-related differences in motivation (Fredrick-Recascino, 2002; Steltenpohl et al., 2019), indicating the importance of understanding the motivational factors for limiting sedentary behavior in older adults separately from other age groups. Though two articles previously investigated behavioral regulations for sedentary behavior in older adults, they were assessed through qualitative work (i.e., focus groups; Chastin et al., 2014; Collins & Pope, 2021). Quantifying the relationship between behavioral regulations to limit sedentary behavior and average daily sedentary time in older adults can advance our understanding of motivational reasons for limiting sedentary behavior and may ultimately improve health risks associated with sedentary behavior among older adults.

In summary, the proposed study aims to address several key limitations regarding previous investigations of behavioral regulations and sedentary behavior. Ultimately, this study aims to advance our understanding of the extent to which behavioral regulations to engage in physical activity and to limit sedentary behavior contribute to average daily sedentary time in older adults.

Present Study

The purpose of this thesis is to examine the extent to which behavioral regulations to engage in physical activity and to limit sedentary behavior, as posited by Self-Determination Theory, are associated with average daily sedentary time in older adults. To accomplish this, data from the initial burst of a measurement burst design study among older adults with three measurements bursts over one year was used. Each burst consisted of a baseline assessment of behavioral regulations to engage in physical activity and to limit sedentary behavior, followed by 14 days of device-based monitoring. Separate regression analyses were conducted to test the relationships between behavioral regulations to engage in physical activity and average daily sedentary time as well as behavioral regulations to limit sedentary behavior and average daily sedentary time. Given past research, it was hypothesized that (1) intrinsic, integrated, identified, and introjected regulation for engaging in physical activity and limiting sedentary behavior will have a negative association with average daily sedentary time, and (2) external regulation and amotivation for engaging in physical activity and limiting sedentary behavior will have a positive association with average daily sedentary time.

In testing these hypotheses, sex, age, and BMI were controlled for. Research has shown differences in sedentary behavior levels by age within older adult populations, with old older adults being associated with more sedentary time (Dohrn et al., 2020). Dohrn et al., (2020) also found sex differences with males engaging in thirty-three more minutes of sedentary behavior than women. Differences in sedentary behavior have also been found by BMI, with those with higher BMIs having higher sedentary behavior than individuals with lower BMIs (Heinonen et al., 2013; Mitchell et al., 2014). Given these previously documented associations between sedentary behavior and demographic characteristics, the a priori decision was made to control for age, sex, and BMI in all regression models.

CHAPTER III: METHODOLOGY

Data for this thesis was a secondary data analysis of data from Project SMART (Studying physical activity Maintenance and Adoption in Real-Time). Project SMART is a measurement burst design study (i.e., incorporates bursts of intensive repeated assessment within a relatively short period of time that are repeated longitudinally, over more widely spaced temporal intervals; Stawski et al., 2015) of older adults' movement-related behaviors with three bursts occurring over one year. Each burst lasted two weeks. Prior to the burst, participants completed a baseline assessment of motivation, physical health, and demographic characteristics. Then over the course of two weeks, participants wore accelerometers and on select days completed a smartphone-based protocol to collect real-time assessments of behavior, feeling states, contexts, and motivation. Following each burst, participants completed a post-assessment of self-reported behavior, mental health, and study feedback. Each data collection period was spaced with approximately 5-6 months in between. The thesis used data from the first burst.

Participants

Older adults (aged 60 years or older) living in Guilford County, NC were recruited to participate in the study. Participants were recruited from fitness facilities and organizations providing programming for older adults. Further, news segments about the study were used to recruit participants. Finally, participants were recruited through word of mouth. Interested individuals contacted the Physical Activity and Lifetime Wellness Lab via email, text, or voice call. Those that expressed interest were given additional information on the study and screened to determine if they would be eligible to participate. The inclusion criteria included: (1) adults aged 60 years or older, (2) currently living in Guilford County and planning to live in Guilford County for the next year, and (3) performing a minimum of 30 minutes of moderate- to vigorous-intensity physical activity in the past week. Exclusion criteria included: (1) functional limitations that would prevent individuals from standing or moving on their own, (2) indications of cognitive impairment during the screening with the Modified Telephone Interview for Cognitive Status (Cook et al., 2009; Duff et al., 2015), and (3) diagnosed by a physician with any form of dementia or Alzheimer Disease.

Procedure

Eligible participants were scheduled to attend training sessions on Day 1 and Day 7 of the data collection burst. The appointments were conducted either virtually (via Zoom) or in-person (i.e., UNCG campus or community locations). A week before their Day 1 appointment, participants were sent the electronic baseline questionnaire using an online Qualtrics survey (Qualtrics, Provo, UT) and asked to complete it prior to the Day 1 appointment. As part of the electronic questionnaire, participants were presented with an electronic version of the consent form and asked to provide electronic consent to participate in the study.

During their Day 1 appointment, participants were given additional background information on the study and taught how to wear two activity monitors during the duration of the data collection burst. One of the devices was an activPAL3 micro (PAL Technologies Ltd., Glasgow, UK), which was sealed in plastic polymer tubing to waterproof the device. Participants were instructed to wear the device on the anterior midline of their thigh during all sleeping and waking activities. Participants were also trained on how to complete an activity monitor log to record any times during the data collection period when they were not wearing the device as well as their sleep and wake time each day.

On Day 7, participants met with research staff to be trained on how to complete a smartphone-based protocol in which participants received brief electronic questionnaires throughout the day. Participants were then instructed to use the smartphone on Days 8-11 to complete the smartphone-based protocol.

On Day 15, participants were instructed to remove the activPAL3 device upon waking. Participants returned equipment via mail or in-person and were asked to complete an electronic post data-collection burst questionnaire. This thesis will use data from the electronic baseline questionnaire and activPAL3 device.

Measures

Sedentary Behavior

The activPAL3 micro accelerometer provides a device-based measure of average daily sedentary time. It can detect different postures including sitting, lying, and standing. The activPAL3 has high test-retest reliability in assessing sedentary-time, standing-time, and sit-to-stand transitions in adults and older adults (Alothman et al., 2020; Klenk et al., 2016; Lyden et al., 2012). The device uses proprietary algorithms to calculate time spent sitting, standing, and stepping in 15-second epochs. Data was aggregated to the day level during each 24 hours period (i.e., 12:00 am-11:59 pm). Self-reported sleep and wake times were used to calculate time spent sitting while awake. Therefore, sedentary behavior was operationalized as the average daily sedentary time (i.e., time spent sitting) during waking hours.

Activity monitor logs and self-reported sleep and wake times were used to determine times when participants were not wearing the activPAL3 device. For a day to be considered a valid day, participants were required to wear the device for at least 10 hours on a given day. At least 4 valid days of activPAL3 data were required for participants' data to be considered representative of their behavior and to be included in analysis (Migueles et al., 2017).

Behavioral Regulations

Behavioral regulations were assessed as part of the electronic baseline questionnaire. A modified version of the Behavioral Regulation in Exercise Questionnaire-3 (BREQ-3; Markland & Tobin, 2004; Wilson et al., 2006) was used to assess behavioral regulations to engage in physical activity and to limit sedentary behavior. For example, participants responded to the item "It's important for me to be physically active regularly" as part of the assessment of behavioral regulations to engage in physical activity and "It's important to me to limit the time I spend sitting regularly" as part of the assessment of behavioral regulations to limit sedentary behavior. Participants were provided with definitions of physical activity and sedentary behavior when completing these assessments. Specific definitions and examples were provided for each behavioral target. Physical activity was defined as activities the require physical effort and increase one's heart rate and/or breathing rate beyond resting levels. Examples of physical activity provided to participants included heavy lifting, aerobics, bicycling at a regular pace, double tennis, and walking. Sedentary behavior was defined as any activity that expends low levels of energy and is completed in a seated or reclined position while awake and examples included sitting while watching TV, sitting while using the computers, sitting while socializing with friend, family.

Participants were asked to reflect on the extent to which each item reflected their motives and answered on a scale of 1-5; not true for me (1), to sometimes true for me (3), to very true for me (5). Each assessment consisted of 24-items with items assessing each of the following subscales: amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, and intrinsic regulation for the corresponding behavior. Each behavioral regulation was assessed through four items: amotivation (2, 8, 14, and 20), external regulation (6, 12, 18, and 24), introjected regulation (4, 10, 16, and 22), identified regulation (1, 7, 13, and 19), integrated regulation (5, 11, 17, and 23), and intrinsic regulation (3, 9, 15, and 21). Standard scoring procedures for the BREQ-3 were followed to calculate the mean score for each behavioral regulation type (Markland & Tobin, 2004; Wilson et al., 2006). Higher scores indicate that participants endorsed more of that behavioral regulation.

There was an error in the wording of one of the items in the BREQ-3 assessing behavioral regulations to limit sedentary behavior. Specifically, item 11 stated "I consider sitting part of my identity." However, to capture behavioral regulations to limit sedentary behavior, the item should have been worded as "I consider limiting the time I spend sitting part of my identity." To account for this error in wording on item 11 (i.e., part of the integrated subscale), responses to item 11 were not used when calculating the composite score on the integrated subscale for limiting sedentary behavior.

Demographic Information

During the baseline questionnaire, demographic information was collected. Demographic information consisted of age, gender, race, ethnicity, BMI, income, employment status, where participants live (i.e., independently in home/apartment, assisted living community, other), and with whom participants live with (i.e., spouse/partner, children, grandchildren, pet, or animal companion). Age, sex, and BMI were a priori included as covariates because previous literature has documented differences in movement-related behaviors by these factors (Dohrn et al., 2020; Heinonen et al., 2013; Mitchell et al., 2014; Mortensen et al., 2006; Prince et al., 2020).

Data Analysis

To accomplish the objectives of this thesis, a series of linear regressions tested the relationship between the independent variable (i.e., behavioral regulation to limit sedentary behavior or engage in physical activity) and the dependent variable (i.e., average daily sedentary time). With each regression model, a regression diagnostic was conducted to test the four assumptions of a linear regression (i.e., linearity, homoscedasticity, independence, & normality) to make sure that these assumptions are satisfied (Howell, 2013). The linearity assumption is when a linear relationship is present between the independent and dependent variables. The assumption is not met when there is no linear relationship. If normality and homoscedasticity assumptions are both met, then there is linearity.

The homoscedasticity assumption is when residuals are equal or have similar variances. The assumption is not met when residual variances are unequal which can cause biased and skewed results (Howell, 2013). To assess homoscedasticity, the Breusch-Pagan test was conducted. The Breusch-Pagan test is used to determine whether or not heteroscedasticity is present in a regression model, but it can also be used to see if homoscedasticity is present (Hinton et al., 2004). The linear regression was conducted, and the unstandardized residuals were saved as new variables (which do not increase with increasing values of independent variables). The squares of the residuals were then computed as a new variable to have a more standardized value. Next, a new linear regression was conducted where the squared residuals replaced sitting time as the dependent variable. In the ANOVA table, if the p-value was greater than 0.05, the null hypothesis that homoscedasticity is present was supported (Hinton et al., 2004).

The independence assumption is when residuals are independent and there is no correlation between the residuals (Hinton et al., 2004). To check this assumption, the Durbin-Watson statistic was assessed when running each linear regression. If the Durbin-Watson value was between 1.5 and 2.5 then there was no autocorrelation in the data (the residuals are independent; (Field, 2009). Finally, the normality assumption is when the residuals are normally distributed. If the residuals are skewed, the assumption is not met (Howell, 2013). To check this assumption, the p-plot from the linear regression was looked at, and if there was a straight, diagonal line, it indicated a normally distributed data.

A series of 14 regression models were tested, one for each measure of behavioral regulation across the two behavioral targets (i.e., to engage in physical activity or to limit sedentary behavior; see example Equations 1-6 below). In addition to all behavioral regulations for each behavioral target being tested separately, one model contained all behavioral regulations for a given behavioral target together (see example Equation 7 below). Below are the models with confounding variables that will be controlled for:

Equation 1: Average Daily Sedentary Time = $B_0 + B_1(\text{Age}) + B_2(\text{Sex}) + B_3(\text{BMI}) + B_4(\text{Amotivation}) + \varepsilon_i$

Equation 2: Average Daily Sedentary Time = $B_0 + B_1(\text{Age}) + B_2(\text{Sex}) + B_3(\text{BMI}) + \mathrm{B}_4(\text{External Regulation}) + \varepsilon_i$

Equation 3: Average Daily Sedentary Time = $B_0 + B_1(\text{Age}) + B_2(\text{Sex}) + B_3(\text{BMI}) + B_4(\text{Introjected Regulation}) + \varepsilon_i$

Equation 4: Average Daily Sedentary Time = $B_0 + B_1(\text{Age}) + B_2(\text{Sex}) + B_3(\text{BMI}) + B_4(\text{Identified Regulation}) + \varepsilon_i$

Equation 5: Average Daily Sedentary Time = $B_0 + B_1(\text{Age}) + B_2(\text{Sex}) + B_3(\text{BMI}) + B_4(\text{Integrated Regulation}) + \varepsilon_i$

Equation 6: Average Daily Sedentary Time = $B_0 + B_1(\text{Age}) + B_2(\text{Sex}) + B_3(\text{BMI}) + B_4(\text{Intrinsic Regulation}) + \varepsilon_i$

Equation 7: Average Daily Sedentary Time = B_0 + B_1(Age) + B_2(Sex) + B_3(BMI) + B_4(Amotivation) + B_5(External Regulation) + B_6(Introjected Regulation) + B_7(Identified Regulation) + B_8(Integrated Regulation) + B_9(Intrinsic Regulation) + ε_i

Controlling for demographic characteristics (i.e., age, sex, BMI) in analyses helps limit the influence of potential confounding factors on the association between behavioral regulations and average daily sedentary behavior. The linear regression was conducted in IBM SPSS Statistics (Version 26) for Windows.

Data Preparation

For continuous demographic variables, age was median split at 69 into young-old (< 69 years) and old-old age groups (≥ 69 years) with any age less than 69 being the reference group whereas BMI was grand mean centered. For the categorical variable, sex, participants were coded as either female (0) or male (1). These data preparation procedures allowed for an interpretable intercept in the modeling approach.

CHAPTER IV: RESULTS

In total, 202 participants completed the first wave of Project SMART. Twenty-seven participants were excluded from analysis due to not completing the baseline questionnaire (n = 7), completing the baseline, but not completing any of the BREQ-3 items for engaging in physical activity (n = 1), or answering both BREQ-3s, but had at least one missing item in one or both BREQ-3 (n = 19) assessments. Therefore, the analytic sample size was 175 participants.

Descriptive characteristics for participants can be found in Table 1. Participants were mostly female (71.4%), white (75.4%), and with a mean age of 69.81 (*SD* = 5.98). All participants wore the activPAL3 for at least 10 hours/day on at least four days. The range of valid days of activity monitor wear was 10-14 days (*M* = 13.45, *SD* = 0.733), with 54.5% of participants wearing the monitor for 14 days (n = 95), 39.6% wearing it for 13 days (n = 69), 2.5% for 12 days (n = 5), 3% for 11 days (n = 5), and 0.5% for 10 days (n = 1).

The average daily sedentary time during waking hours was 525.42 minutes (*SD* = 114.72), or about 8.76 hours (*SD* = 1.91), per day. There was no significant difference between females (*M* = 505.47, *SD* = 112.74) and males (*M* = 575.51, *SD* = 104.87) average daily sedentary time, $t(170) = -3.75$, $p = .597$. Old-old adults (≥ 69 years) were found to engage in significantly more average daily sedentary time (*M* = 528.05, *SD* = 128.53) than the young-old adults (< 69 years; *M* = 522.26, *SD* = 96.19), $t(170) = .328$, $p = .018$. There was no significant differences in average daily sedentary time between BMI groups, $t(170) = 2.075$, $p = .071$.

In Table 2, among the correlations between demographic variables and average daily sedentary time, there was a very weak positive correlation between sex and average daily sedentary time, *r* (171) = .276, $p < 0.001$. Sex and BMI were not significantly related to average daily sedentary time.

Table 1. Descriptive Characteristics of Participants

Demographics	n	%
Sex		
Female	125	71.4%
Male	50	28.6%
Age		
60-69	89	50.9%
70-79	73	41.7%
≥ 80	13	7.4%
Race		
Black/African American	40	22.9%
White	132	75.4%
Asian	1	0.6%
Two or more races	1	0.6%
BMI		
≤ 18.5	3	1.7%
> 18.6 & ≤ 24.99	74	42.3%
> 25 & ≤ 29.99	54	30.9%
> 30 & ≤ 34.99	27	15.4%
> 35 & ≤ 39.99	10	5.7%
≥ 40	7	4.0%
Ethnicity (Hispanic/Latino/Spanish Origin)		
Yes	8	4.6%
No	167	95.4%
Employment status*		
Employed full-time	17	9.8%
Employed full-time	26	14.9%
Retired	129	74.1%
Out of work for less than a year	1	0.6%
Unable to work	1	0.6%
Income*		
Less than $4,999	8	4.6%
$5,000-$19,999	28	16.1%
$20,000-$39,999	35	20.1%
$40,000-$59,999	33	19.0%
$60,0000-$79.999	31	17.8%
$80,000-$99,999	39	22.4%

Where participants live*		
Independently at home/apartment	174	99.4%
Other	0	
With whom participants live*		
Spouse/partner	122	69.7%
Live alone	34	19.4%
Pet or animal companion	8	4.6%
Children	6	3,4%
Other family members	2	1.1%
Other non-relatives	1	0.6%
Grandchildren	1	0.6%

Note: *One individual did not complete all demographic questions

Table 2. Correlations Between Demographic Characteristics and Average Daily Sedentary Time

Demographics	r	*p*
Sex	.276**	<.001
Age	.025	.743
BMI	.139	.069

Note. **Correlation is significant at the 0.01 level.

Internal Consistency of Items within Behavioral Regulation Subscales

The internal consistency of the modified BREQ-3 for limiting sedentary behavior was greater than 0.70 for all as shown in Table 3. The internal consistency of the modified BREQ-3 for engaging in physical activity was greater than 0.50 for all subscales as seen in Table 2. The amotivation subscale had internal consistencies of 0.58. All other subscales had internal consistencies of greater than 0.70. Despite suboptimal internal consistencies of the amotivation subscale, the decision was made to leave the subscale intact and include all proposed items in the subscale outlined in the BREQ-3's standard scoring procedures.

Table 3. Internal Consistency of the Modified BREQ-3

Behavioral Regulation	Items	Limit Sedentary Behavior Internal Consistency	Engage in Physical Activity Internal Consistency
Amotivation	2, 8, 14, 20	0.782	0.582
External Regulation	6, 12, 18, 24	0.842	0.845
Introjected Regulation	4, 10, 16, 22	0.790	0.787
Identified Regulation	1, 7, 13, 19	0.820	0.706
Integrated Regulation	5, 17, 23	0.858	0.908
Intrinsic Regulation	3, 9, 15, 21	0.836	0.914

Note. Integrated subscale did not include item 11 due to not indicating limiting sedentary behavior in the item

Behavioral Regulations Descriptive Statistics

Descriptive statistics for behavioral regulations to limit sedentary behavior and behavioral regulations for engaging in physical activity are shown in Table 4 and 5, respectively. For regulations to limit sedentary behavior (rated on a 1 to 5 scale with higher scores indicating greater endorsement of that behavioral regulation), participants had moderate levels of identified regulation (M = 3.769, SD = 1.027), integrated regulation (M = 3.343, SD = 1.208), and intrinsic regulation (M = 3.233, SD = 1.01). Levels of amotivation (M = 1.544, SD = 0.823), external regulation (M = 1.350, SD = 0.636), and introjected regulation (M = 2.399, SD = 1.03) to limit sedentary behavior were low.

For the descriptive statistics of the behavioral regulations for engaging in physical activity, participants had moderate to high levels of identified regulation (M = 4.487, SD = 0.606), integrated regulation (M = 4.209, SD = 0.984), intrinsic regulation (M = 4.183, SD = 0.795) and introjected regulation (M = 3.123, SD = 1.037) for engaging in physical activity.

Levels of amotivation (M = 1.081, SD = 0.301) and external regulation were low (M = 1.599, SD = 0.804).

Correlations Between Behavioral Regulation Subscales

Correlations between behavioral regulation subscales for both limiting sedentary behavior and engaging in physical activity can be found in Tables 4 and 5, respectively. Within the behavioral regulation subscales for limiting sedentary behavior, correlations between the subscales ranged from weak to strong (rs = .055 to .830) and were in the expected directions. The majority of the subscales were significantly correlated with each other at the $p < 0.01$ level. Similarly, the correlations between the behavioral regulation subscales for engaging in physical activity ranged from weak to strong (rs = -.063 to .690) and were in the expected directions. The majority of the subscales were significantly correlated with each other at the $p < 0.01$ level.

Table 4. Descriptive Statistics and Correlations Between Behavioral Regulations to Limit Sedentary Behavior Subscales

Behavioral Regulations	Mean	SD	1.	2.	3.	4.	5.	6.
1. Amotivation	1.544	0.823	1					
2. External Regulation	1.350	0.636	.062	1				
3. Introjected Regulation	2.399	1.031	-.170*	.321**	1			
4. Identified Regulation	3.769	1.027	-.509**	.089	.548**	1		
5. Integrated Regulation	3.343	1.208	-.467**	.055	.569**	.830**	1	
6. Intrinsic Regulation	3.233	1.012	-.297**	.136	.518**	.780**	.756**	1

Note. *Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

Table 5. Descriptive Statistics and Correlations Between Behavioral Regulations to Engage in Physical Activity Subscales

Behavioral Regulations	Mean	SD	1.	2.	3.	4.	5.	6.
1. Amotivation	1.081	0.301	1					
2. External Regulation	1.599	0.804	.247**	1				
3. Introjected Regulation	3.123	1.037	-.063	.187*	1			
4. Identified Regulation	4.487	0.606	-.286**	-.130	.473**	1		
5. Integrated Regulation	4.209	0.984	-.207**	-.104	.395**	.690**	1	
6. Intrinsic Regulation	4.184	0.795	-.223**	-.263**	.257**	.646**	.667**	1

Note. *Correlation is significant at the 0.05 level.

**Correlation is significant at the 0.01 level.

Table 6 presents correlations between behavioral regulations for liming sedentary behavior and average daily sedentary time. Among the behavior regulations for limiting sedentary behavior, there was a very weak negative correlation between average daily sedentary time and identified regulation, r (171) = -.183, p = .017, integrated regulation r (173) = -.229, p = .003, and intrinsic regulation r (173) = -.207, p = .007. There was a very weak negative correlation between introjected regulation and average daily sedentary time, but it was not significant, r (173) = -.136, p = .074. There was a very weak positive, but not significant, correlation between average daily sedentary time and amotivation, r (173) = .045, p = .555, and external regulation r (173) = .052, p = .500. These correlations were in the expected direction as regulations more self-determined and internalized to limit sedentary behavior would be negative with average daily sedentary time.

Additionally, Table 6 presents correlations between behavioral regulations for engaging in physical activity and average daily sedentary time. Among the behavioral regulations for engaging in physical activity, there was a very weak negative correlation between integrated regulation and average daily sedentary time, r (173) = -.233, p = .003. There was a very weak negative, but not significant, correlations between average daily sedentary time and intrinsic regulation, r (173) = -.141, p = .066, introjected regulation, r (173) = -.026, p = .737, and identified regulation, r (173) = -.113, p = .141. There was also a very weak positive, but not significant, correlation between average daily sedentary time and both amotivation, r (173) = .118, p = .123, and external regulation, r (173) = .140, p = .067. These correlations were in the expected direction as regulations more self-determined and internalized to engage in physical activity would be negative with average daily sedentary time.

Table 6. Correlations Between Average Daily Sedentary Time and Behavioral Regulations

	Correlations between Behavioral Regulations to Limit Sedentary Behavior and Average Daily Sedentary Time		Correlations between Behavioral Regulations to Engage in Physical Activity and Average Daily Sedentary Time	
Behavioral Regulation	*r*	*p*	*r*	*p*
Amotivation	0.045	0.555	0.118	0.123
External Regulation	0.052	0.500	0.140	0.067
Introjected Regulation	-0.136	0.074	-0.026	0.737
Identified Regulation	-0.183*	0.017	-0.113	0.141
Integrated Regulation	-0.229*	0.003	-0.223**	0.003
Intrinsic Regulation	-0.207**	0.007	-0.141	0.066

Note. *Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level

Correlations between behavioral regulation subscales for limiting sedentary behavior and the corresponding subscale for behavioral regulations for engaging physical activity were calculated (see Table 7). All correlations between corresponding subscales were significant. All correlations were generally weak to moderate (*r*s = .291 to .485) with the exception for the external regulation subscales (r (173) = .653, p <.001). The fact that the correlations between these subscales were, for the most part, weak to moderate indicate that the behavioral regulation subscales for limiting sedentary behavior and for engaging in physical activity are likely capturing different motivational processes across the distinct movement-related behaviors and are not redundant.

Table 7. Correlations Between Behavioral Regulation Subscales for Limiting Sedentary Behavior and Engaging in Physical Activity

Behavioral Regulation	*r*	*p*
Amotivation	.291**	<.001
External Regulation	.653**	<.001
Introjected Regulation	.485**	<.001
Identified Regulation	.413**	<.001
Integrated Regulation	.427**	<.001
Intrinsic Regulation	.283**	<.001

Note. **Correlation is significant at the 0.01 level.

Behavioral Regulations to Limit Sedentary Behavior Predicting Average Daily Sedentary Time

Results from linear regression models regressing average daily sedentary time on behavioral regulation to limit sedentary behavior are presented in Table 8.

Amotivation

In total, amotivation and covariates (i.e., sex, BMI, and age) explained 9.8% of variance in average daily sedentary time. Results indicated there was a collective significant effect of amotivation and the covariates on average daily sedentary time (F(4, 167) = 4.532, p = .002, R^2 =

.098). In the model, amotivation did not significantly predict average daily sedentary time (B = -0.454, β = -.003, p = .966). Significant predictors in the model included sex (B = 70.978, β = .280, p < .001) and BMI (B = 2.905, β = .147, p = .050). Specifically, individuals identifying as male and individuals with higher BMI tended to engage in greater levels of average daily sedentary time.

External Regulation

In total, external regulation and covariates explained 9.8% of variance in average daily sedentary time. Results indicated there was a collective significant effect of external regulation and the covariates on average daily sedentary time (F(4, 167) = 4.532, p = .002, R^2 = .098). External regulation did not significantly predict average daily sedentary time (B = 0.731, β = -.004, p = .957). The only significant predictor in the model was sex (B = 51.997, β = .207 p = .008) Specifically, individuals identifying as male tended to engage in greater levels of average daily sedentary time.

Introjected Regulation

In total, introjected regulation and covariates explained 11.3% of the variance in average daily sedentary time. Results indicated there was a collective significant effect of introjected regulation and the covariates on average daily sedentary time (F(4, 167) = 5.293, p = <.001, R^2 = .113). Introjected regulation did not significantly predict average daily sedentary time (B = -13.438, β = -.121, p = .099). The only significant predictor in the model was sex (B = 69.882, β = .276, p < .001). Specifically, individuals identifying as male tended to engage in greater levels of average daily sedentary time.

Identified Regulation

In total, identified regulation and covariates explained 11.6% of the variance in average daily sedentary time. Results indicated there was a collective significant effect of identified regulation and the covariates on average daily sedentary time (F(4, 167) = 5.496, p <.001, R^2 =0.115). Identified regulation did not significantly predict average daily sedentary time (B = -15.467, β = -.139, p = .064). The only significant predictor in the model was sex (B = 68.075, β = .269, p = <.001). Specifically, individuals identifying as male tended to engage in greater levels of average daily sedentary behavior.

Integrated Regulation

In total, integrated regulation and covariates explained 13.3% of the variance in average daily sedentary time. Results indicated there was a collective significant effect of integrated regulation and the covariates on average daily sedentary time (F(4, 167) = 6.393, p <.001, R^2 = .133). Integrated regulation did significantly predict average daily sedentary time (B = -18.055, β = -.191, p =.010). For every one unit increase in integrated regulation (without item 11), average daily sedentary time decreased by 18.055 minutes. The only other significant predictor in the model was sex (B = 67.641, β = .267, p < .001). Specifically, individuals identifying as male tended to engage in greater levels of average daily sedentary time.

Intrinsic Regulation

In total, intrinsic regulation and covariates explained 13.2% of the variance in average daily sedentary time. Results indicated that there was a collective significant effect of intrinsic regulation and the covariates on average daily sedentary time (F(4, 167) = 6.336, p <.001, R^2= .132). Intrinsic regulation did significantly predict average daily sedentary time (B = -20.922, β = -.185, p = .012). In other words, for every one unit increase in intrinsic regulation, average daily sedentary time decreased by 20.922 minutes. The only other significant predictor in the model was sex (B = 69.652, *β* = .274, *p* < .001). Specifically, individuals identifying as male tended to engage in greater levels of average daily sedentary time.

All Behavioral Regulations

Table 9 presents the linear regression model regressing average daily sedentary time on all behavioral regulation simultaneously. In total, behavioral regulations and covariates explained 14.9% of the variance in average daily sedentary time. Results indicated that there was a collective significant effect of all behavioral regulations and the covariates on average daily sedentary time (F(9, 162) = 3.163, p = .002, R^2 = .149). No behavioral regulation was a significant predictor of average daily sedentary time. The only significant predictor in the model was sex (*B* = 68.973 *β* = .272, *p* < .001). Specifically, individuals identifying as male tended to engage in greater levels of average daily sedentary time.

Table 8. Linear Regression Regressing Average Daily Sedentary Time on Individual Behavioral Regulations for Limiting Sedentary Behavior

Model	R^2	Adjusted R^2	Residual Error (ε_i)	Predictor	B	*SE*	*β*	Contribution *p*-value
Amotivation	.098	.076	110.25	Intercept	505.14	13.253		<.001
				Behavioral Regulation	-0.454	10.544	-.003	.966
				Sex	70.99*	18.755	.280	<.001
				BMI	2.905*	1.470	.147	.050
				Age	1.843	17.284	.008	.915
External Regulation	.098	.076	110.25	Intercept	503.55	22.53		<.001
				Behavioral Regulation	0.731	13.547	.004	.957
				Sex	70.82*	18.782	.279	<.001
				BMI	2.881	1.471	.146	.052
				Age	1.741	16.975	.008	.918
Introjected Regulation	.113	.091	109.36	Intercept	537.62	23.922		<.001
				Behavioral Regulation	-13.438	8.107	-.121	.099
				Sex	69.882*	18.554	.276	<.001
				BMI	2.800	1.440	.142	.054
				Age	0.580	16.832	.003	.973
Identified Regulation	.116	.095	109.12	Intercept	565.089	35.025		<.001
				Behavioral Regulation	-15.467	8.291	-.139	.064
				Sex	68.075*	18.566	.269	<.001
				BMI	2.389	1.461	.121	.104
				Age	-0.390	16.378	-.002	.981
Integrated Regulation	.133	.112	108.10	Intercept	566.552	27.251		<.001
				Behavioral Regulation	-25.467*	9.163	-.203	.006
				Sex	67.641*	18.374	.267	<.001
				BMI	2.171	1.449	.110	.136
				Age	0.638	16.630	.003	.969
Intrinsic Regulation	.132	.111	108.16	Intercept	573.884	30.147		<.001
				Behavioral Regulation	-20.922*	8.200	-.185	.012

Sex	69.652*	18.351	.274	<.001
BMI	2.524	1.430	.128	.989
Age	-0.238	16.652	-.001	.943

Note: Regression is significant at the 0.05 level

Table 9. Linear Regression Simultaneously Regressing Average Daily Sedentary Time on all Behavioral Regulations for Limiting Sedentary Behavior

	R^2	Adjusted R^2	Residual Error (ε_i	B	SE	β	*p*
Model 1	0.149	0.102	108.69				
Intercept				592.842	49.960		<.001
Amotivation				-13.715	12.475	-.099	.273
External Regulation				7.397	14.340	-.041	.607
Introjected Regulation				-1.663	10.745	-.015	.877
Identified Regulation				9.998	17.266	.090	.563
Integrated Regulation				-20.002	13.801	-.211	.249
Intrinsic Regulation				-13.939	14.259	-.123	.330
Sex				68.973*	18.638	.272	<.001
BMI				2.340	1.492	.119	.119
Age				5.685	17.177	.025	.741

Note. Model 1 ($F(9, 162) = 3.163$, $p = .002$, $R^2 = 0.149$).

*Regression is significant at the 0.05 level

Behavioral Regulations for Engaging in Physical Activity Predicting Average Daily Sedentary Time

Results from linear regression models regressing average daily sedentary time on behavioral regulation to engage in physical activity are presented in Table 10.

Amotivation

In total, amotivation and covariates (i.e., sex, BMI, and age), explained 10.5% of variance in average daily sedentary time. Results indicated there was a collective significant effect of amotivation and the covariates on average daily sedentary time ($F(4, 167) = 4.902$, $p <.001$, $R^2 = .105$). In the model, amotivation did not significantly predict average daily sedentary time (B = 32.220, $\beta = .085$, $p = .249$). The only significant predictor in the model was sex (B = 69.347, $\beta = .274$, $p < .001$). Specifically, individuals who identified as male engaged in higher levels of average daily sedentary time.

External Regulation

In total, external regulation and covariates explained 10.6% of variance in average daily sedentary time. Results indicated there was a collective significant effect of external regulation and the covariates on average daily sedentary time ($F(4, 167) = 4.969$, $p < .001$, $R^2 = .106$). External regulation did not significantly predict average daily sedentary time (B = 12.376, $\beta = .094$, $p = .211$). The only significant predictor in the model was sex (B = 69.008, $\beta = .272$, $p < .001$). Specifically, individuals identifying as male engaged in higher levels of average daily sedentary time.

Introjected Regulation

In total, introjected regulation and covariates explained 10.2% of variance in average daily sedentary time. Results indicated there was a collective significant effect of introjected regulation and the covariates on average daily sedentary time (F(4, 167) = 4.767, p = .001, R^2 = .102). Introjected regulation did not significantly predict average daily sedentary time (B = -7.620, β = -.068, p = .358). The only significant predictors in the model included sex (B = 73.032, β = .288, p < .001) and BMI (B = 2.939, β = .149, p = .044). Specifically, individuals identifying as male and individuals with higher BMI engaged in higher levels of average daily sedentary time.

Identified Regulation

In total, identified regulation and covariates explained 10.7% of variance in average daily sedentary time. Results indicated there was a collective significant effect of identified regulation and the covariates on average daily sedentary time (F(4, 167) = 5.010, p < .001, R^2 = .107). Identified regulation did not significantly predict average daily sedentary time (B = -18.899, β = -.098, p = .191). The only significant predictor in the model was sex (B = 71.350, β = .282, p < .001). Specifically, individuals identifying as male engaged in higher levels of average daily sedentary time.

Integrated Regulation

In total, integrated regulation and covariates explained 13.6% of variance in average daily sedentary time. Results indicated there was a collective significant effect of integrated regulation and the covariates on average daily sedentary time (F(4, 167) = 6.599, p = <.001, R^2= .126). Integrated regulation did significantly predict sedentary time (B = -24.510, β = -.205, p = .007). For every one unit increase in integrated regulation, average daily sedentary time decreased by 24.510 minutes. The only other significant predictor in the model was sex (B = 71.287, β = .281, p = .007). Specifically, individuals identifying as male engaged in higher levels of average daily sedentary time.

Intrinsic Regulation

In total, intrinsic regulation and covariates explained 11.1% of variance in average daily sedentary time. Results indicated there was a collective significant effect of intrinsic regulation and the covariates on average daily sedentary time ($F(4, 166) = 5.157$, $p < .001$, $R^2 = .111$). Intrinsic regulation did not significantly predict average daily sedentary time (B = -17.853, β = -.122, $p = .108$). The only significant predictor in the model was sex (B = 70.882, β = .280, $p < .001$). Specifically, individuals identifying as male engaged in higher levels of average daily sedentary time.

All Behavioral Regulations

The linear regression model regressing average daily sedentary time on all behavioral regulation at once and covariates (see Table 11) explained 14.6% of the variance in average daily sedentary time. Results indicated there was a collective significant effect of the behavioral regulations and covariates on average daily sedentary time ($F(9, 161) = 3.048$, $p = .002$, $R^2 = .146$). Out of the behavioral regulations, only integrated regulation significantly predicted average daily sedentary time (B = -28.739, β = -.240, $p = .032$). In other words, for every one unit increase in integrated regulation, average daily sedentary time decreased by 28.739 minutes. The only other significant predictor in the model was sex ($B = 69.107$, $\beta = .273$, $p < .001$). Specifically, individuals identifying as male engaged in higher levels of average daily sedentary time.

Table 10. Linear Regression Between Average Daily Sitting Time and Behavioral Regulations for Engaging in Physical Activity

Behavioral Regulation	R^2	Adjusted R^2	Residual Error (ε_i)	Predictors	B	SE	*β*	Contribution *p* value
Amotivation	0.105	0.084	109.81	Intercept	470.345	32.405		<.001
				Behavioral Regulation	32.220	27.875	.085	.249
				Sex	69.347*	18.671	.274	<.001
				BMI	2.731	1.452	.139	.062
				Age	1.207	16.894	.005	.943
External Regulation	0.106	0.085	109.73	Intercept	483.365	21.416		<.001
				Behavioral Regulation	13.376	10.641	.094	.211
				Sex	69.008*	18.670	.272	<.001
				BMI	2.511	1.476	.127	.091
				Age	2.058	16.879	.009	.903
Introjected Regulation	0.102	0.081	109.97	Intercept	483.365	21.416		<.001
				Behavioral Regulation	-7.620	8.271	-.068	.358
				Sex	73.032*	18.790	.288	<.001
				BMI	2.939*	1.448	.149	.044
				Age	3.284	17.001	.014	.847
Identified Regulation	0.107	0.086	109.69	Intercept	588.498	65.726		<.001
				Behavioral Regulation	-18.899	14.388	-.098	.191
				Sex	71.350*	18.603	.282	<.001
				BMI	2.542	1.468	.129	.085
				Age	3.345	16.916	.015	.844
Integrated Regulation	0.136	0.116	107.87	Intercept	606.662	39.585		<.001
				Behavioral Regulation	-24.510*	8.973	-.205	.007
				Sex	71.287*	18.292	.281	<.001
				BMI	1.787	1.476	.091	.228
				Age	4.218	16.615	.018	.800

Intrinsic Regulation	0.111	0.089	109.64	Intercept	579.217	47.650		<.001
				Behavioral Regulation	-17.853	11.060	-.122	.108
				Sex	70.882*	18.610	.280	<.001
				BMI	2.340	1.480	.119	.116
				Age	2.649	16.949	.012	.876

Note. *Regression is significant at the 0.05 level

Table 11. Linear Regression Between Average Daily Sedentary Time and all Behavioral Regulations for Engaging in Physical Activity

	R^2	Adjusted R^2	Residual Error (ε_i)	B	SE	β	*p*
Model 2	0.146	0.098	109.11				
Intercept				517.435	86.213		<.001
Amotivation				15.982	29.621	.042	.590
External Regulation				12.458	11.570	.088	.283
Introjected Regulation				-3.640	9.946	-.033	.715
Identified Regulation				16.559	21.788	.086	.448
Integrated Regulation				-28.739*	13.275	-.240	.032
Intrinsic Regulation				1.896	15.534	.013	.903
Sex				69.107*	18.742	.273	<.001
BMI				1.529	1.529	.078	.319
Age				3.390	16.950	.015	.842

Note. ($F(9, 161) = 3.048$, $p = .002$, $R^2 = .146$)

*Regression is significant at the 0.05 level

CHAPTER V: DISCUSSION

This thesis is the first, to the author's knowledge, to examine relations between behavioral regulations (for both engaging in physical activity and limiting sedentary behavior) posited within Self-Determination Theory and average daily sedentary time in older adults. Examining associations with these two types of behavioral regulations with distinct behavioral targets is necessary to advance the literature. Understanding what motivates individuals to engage in physical activity as well as limit sedentary behavior is important for informing interventions targeting these behaviors and in the long-term improving health outcomes. Ultimately, results indicated that behavioral regulations for engaging in physical activity and limiting sedentary behavior are distinct (as indicated by the relatively low-level correlations between corresponding subscales related to the two behavioral targets).

Further there appeared to be distinct relations between behavioral regulations, depending on the behavioral target, and average daily sedentary time. Although both integrated regulation for engaging in physical activity and for limiting sedentary behavior were significantly and negatively related to subsequent average daily sedentary time, only intrinsic regulation for limiting sedentary behavior negatively predicted subsequent average daily sedentary time whereas the same behavioral regulation for engaging in physical activity did not predict average daily sedentary time. This supports the importance of investigating psychological antecedents for limiting sedentary behavior and engaging in physical activity and conceptualizing these behaviors independently (Biddle, 2011; Katzmarzyk, 2010). Moreover, the results from this study indicate that there are different motives behind limiting sedentary behavior and engaging in physical activity in predicting average daily sedentary time. It is possible that individuals may feel more motivated to limit sedentary behavior, as opposed to engage in moderate to vigorous physical activity, because limiting sedentary behavior by displacing it with standing or other forms of light intensity physical activity may be more feasible and acceptable for older adults. Assessing both motives for limiting sedentary behavior and engaging in physical activity are likely important for enhancing movement-related intervention effectiveness in older adults.

Overall, the findings from this study advance the literature by being the first to investigate associations between behavioral regulations to limit sedentary behavior and subsequent average daily sedentary time. This study is also the first to descriptively compare behavioral regulations to limit sedentary behavior with behavioral regulations to engage in physical activity in terms of their relationship with average daily sedentary time.

Consistent with our hypotheses, integrated regulation for both engaging in physical activity and limiting sedentary behavior were negatively associated with average daily sedentary time. The finding that both forms of integrated regulation are negatively associated with behavior aligns with the basic principles of Self-Determination Theory that when one's motivation for a behavior is more internalized and more self-determined there is likely to be an association with behavioral engagement. This finding is also consistent with previous research in both the physical activity literature (Teixeira et al., 2012) and emerging sedentary behavior literature (Quartiroli & Maeda, 2014). However, this is the first study to capture integrated regulation to limit sedentary behavior and establish an association with subsequent sedentary behavior. Ultimately, integrated regulation occurs when a behavior is congruent with an individual's sense of self (Deci & Ryan, 2012; Ryan & Deci, 2017), and results from this study indicate that both a sense of self revolving around engaging in physical activity as well as a sense of self revolving around limiting sedentary behavior both have implications for sedentary time.

Contrary to our hypotheses, intrinsic regulation to limit sedentary behavior, but not intrinsic regulation to engage in physical activity, was significantly associated with subsequent average daily sedentary time. Divergent findings between the two types of behavioral regulations may not be surprising given the distinct behavioral targets of each type of behavioral regulation. Previous research has documented that behavior regulations for one movement-related behavior (i.e., physical activity) may have limited explanatory power for another movement-related behavior (i.e., sedentary behavior; Quartiroli & Maeda, 2014). The findings from this study support accumulating evidence that motivational processes driving sedentary behavior may be distinct from those driving physical activity behavior (Quartiroli & Maeda, 2014; Rollo et al., 2016)

Previous research among adults has documented that intrinsic regulation for sedentary behavior is positively associated with weekday and weekend day leisure time or recreational sedentary behavior, but not with weekday sedentary behavior related to work or school (Gaston et al., 2016). Therefore, it may be that intrinsic regulation for limiting sedentary behavior is most useful in predicting leisure or recreational sedentary behavior (i.e., behavior that is a choice). Given that most of our sample was not working (72.8%), older adults in the present study may have fewer rigid responsibilities that require sedentary behavior (e.g., sitting at a desk to work) resulting in a significant negative association between intrinsic regulations to limit sedentary behavior and subsequent device-based average daily sedentary time.

Contrary to our hypotheses, amotivation, external regulation, introjected regulation, and identified regulation for both engaging in physical activity and limiting sedentary behavior, were unrelated to subsequent average daily sedentary time. Previous research among adults suggests that less self-determined, more controlled form of regulation are not associated with sedentary behavior. For instance, Gaston and colleagues (2016) previously documented null associations between identified regulation for sedentary behavior and subsequent self-reported domain specific sedentary behavior among adults. Previous work in the physical activity literature suggests that identified regulation may be more strongly related to physical activity during the initial adoption of behavior as opposed to the maintenance of behavior (Teixeira et al., 2012). It is possible that because the sample was composed of roughly equal proportions of those engaged in more than 8 hours of sedentary behavior per day (58.9%; a level of behavior associated with elevated health risks; Gilchrist et al., 2020; Rezende et al., 2014) and those engaged in less than 8 hours of sedentary behavior per day, the sample may be composed of sedentary behavior reduction adopters and maintainers. Because the sample likely consisted of both sedentary behavior reduction adopters and maintainers this may have attenuated associations between identified regulation and sedentary behavior. Further, because of the high levels of physical activity in the sample (M = 110.20 minutes of average time spent stepping, SD = 37.83 minutes), it is possible that many participants were engaged in physical activity maintenance as opposed to adoption which may explain null findings between identified regulation for engaging in physical activity and subsequent behavior.

Gaston and colleagues (2016) also found that introjected and external regulation for sedentary behavior were unrelated to leisure/recreational sedentary behavior, and that only introjected regulation was associated with work or school sedentary behavior. Again, it may be the fact that sitting is traditionally required to complete certain activities associated with work or school that leads individuals to be motivated by prods or pressures to avoid negative feelings and approach positive feelings, but this may not be a strong enough motivator to impact average daily sedentary time or leisure/recreational sedentary behavior. Additionally, Quartiroli & Maeda

(2014) found that introjected and external regulation as well as amotivation for physical activity were not correlated with total sedentary behavior, consistent with the findings in this study. Previous research regarding behavioral regulations for physical activity and physical activity behavior suggest less consistency in associations between less self-determined, more controlling behavioral regulations (compared to more self-determined autonomous forms of motivation) and physical activity behavior (Teixeira et al., 2012). The same may also be true of behavioral regulations for limiting sedentary behavior. As individuals adopt a behavior, such as limiting sedentary behavior, less self-determined and more controlling behavioral regulations may, in some instances, help to facilitate adoption of the target behavior.

When all behavioral regulations were included in the same model, only integrated regulation for engaging in physical activity significantly predicted average daily sedentary time, but not for limiting sedentary behavior. However, these findings should be interpreted with caution given the medium-to-strong correlations noted between most behavioral regulation subscales, which may make it difficult to capture the unique contribution of each behavioral regulation in predicting behavior. Previous work examining physical activity and behavioral regulations has explored motivational profiles across behavioral regulations and have found differences among profiles and levels of physical activity and drop-out rates of organized physical activity programs (Friederichs et al., 2015; Ostendorf et al., 2021; Stephan et al., 2010). Indeed, this approach aligns with qualitative findings among older adults, which suggest that multiple types of behavioral regulations may contribute to sedentary behavior within individuals (Collins & Pope, 2021).Understanding the role that multiple types of behavioral regulations simultaneously play in regulating behavior within individuals and how these profiles may differ across from individuals could enhance intervention effectiveness and is an important direction for future research.

Within the linear regressions, sex was a consistent significant predictor of average daily sedentary time such that individuals identifying as male tended to engage in more average daily sedentary time. Though past literature assessing behavioral regulations did not indicate any differences in behavioral regulations by sex, past research assessing sedentary behavior levels have noted sex differences (Bellettiere et al., 2015; Bernaards et al., 2016; O'Donoghue et al., 2016; Prince et al., 2020). Across most of the lifespan, females tend to engage in higher levels of sedentary behavior than males (Prince et al., 2020); however, in older adulthood this trend reverses with males engaging in higher levels compared to females (Bellettiere et al., 2015; Bernaards et al., 2016). The results from this study were consistent with other work suggesting males become more sedentary compared to females in old age.

Contrary to the a priori assumption that age and BMI would be a significant predictor of average daily sedentary time, age and BMI were not consistent, significant predictors of average daily sedentary time in any regression models. Past literature has indicated differences across the lifespan for engagement in sedentary behavior (Bernaards et al., 2016; Diaz et al., 2016), but age may not have been a significant predictor of sitting time in this study due to the majority of the sample of older adults being close in age range (almost a 50-50 split with less than 69 year olds [53%] and those 69 years or older [47%]). Regarding BMI, previous research has indicated that obese individuals tend to engage in higher levels of sedentary behavior (Chastin et al., 2015). However, in this study only one-quarter of the sample was classified as obese based on BMI values. Our modeling approach which used a continuous BMI variable may have attenuated associations between BMI and average daily sedentary time in this study. Future research may also benefit from exploring demographic factors that may moderate associations between behavioral regulations and sedentary behavior. Potential moderators can include age, where associations between behavioral regulations and sedentary behavior can be moderated by different age groups (i.e., older adults, adults, adolescents, or children). Past research has found age to moderate the associations between behavioral regulations and physical activity (Brunet & Sabiston, 2011).

Limitations & Future Directions

The limitations of this study should be noted. First, this study includes a sample of older adults that was mostly female, white, and living in the southeast United States, potentially limiting generalizability. Future research should assess older adults in more diverse samples and with a more even ratio of women to men. Past research has indicated sex differences in behavioral regulations. In one study, males were found to have higher competence motivation compared to women (Frederick-Recascino, 2002). Another study found that males had a positive association between external regulation and physical activity and a negative association between introjected regulation and physical activity, whereas females had a positive association between introjected regulation and physical activity and no association between external regulation and physical activity (Teixeira et al., 2012). In regards to race, past research has shown that racial minorities have higher levels of physical inactivity/sedentary levels (Armstrong et al., 2018) along with motivational differences among different races (Egli et al., 2011). Within interventions, it is important to promote motivation that aligns with the specific population.

Additionally, the BREQ-3 was modified to assess behavioral regulations to limit sedentary behavior. This modified measure has not been validated but it was investigated whether subscales within the modified measure were correlated with other subscales and behavior in expected directions consistent with the tenets of Self-Determination Theory. There was one error in the modification of the measure in that the behavioral target of Item 11 (from the integrated subscale) focused on engaging in sedentary behavior as opposed to limiting sedentary behavior. All analysis investigating associations with the integrated subscale were ran with and without item 11 and findings were consistent across both modeling approaches. However, future work would benefit from validating a measure to assess behavioral regulations to limit sedentary behavior given that reducing and/or limiting sedentary behavior is an increasingly common target for behavioral intervention (Keadle et al., 2017; Nguyen et al., 2020; Rosenberger, 2012).

From a theoretical perspective, this study examined the role of each behavioral regulation, aggregated across all study participants, to predict average daily sedentary time. However, Self-Determination Theory acknowledges that multiple types of behavioral regulations may simultaneously play a role in regulating behavior (Deci & Ryan, 2012; Ryan et al., 2009; Ryan & Deci, 2017). For instance, one individual's behavior may largely be driven by introjected regulation as well as the three more autonomous, self-determined behavioral regulations whereas another individual's behavior may be largely regulated by intrinsic and integrated regulations. Therefore, future research would benefit from exploring behavioral regulation profiles (consisting of various levels of multiple types of behavioral regulations) to investigate relations with sedentary behavior.

Conclusion

This is the first study to assess associations between behavioral regulations to limit sedentary behavior and to engage in physical activity with average daily sedentary time. Results indicate that behavioral regulations for engaging in physical activity and limiting sedentary behavior are distinct. Integrated regulation for engaging in physical activity and limiting sedentary behavior were found to be associated with average daily sedentary time; identified and intrinsic regulation to limit sedentary behavior were also found to be associated with average daily sedentary time, but these same behavioral regulations for engaging in physical activity were not associated with average daily sedentary time. This study further develops a knowledge base surrounding behavioral regulations for limiting sedentary behavior. Further, this work provides insight into the types of behavioral regulations that regulate older adults' behavior to help inform movement-related interventions rooted in Self-Determination Theory. Future research should continue to investigate associations between behavioral regulations and sedentary behavior by exploring behavioral regulation profiles as well as expanding this work to more diverse populations.

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