OLDER ADULTS' MAINTENANCE OF PHYSICAL ACTIVITY: AN INVESTIGATION OF THE MOTIVES OF ENJOYMENT, SATISFACTION, IDENTITY, AND SELF-DETERMINATION

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To my own enjoyment, satisfaction, identity, and self-determination.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Many older adults report that they do not regularly engage in physical activity, highlighting the need for the creation of interventions that are more conducive to promoting sustained behavioral engagement. Physical activity intervention development should first begin with the identification of modifiable factors that are related to the behavior and the conditions under which these factors do and do not impact physical activity, as well as the validation of instruments to measure these factors. Enjoyment of physical activity, satisfaction with physical activity, self-determination, and physical activity identity have been theorized as four "maintenance motives" necessary for health behavior maintenance. The purpose of this dissertation research project was to identify which of these theory-based motives are associated with the maintenance of physical activity for older adults (≥ 55 years of age) and to test the robustness of measures of motive assessment. This dissertation consists of several studies detailed in five chapters. Chapter 2 reports the findings of two studies that examined older adults' beliefs related to their physical activity maintenance through both a free-response format and in-depth semi-structured interviews. Chapters 3 and 4 describe a systematic review and meta-analysis that explored the relations between enjoyment, satisfaction, self-determination, and identity and older adults' physical activity maintenance. The following two chapters include two studies that investigated the robustness of measurement instruments assessing self-determined regulatory styles for physical activity (i.e., self-determination) and physical activity identity (Chapter 5) and physical activity enjoyment and satisfaction (Chapter 6). Together, findings suggest that these four motives are related to the maintenance of physical activity for older adults, with more evidence supporting the relation between self-determination and maintenance. Findings provide insight as to for whom (e.g., older adults with health conditions) and in which context (e.g., re-engaging in physical activity after time away) motives may exert their influence on behavior. Moreover, this dissertation project reports psychometric properties of new and modified measures that can be used to assess the maintenance motives in future studies. This dissertation contributes to the literature by enabling researchers to more accurately and confidently choose and measure proposed mechanisms of change and thus provides a foundation upon which future physical activity intervention development can expand.

CHAPTER 1. INTRODUCTION

Most adults over the age of 55 (henceforth, older adults) do not participate in recommended amounts of physical activity on a regular basis (Katzmarzyk et al., 2017; Schoenborn & Heyman, 2009). A growing line of research has been devoted to implementing and evaluating behavioral interventions designed to promote physical activity among this population (Chase, 2015; Conn et al., 2002; Martin & Sinden, 2001; Muellmann et al., 2018; O'Brien et al., 2015; Sansano-Nadal et al., 2019; van der Bij et al., 2002). While such interventions have shown success in the short term (Chase, 2015; Conn et al., 2002; Muellmann et al., 2018; van der Bij et al., 2002), there is evidence that reveals declines in activity during longer term interventions (van der Bij et al., 2002) and beyond intervention completion (Conn et al., 2002; Sansano-Nadal et al., 2019; van der Bij et al., 2002). Importantly, in order to reap many of the benefits of physical activity, this behavior needs to be maintained. Acute effects of a single bout of physical activity (e.g., increased positive affect) are short-lived (e.g., 30 minutes; Reed & Ones, 2006), and other chronic physiological adaptations (e.g., cardiorespiratory fitness) regress back to baseline after a relatively brief period of inactivity (e.g., four weeks; Mujika & Padilla, 2000). Thus, a critical public health issue that requires addressing is how best to help older adults maintain their physical activity. Should this problem be ignored, many behavioral interventions will continue to produce short-term effects that do little to sustain long-term health. The overall purpose of this dissertation project was to identify theory-based motives associated with the maintenance of physical activity and to test the robustness of measures of motive assessment among older adults.

1.1 Definition of Physical Activity Maintenance

Physical activity maintenance is a different phenomenon from that of physical activity initiation (Dishman, 1982; Laitakari et al., 1996; Sallis & Hovell, 1990), yet neither have an agreed upon definition in the physical activity literature (Hawley-Hague et al., 2016; Marcus et al., 2000). Many studies consider initiation as engaging in physical activity for up to six months, whereas maintenance has been defined as physical activity beyond six months of participation (Amireault et al., 2013; Laitakari et al., 1996; Marcus et al., 2000; van Stralen et al., 2009). This six-month threshold has been supported by past research concluding that exercise participant

dropout rates exceed 50% within six months after initiation (Dishman, 1982), as well as by the transtheoretical model of health behavior change (Prochaska & Velicer, 1997). However, time-restricted definitions of initiation and maintenance are arguably arbitrary "lines in the sand" (West, 2009, p. 1037). For example, there is likely no meaningful difference in a person's health after six months of physical activity compared to the day prior, yet this person would have crossed the threshold into a maintenance stage. In this dissertation project, physical activity maintenance is conceptualized as repeated episodes of sustained engagement in physical activity during a period of observation that can be (and are likely to be) interspersed with episodes of inactivity, after which the behavior is resumed (Kahlert, 2015; Marcus et al., 2000; Powell et al., 2011; Seymour et al., 2010).

Given there is a conceptual distinction between initiation and maintenance (Laitakari et al., 1996; Sallis & Hovell, 1990), it has been suggested that factors that encourage individuals to begin enacting a behavior differ from those that encourage its ongoing participation (Dishman, 1982; Kwasnicka et al., 2016; Laitakari et al., 1996; Rothman, 2000). Many physical activity interventions and observational studies, however, have not been designed to account for these differences, as they draw from behavioral frameworks (e.g., the social cognitive framework, the socioecological framework) that do not include theories with specific hypotheses related to behavioral maintenance (Kwasnicka et al., 2016; Rhodes et al., 2019). Consequently, although some theoretical constructs have proven useful in distinguishing between maintainers and non-maintainers (e.g., intention, self-efficacy; Amireault et al., 2013; Rhodes & Quinlan, 2015; van Stralen et al., 2009), intervention targets (i.e., factors suggested to be mechanisms of behavior change) and strategies based on these non-maintenance-specific theories may facilitate physical activity participation in the shorter term but do not necessarily lead to long-term regular engagement (Kwasnicka et al., 2016). Interventions should therefore be designed in ways that are more conducive to promoting sustained physical activity among older adults by including a focus on factors specifically posited to be related to the maintenance of physical activity. This dissertation focuses on theory-based motives for the maintenance of physical activity.

1.2 The Experimental Medicine Approach

Past intervention development has relied on conducting what are known as "traditional efficacy trials" (Collins et al., 2007; Sheeran et al., 2017). In such trials, strategies to alter

behavior are developed, implemented, and subsequently assessed for their ultimate impact on behavior; however, assessments of the mechanisms of change are largely ignored (Sheeran et al., 2017). The traditional efficacy trial approach is potentially inefficient for two main reasons. First, if the intervention is not successful, investigators are unable to determine whether the intervention target through which a strategy was presumed to elicit change was unfitting for the population involved in the intervention, or if the strategy used to modify the target was inappropriate (Sheeran et al., 2017). Second, if the intervention is successful, investigators will still have missing information about why it worked because the traditional approach evaluates the intervention in its entirety (Collins et al., 2007). For example, if several strategies are employed to engage several targets, there will be little information regarding which strategy-target pair was responsible for the positive behavior change. Without this knowledge regarding why the intervention worked, attempts to pare down the intervention to its effective components will be based on best guesses. Should another research team wish to implement the intervention but lack the resources to employ all strategies, the original team cannot reliably identify which portions need to remain in the intervention. This could result in unnecessary expenditures of limited resources and time with little to show for it.

Acknowledging these limitations, researchers have called for more systematic approaches to intervention development that emphasize the importance of understanding the mechanisms of change (Collins et al., 2005; Czajkowski et al., 2015; Onken et al., 2014; Riddle, 2015; Sheeran et al., 2017). The Experimental Medicine approach (Aklin et al., 2020; Riddle, 2015; Sheeran et al., 2017) outlines a four-step process of intervention development that explicitly focuses on these mechanisms. Figure 1.1 illustrates these steps compared to the standard efficacy trial approach.

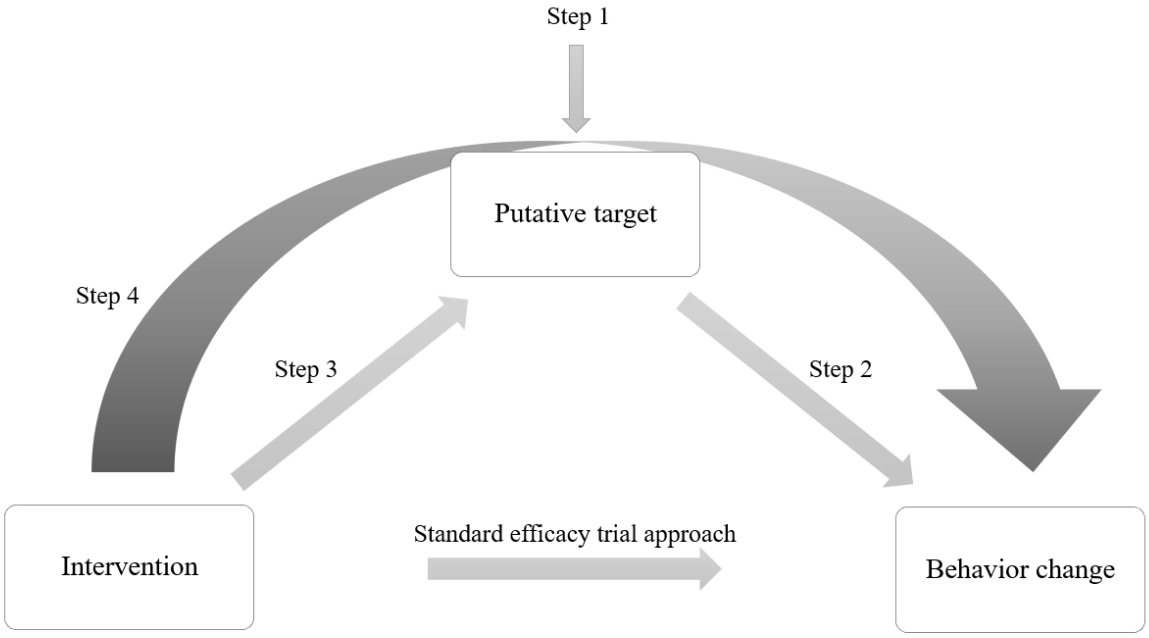

Figure 1.1. Steps 1 through 4 of the Experimental Medicine approach.
Adapted from Sheeran et al. (2017).

The first step of the Experimental Medicine approach involves identifying factors related to the behavior that are potentially modifiable and could be used as targets in future interventions. The second step involves developing and verifying appropriate measures of assessment and determining under what conditions (e.g., for whom) these factors affect behavior. Having valid target assays is an essential component of the Experimental Medicine approach which enables confident conclusions regarding the mechanisms of change. Step three consists of testing different intervention strategies to determine how best to modify or engage a putative target, and step four uses the information gathered from the prior steps to develop a randomized controlled trial to test the full intervention. The Experimental Medicine approach ensures that links exist between targets, intervention strategies, and behavior for a population of interest prior to intervention deployment.

Effective behavioral interventions rely on the appropriate selection of intervention targets. By bringing a focus on the mechanisms of change to the forefront of intervention development, researchers are able to assess not only whether an intervention as a whole successfully changes behavior, but also why the behavior change occurred. This approach clarifies which factors to

adopt as targets and how best to engage these targets to ultimately change behavior. In accordance with the Experimental Medicine approach, the creation of interventions that are more conducive to physical activity maintenance for older adults should begin with determining which factors are specifically related to physical activity maintenance for this population, under what conditions these factors are more or less relevant for sustained behavior, and how these factors are best measured. The following section will outline a framework that provides a foundation for the selection of potential factors.

1.3 A Framework for Behavioral Maintenance

Although many theories do not explicitly address behavioral maintenance (Kwasnicka et al., 2016), formal frameworks that include hypotheses related to maintenance do exist (e.g., Nigg et al., 2008; Prochaska & Velicer, 1997; Rothman, 2000; Schwarzer, 2008). More recently, Kwasnicka et al. (2016) conducted a systematic review of health behavior theories with the purpose of synthesizing theoretical explanations of behavior change maintenance. Through this review, they identified five themes related to the maintenance of health behavior: maintenance motives, self-regulation, resources, habit, and environmental and social influences. A short synopsis of each theme is presented in Table 1.1.

Table 1.1. Five themes related to health behavior maintenance.

Theme	Explanation
Maintenance motives	Individuals will maintain a behavior if they are either satisfied with the behavioral outcomes, enjoy the behavior, identify with the behavior, or have higher levels of self-determination to perform the behavior.
Self-regulation	Individuals will maintain a behavior when they can monitor and regulate their new behavior and overcome any presented obstacles.
Resources	Individuals will maintain a behavior if they have sufficient resources (e.g., inhibitory processes).
Habit	Individuals will maintain a behavior when it has become part of their routine.
Environmental and social influences	Individuals will maintain a behavior when the social and physical environments are supportive of the behavior.

The maintenance motives of satisfaction, enjoyment, identity, and self-determination are considered the primary drivers of volitional behavior. These theory-based motives facilitate maintenance through regular gratification from the behavior and thus subsequently help individuals establish priorities and allocate relevant resources in order to engage in the behavior over time (Kwasnicka et al., 2016). Therefore, enjoyment, satisfaction, identity, and self-determination are promising candidate targets for future interventions aimed at helping older adults maintain their physical activity.

1.4 Summary and Specific Aims

Many older adults report that they do not regularly engage in physical activity. It is essential that behavioral interventions target factors that are specifically related to the maintenance of physical activity to better promote long-term behavioral engagement. The Experimental Medicine approach offers guidance for establishing appropriate targets to use in interventions, and Kwasnicka et al.'s (2016) framework provides a starting point for selecting potential targets (i.e., the maintenance motives). The work included in this dissertation aligns with the first two steps of the Experimental Medicine approach. The purpose of this dissertation research project was to identify which maintenance motives are associated with older adults' physical activity maintenance and to test the robustness of measures of motive assessment. The underlying specific aims were threefold:

Aim 1: Identify which theory-based motives are related to physical activity maintenance for older adults.

Aim 2: Determine under what conditions (e.g., for whom, in which context) these motives are related to physical activity maintenance.

Aim 3: Investigate the robustness – including measurement invariance across time and gender and convergent and divergent validity – of measures developed to assess these theory-based motives.

This dissertation research project will enable behavioral scientists and researchers to more accurately and confidently choose and measure proposed mechanisms of change in interventions aimed at motivating older adults to sustain their physical activity. Consequently, this dissertation helps determine the factors that should be given priority in step three of the Experimental Medicine approach (i.e., identifying strategies that best modify potential intervention targets). Short of such information, the effectiveness of physical activity interventions will remain suboptimal and will have limited impact in sustaining long-term health.

1.4.1 Dissertation Outline

The following five chapters present a program of work comprised of a systematic review and meta-analysis and a series of original qualitative and quantitative studies. The rationale and methods for each study are reported and described in detail in corresponding chapters. Chapter 2 consists of a qualitative project designed to elicit older adults' beliefs about physical activity maintenance. The studies presented in Chapter 2 have been published as one manuscript in *The Gerontologist*. Chapters 3 and 4 present a protocol for and systematic review and meta-analysis of the quantitative literature surrounding the four maintenance motives within the context of older adults' physical activity maintenance. These articles have been published in *BMJ Open* and *Health Psychology Review*, respectively. The study discussed in Chapter 5 investigates the psychometric properties of two measures designed to assess physical activity regulatory styles and physical activity identity; the study discussed in Chapter 6 similarly investigates two measures designed to assess physical activity enjoyment and satisfaction. These studies were submitted for publication to the *Journal of Sport and Exercise Psychology* and the *Journal of Aging and Physical Activity*, respectively. Finally, Chapter 7 presents a general discussion of the work, including an overview of the findings, implications, and limitations and strengths.

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CHAPTER 2. WHAT KEEPS THEM GOING, AND WHAT GETS THEM BACK? OLDER ADULTS' BELIEFS ABOUT PHYSICAL ACTIVITY MAINTENANCE

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2.1 Abstract

The overall purpose of this paper was to investigate beliefs related to physical activity maintenance among adults aged ≥ 60 years. Study 1 identified modal, salient behavioral, normative, and control beliefs using a free-response format. Study 2 was designed to gain a deeper understanding about these beliefs through in-depth semi-structured interviews. Findings indicate that perceived physical and emotional benefits, scheduling and having a physical activity routine, social support, and features of indoor and outdoor locations are facilitating of maintenance. Some beliefs appear more relevant to sustained engagement in physical activity, while others may be more helpful for re-engagement after a setback. This investigation raises new hypotheses for future research and provides insight for the use and adaptation of behavior change strategies that are potentially more acceptable and effective for the promotion of physical activity maintenance for older adults.

2.2 Introduction

Physical activity represents one of the best strategies for people of all ages to maintain overall health, mobility, and independent living. For older adults, regular engagement in physical activity is associated with a reduced risk of cardiovascular disease, diabetes, osteoporosis, and age-related loss of physical and cognitive functions (Chodzko-Zajko et al., 2009; McAuley, Szabo, Gothe, & Olson, 2011). Although some older adults enter behavioral programs and initially increase their physical activity, many fail to stick with physical activity participation over time (Hertogh, Vergouwe, Schuit, Peeters, & Monninkhof, 2010; McAuley et al., 2007). This is an important public health problem because the benefits of a single physical activity session are short-lived, and chronic adaptations to repeated exercise training are quickly lost

within weeks of inactivity (Chodzko-Zajko et al., 2009; Mujika & Padilla, 2000a, 2000b). Clearly, there is a need to identify strategies that are more conducive to maintaining physical activity over time. Identifying older adults' beliefs associated with the maintenance of physical activity is one step in pursuit of that goal. This paper reports the findings of two studies that investigated beliefs related to physical activity maintenance among adults ≥ 60 years.

2.3 Rationale

According to health behavior theories rooted in the social cognitive framework (Bandura, 1998; Fishbein & Ajzen, 2010), people act upon the beliefs or expectations they hold about a specific behavior. *Salient* beliefs – those that are activated spontaneously without much cognitive effort when prompted to think about a specific behavior – represent the basic building blocks upon which people form their intentions to act and self-regulate behaviors (Fishbein & Ajzen, 1975, 2010). For instance, beliefs about consequences (e.g., behavioral beliefs) represent the subjective probabilities people hold about the positive and negative outcomes they might experience if they engage in a given behavior (Fishbein & Ajzen, 1975, 2010). If engaging in a behavior is expected to result in more positive than negative outcomes, people will be more likely to form an intention to act and engage in that behavior. Beliefs about consequences thus serve as standards against which people evaluate the outcomes that have resulted from engaging in the behavior. Beliefs about capabilities (e.g., control and efficacy beliefs) represent the subjective probabilities people hold about their abilities to organize, execute, and regulate action despite the presence of barriers (Bandura, 1997, 1998). People with high confidence in their capabilities to engage in a behavior set for themselves challenging behavioral goals and maintain strong commitment to them, sustain their efforts in the face of barriers and unsatisfying behavioral experiences, and recover their sense of efficacy or control more easily after setbacks. Salient beliefs that are held with the greatest frequency in a population represent a set of beliefs that are *modal* (Fishbein & Ajzen, 1975, 2010).

Although many studies have identified physical activity beliefs in adults aged 18 – 64 years (Downs & Hausenblas, 2005), few have investigated those associated with the *maintenance* of physical activity in adults aged ≥ 60 years (e.g., Brunet, Taran, Burke, & Sabiston, 2013; Horne, Skelton, Speed, & Todd, 2012; Lee, Avis, & Arthur, 2007; Maula et al., 2019; Miller & Brown, 2017; Price, Greer & Tucker, 2013; Sweet, Perrier, Saunders, Caron, &

Dufour Neyron, 2019; Timmons, Griffin, Cogan, Matthews, & Egan, 2019; Wahlich et al., 2017). Beliefs about consequences include the "feel good" effect (e.g., feeling energized or invigorated), as well as the enjoyment of positive social relations with friends or neighbors (Brunet et al., 2013; Horne et al., 2012; Lee et al., 2007; Maula et al., 2019; Miller & Brown, 2017; Timmons et al., 2019; Wahlich et al., 2017). Older adults also believe that maintaining physical activity is an effective way to prevent chronic illnesses, "slow down" the aging process, and remain independent (Maula et al., 2019; Sweet et al., 2019; Wahlich et al., 2017). Illnesses or injuries, weather, cost, and not having an exercise partner have been reported as barriers (Brunet et al., 2013; Floegel et al., 2015; Horne et al., 2012; Maula et al., 2019; Miller & Brown, 2017; Sweet et al., 2019; Timmons et al., 2019; Wahlich et al., 2017).

2.4 Physical Activity Maintenance

The maintenance of behavior change is considered an ongoing process (Kwasnicka, Dombrowski, White, & Sniehotta, 2016; Seymour et al., 2010; Wing, 2000). Although there is variation in the usage of the term "maintenance" across physical activity studies (Amireault, Godin, & Vézina-Im, 2013; van Stralen, de Vries, Mudde, Bolman, & Lechner, 2009), the maintenance process involves the repetition of episodes of sustained engagement that can be discontinued for a short (lapse) or a longer (relapse) period of time and then resumed after a setback (Kahlert, 2015; Marcus et al., 2000; Sallis & Hovell, 1990). Consistent with this conceptualization of behavioral maintenance, the health action process approach (Schwarzer, 1999, 2008) and self-efficacy theory (Bandura, 1997) posit that the type of self-efficacy, along with the underlying efficacy beliefs, differs depending on whether the action is initiated, sustained, or recovered after its interruption. Consequently, the set of salient beliefs related to *sustained engagement* may differ, at least partly, from the set of salient beliefs related to *re-engagement* in physical activity. The extent to which these sets of beliefs are similar or different is unknown. It is important to bridge this knowledge gap because interventions engaging specific beliefs can be either inconsequential or worthwhile, depending on whether people are attempting to sustain or re-engage in physical activity. Absent of such information, opportunities to either prevent lapses or shorten the amount of time it takes for people to resume action after such lapses may well be missed.

2.5 Objectives

This paper reports two analyses of beliefs related to the maintenance of physical activity among adults aged 60 years or older. Study 1 draws from the reasoned action approach (Fishbein & Ajzen, 2010) and was designed to identify modal, salient behavioral beliefs (i.e., beliefs that the behavior will lead to positive or negative outcomes), normative beliefs (i.e., beliefs that important people support or do not support the behavior), and control beliefs (i.e., beliefs that certain factors can facilitate or hinder performance of the behavior) using a free-response format. Study 2 takes an interpretive approach (Glesne, 2016) and was designed to gain a deeper understanding of the extent to which – and how – modal, salient physical activity beliefs influence older adults' experiences with maintaining physical activity through in-depth semi-structured interviews. Together, the findings from both studies make a novel contribution to the physical activity psychology and gerontology literature by identifying potential behavioral program targets that span multiple levels of influence and raise specific hypotheses concerning the relevance of such targets not only for sustaining physical activity, but also for re-engaging in physical activity after a setback.

2.6 Study 1

2.6.1 Methods

Participants of Study 1 consisted of physically active adults aged ≥ 60 years without severe cognitive impairment (i.e., making ≤ 1 error on a three-item recall and three-item temporal orientation screener; Callahan, Unverzagt, Hui, Perkins, & Hendrie, 2002). No participant was excluded based on gender or ethnic background. In order to better ensure optimal data saturation for identifying salient beliefs (Francis et al., 2010; Godin & Kok, 1996), the sample included a total of 25 participants from a fitness center (n = 15) and a community center (n = 10) in Northwest Indiana who reported engaging in leisure-time physical activity ≥ 3 times per week for at least 15 minutes during a typical week. This study was approved by Purdue University's Institutional Review Board (protocol number: 1604017619), and all participants provided their informed consent.

Study promotional flyers were posted in the participating fitness and community center. A consent form, a pre-paid and pre-addressed return envelope, the study questionnaire, and a $10

compensation were mailed to each eligible participant. Each participant completed the questionnaire at home.

2.6.1.1 Measures

2.6.1.1.1 Beliefs Associated with the Maintenance of Physical Activity

In accordance with the reasoned action approach guidelines (Fishbein & Ajzen, 2010), participants were asked to answer open-ended questions concerning their behavioral, normative, and control beliefs associated with the sustained engagement of physical activity. Two additional questions assessed the participants' control beliefs associated with re-engagement in physical activity after imagining themselves being completely inactive for one week (see Appendix A for the complete list of questions). The rationale for one week of inactivity is supported by findings from prior research indicating that declines in physical activity, for a period as short as one week, increase the likelihood of inactivity for a second consecutive week and subsequent failure to re-engage in physical activity (Armitage, 2005).

2.6.1.1.2 Leisure-Time Physical Activity (LTPA)

Each participant completed the Godin-Shephard Leisure-Time Physical Activity Questionnaire (Godin & Shephard, 1985) after listing his or her beliefs about the maintenance of physical activity. People were instructed to consider a typical week and report how many times on average they perform strenuous, moderate, and/or mild physical activity for more than 15 minutes during their free time. A total leisure score index and a moderate-to-strenuous leisure score index were then calculated (Amireault & Godin, 2015). Validity evidence supporting the use of this questionnaire, along with the interpretation of its leisure score indices in adults, have been provided (Amireault & Godin, 2015; Jacobs, Ainsworth, Hartman, & Arthur, 1993; Miller & Freedson, 1994).

2.6.1.1.3 Descriptive Variables

Height and weight were self-reported by the participants, and body mass index (BMI) was calculated by dividing weight (kg) by height squared (m^2). Age, biological sex, relationship

status, educational level, employment status, and self-identified comorbidities (cardiovascular disease, type 2 diabetes, cancer, pulmonary disease, and arthritis) were reported.

2.6.1.2 Data Analysis

A content analysis of the participants' written responses was performed to identify modal salient beliefs (Fishbein & Ajzen, 2010). Participants' responses were independently transcribed and categorized by the authors for each of the four types of beliefs (i.e., behavioral, normative, control – sustained engagement, and control – re-engagement). The authors met to discuss and compare beliefs categories for the four types of beliefs. During this process, some beliefs answers were re-categorized, while others were divided into more specific categories. For example, a disadvantage listed by one participant was removed and re-categorized as a control belief. This response ("travel time to [exercise center]") was better understood as a control belief rather than a disadvantage resulting from physical activity. Frequency tables for each type of belief were created, and beliefs categories were independently labeled and rank-ordered by the number of responses in each category. Modal beliefs were then identified according to a decision rule proposed by Fishbein & Ajzen (2010): beliefs categories that included responses making up 75% of the total number of responses per belief were considered the modal, salient beliefs.

2.6.2 Results

The characteristics of the 25 participants [18 female, 7 male; aged 66 to 88 years (M = 75.9, SD = 5.8)] are displayed in Table 2.1. The majority of respondents were white/Caucasian (96%), married or living with a life partner (56%), and retired (92%).

Table 2.1. Selected table characteristics (N = 25).

Characteristics	Mean (SD)	Minimum	Median	Maximum
Age (years)	75.9 (5.8)	66.0	76.0	88.0
BMI (kg/m^2)	27.3 (3.9)	20.7	26.5	37.7
Leisure Score Index (Total)	32.9 (16.2)	15.0	26.5	72.0
Leisure Score Index (MVPA)[a]	25.5 (15.5)	10.0	17.5	62.0

Notes. BMI: Body Mass Index. MVPA: Moderate-to-Vigorous Physical Activity. [a]Leisure Score Index calculated using reported frequency of moderate and vigorous leisure-time physical activity. A score of 24 or higher indicates achievement of physical activity guidelines.

2.6.2.1 Behavioral Beliefs

Thirteen salient behavioral beliefs were identified and are listed in Table 2.2. A majority of respondents believed that maintaining regular engagement in physical activity helps increase or maintain bone and muscle strength. About a third of the sample endorsed improvement in flexibility, mobility, and balance, and enhanced sleep quality and energy from maintaining regular engagement in physical activity. Respondents indicated that time away from other activities was a disadvantage of maintaining regular engagement in physical activity. Pain and fatigue experienced after exercising were also considered negative outcomes perceived from sustaining regular engagement in physical activity.

Table 2.2. Modal salient behavioral beliefs (N = 25; k = 106).

Belief themes	**Frequency of mention (%)[a,b]**		**Examples**
Advantages/Likes			
Bone and muscle strength	13	(12%)	"Keeps my body in shape and muscles toned"
Flexibility/Mobility/Balance	9	(8%)	"Helps keep me flexible and able to move"
Better sleep, energy and alertness	9	(8%)	"Makes body and mind wake up"
General health	6	(6%)	"Better overall health"
Positive feeling	6	(6%)	"Instant gratification"
Social interactions	6	(6%)	"Working out with others"
Performing activities of daily living	5	(5%)	"Maintaining the ability to function daily"
Stress relief	4	(4%)	"Reduces stress"
Weight management	4	(4%)	"Maintain or lose weight"
Cardio metabolic health	4	(4%)	"Lower blood pressure"
Disadvantages/Dislikes			
Time away from other activities	9	(8%)	"Lack of time to do other activities"
Pain from exercise	7	(7%)	"Back and neck will hurt for days after exercise"
Tired after exercise	4	(4%)	"I'm tired"
Total	**86**	**(81%)**	

Notes. [a]Participants could contribute to more than one belief theme. [b]Percentages may not sum due to rounding. N = number of participants. k = number of distinct responses.

2.6.2.2 Normative Beliefs

Three modal, salient normative beliefs were identified and displayed in Table 2.3. Family members, including spouses, were the most often reported supporters of sustained engagement in physical activity. About a third of the respondents suggested that exercise training staff also encourage physical activity, whereas others mentioned "peers," "friends," "coworkers," and "colleagues."

Table 2.3. List of modal salient normative beliefs (N = 25; k = 38).

Belief themes	**Frequency of mention (%)[a,b]**		**Examples**
Family	16	(42%)	"Family members" / "[My] children" / "Spouse"
Spouse	*9*	*(24%)*	*"Wife" / "Husband"*
Exercise training staff	8	(21%)	"Class instructor" / "Staff"
Friends/Peers/Coworkers	7	(18%)	"Friends" / "Peers who exercise regularly"
Total	**31**	**(82%)**	

Notes. [a]Participants could contribute to more than one belief theme. [b]Percentages may not sum due to rounding. N = number of participants. k = number of distinct responses.

2.6.2.3 Control Beliefs – Sustained Engagement

The salient control beliefs associated with sustained engagement in physical activity are displayed in Table 2.4. The ability to consistently schedule exercise into one's day, whether it be planned into a "regular" schedule or a "flexible" one, was identified as a factor facilitating the maintenance of physical activity. Social support (e.g., help from "[fitness center] staff," having "someone to go exercise with") was also identified as a facilitating factor. The most frequently reported barriers included injuries, illnesses, or pain; and having other commitments, such as having an "out of town visitor" or a "lunch with friends." Both travel and inclement weather were also identified as barriers to maintain engagement in physical activity.

Table 2.4. Modal salient control beliefs (N = 25; k = 40) – sustained regular engagement in physical activity.

Belief themes	**Frequency of mention (%)[a,b]**		**Examples**
Facilitating Factors			
Scheduling	7	(13%)	"Have a regular program and time"
Social support	5	(9%)	"Have someone to go with"
Barriers			
Injuries/Illnesses/Pain	13	(24%)	"Injuries or illness"
Other commitments	7	(13%)	"Family commitments that would require to be away"
Travel	4	(7%)	"Travel plan"
Inclement weather	4	(7%)	"Snow"
Total	**40**	**(74%)**	

Notes. [a]Participants could contribute to more than one belief theme. [b]Percentages may not sum due to rounding. N = number of participants. k = number of distinct responses.

2.6.2.4 Control Beliefs – Re-Engagement

The salient control beliefs associated with re-engaging in regular physical activity after imagining oneself being inactive for seven consecutive days are reported in Table 2.5. Social support (e.g., "encouragement" and "support" from family and friends), personal motivation (e.g., "internal motivation"), and accessibility (e.g., "availability of facilities," "transportation to [a] gym") were identified as factors facilitating re-engagement in physical activity. The most frequently reported barriers to re-engagement in physical activity were injuries, illnesses, or pain; and having other commitments.

Table 2.5. Modal salient control beliefs (N = 25; k = 40) – re-engagement in regular physical activity.

Belief themes	**Frequency of mention (%)[a,b]**		**Examples**
Facilitating Factors			
Social support	6	(13%)	"Encouragement and support from family"
Personal motivation	4	(9%)	"Internal motivation"
Accessibility	4	(9%)	"Availability of hours and assistance at the fitness center"
Barriers			
Injuries/Illnesses/Pain	14	(30%)	"Disability/illness"
Other commitments	7	(15%)	"Outside obligations"
Total	**35**	**(76%)**	

Notes. [a]Participants could contribute to more than one belief theme. [b]Percentages may not sum due to rounding. N = Number of participants. k = Number of distinct responses.

2.7 Study 2

Although the results of Study 1 were informative, the free elicitation format did not provide much context or insight as to how, and to what extent, these beliefs influence the maintenance of physical activity. In Study 2, we further explored the expressed beliefs of Study 1. Specifically, the purpose of Study 2 was to gain a deeper understanding of the findings pertaining to control beliefs for the sustained engagement of and re-engagement in physical activity, as the delineation between the two aspects of physical activity maintenance is largely unexplored.

2.7.1 Methods

Participants of Study 2 consisted of 13 adults aged ≥ 60 years who engage in physical activity at least three times per week. No participant was excluded based on gender or ethnic background. This study was approved by Purdue University's Institutional Review Board (protocol number: IRB-2019-610). The majority of participants were recruited through an older

adult research registry affiliated with the university, and one participant volunteered after reading a study promotional flyer posted in a community setting; participants recruited from the registry reported no indication of Alzheimer's disease or memory loss, and the individual recruited from the flyer reported no serious ailments in general. All participants provided their informed consent and were compensated with $10 for their time.

2.7.1.1 Semi-Structured Interviews

Our questions were crafted using the word "maintenance" rather than "sustained engagement" or "re-engagement" to guard against any leading questions or preconceived notions of when in the maintenance process certain beliefs may be considered important or influential. Instead, we asked questions using the words "when" and "how" to allow for aspects related to either sustained engagement or re-engagement to surface organically. A full list of questions can be found in Appendix B. Interviews were conducted in person, audio-recorded, de-identified, and sent to a third-party service to be transcribed. Interviews and the primary data analyses were conducted by the first author.

2.7.1.2 Data Analysis

The audio-recorded versions of the interviews were listened to and checked for accuracy, and summaries were written about what the participant and interviewer discussed. All transcriptions were re-read, and codes (i.e., words or short phrases) were attributed to the data such that each code captured the essence of the datum in a concise way (Saldaña, 2009). This allowed the data to be linked with other instances of similar meanings. Codes were then deposited in a codebook where they were listed along with descriptions of what they meant with regard to each interviewee's experience (Glesne, 2016). This assemblage enabled the viewing of all codes for all interviews at one time. Codes were grouped into categories, and commonalities between categories led to the formation of broader themes (Saldaña, 2009). The final two interviews did not result in any new information; data saturation was reached at 13 participants.

A draft of the results was presented to the second author to read. This author had read the interview transcripts and therefore was able to assess if the findings resonated with his understanding of the data. We met to discuss the interpretation, overall agreeing on the findings

from the interviews. This discussion also resulted in regrouping a category from one theme into another to better capture the nuances between ideas and how certain influences impact physical activity maintenance. While our agreement is suggestive of the trustworthiness of the following interpretations (Glesne, 2016), we acknowledge that we share a similar prior understanding of the physical activity literature, as well as prior hypotheses based on the first study reported, and qualitative findings are influenced by the investigators' own perceptions and interests (Jootun, McGhee, & Marland, 2009).

2.7.2 Results

Interviews were conducted with 13 participants [8 female, 5 male; aged 67 to 90 years (M = 76.2, SD = 7.1)]. Twelve had been active in some way throughout their lives, and all reported participating in physical activity at least three days per week; many were physically active five days or more. In the following sections, five themes are discussed. Shorter participant quotes are woven into the text, whereas longer participant quotes are presented in Figure 2.1.

2.7.2.1 Feel Good Now and Prevent Decline Later

The participants observed that physical activity made them "feel good" in the moment. For some, this manifested as reduced stress and tension or increased relaxation, and others felt more energized. The enjoyment of the social aspects afforded by the physical activity experience was also mentioned as a motivating benefit.

Another motivator for both sustained engagement and re-engagement in physical activity was the desire to prevent future decline. Many had witnessed other individuals lose certain abilities or "go downhill" with regard to their physical health, and they believed that being physically active was a way to avoid the same fate. The participants were proud of their current abilities and wanted to maintain them. Both Hank and the participant who identified as "Planful" concisely stated, "Move it or lose it." For Roger and Kathleen, seeing others who were less able than they (e.g., those who have difficulty getting out of chairs without struggling) helped them re-engage in physical activity after a time spent being less active than usual. Furthermore, activities such as dancing and Zumba were believed to be beneficial for cognitive purposes.

2.7.2.2 A Well Thought Out Routine Makes It Easier

When asked how they scheduled their physical activity, the participants expanded upon the value of their physical activity routines: these routines make maintaining the behavior easier. Many of the participants have a weekly schedule of physical activities, and others have a specific exercise regimen they complete. Several participants even track their activity or steps on a calendar or device, which helps them manage their schedule or plan for more activity to meet their goals. These individuals have become aware of what works for them specifically, and they have been able to create a routine that caters to their lifestyle. For instance, "History Woman" knows that she is "not a good morning person" and prefers to be active later when her medicine "kicks in." Knowing when physical activity will happen takes the guess work out of the day. To many, motivation is not needed when physical activity has become habitual. Having a routine not only helps individuals sustain their physical activity but is also helpful for re-engaging in physical activity.

Physical activity has become so much a normal part of these participants' daily lives that some alluded to having integrated physical activity into their identity. Even Birdie, the only participant without a long history of physical activity, revealed that her "identity has changed so that [she's] a healthy person." Furthermore, some participants indicated that they were the planning type: Juliet enjoys the structure that having scheduled physical activity gives to the day, Sally called herself a "scheduled person," and one participant even requested that his pseudonym be "Planful." This suggests that the participants' values and personalities were conducive to creating such influential physical activity routines.

2.7.2.3 Supportive Functions: Advice, Feedback on Progress, and Encouragement

The participants also spoke about how support from members of their network helped them sustain their physical activity. For example, personal trainers and class instructors offer invaluable feedback and advice. These individuals serve as reference points for understanding whether certain exercises are being performed correctly and with good form, which allows the physical activity to be carried out safely. Participants were also motivated by receiving feedback about their progress, including improvements in abilities as well as healthy biomarkers. As Paul stated, "My blood pressure was good, my A1C was good, and all this other stuff. So, I guess

[getting a screening] kind of motivates you too . . . Wow, man, [physical activity] is really working."

Several participants reported having been given exercise programs that they follow, but importantly, any recommended physical activity should be viewed as appropriate. After a few sessions with a personal trainer, Tabby remembered, "It was over the top . . . he had all this stuff, and it was all so complicated. I got completely overwhelmed and intimidated, and [the exercises] went in the recycle bin about six months later."

Encouragement – particularly from spouses – was also promoting of physical activity maintenance. Husbands and wives spoke about the mutual support they provide each other for being active. Often, these pairs were active together, and Sandra commented that having her husband exercise as well was reinforcing, since it indirectly implied that he agrees that physical activity is a good behavior. Other members of exercise classes were also seen as supportive. Hank recalled New Year's Eve when his wife wanted to retire from dancing for the night, but his dance friends provided another ride home for her and encouraged him to stay. Juniper's aerobics class also cares for their members: "If you usually show up [to the class], and you don't show up, they're concerned."

2.7.2.4 The Importance of a Location that Meets One's Needs and Preferences

Participants were asked how having access to certain indoor and/or outdoor recreation facilities or outlets helped them remain physically active. They replied with words such as "vital" and "critical," and they elaborated on different aspects that they found important. Convenience, helpful or fun amenities, and enjoyable weather or the provision of an escape from poor weather were three features of locations that were discussed.

Having access to convenient indoor and/or outdoor locations to be active was beneficial for age-related changes ("It's just wonderful because as I've aged, I don't drive as much, I don't do this, I don't do that. This is on my campus, so I just walk out my door and walk over there"), and it could also facilitate more sporadic physical activity. Some participants mentioned that when an exercise class moved locations farther away, several people dropped out of the program, and difficult parking was also perceived as inhibiting to being physically active at certain locations. Additionally, participants spoke to the importance of class times fitting one's personal schedule and the benefit of knowing busy hours. These individuals clearly did not want to spend

a lot of time commuting to and from their chosen physical activity location, nor did they want to spend an unnecessary amount of time within the facility. Sandra concluded that this was due to the importance of time. She noted, "You can't be gone forever . . . Why is time important? Because I have a life, and I want to live it."

Certain amenities within recreational facilities, as well as pleasant additions to these facilities, also facilitated participants' regular participation. Water fountains, showers, and bathrooms were considered handy, and preferable music helped promote enjoyment of the activity. Juniper's aerobics class moves to music: "A fun thing about it is that it's older music. It's music from our youth." Engaging scenery – especially in nature – also makes physical activity more enjoyable.

Finally, many of the interviewees spoke about weather as both a barrier and facilitator. Many enjoyed walking in "nice" weather but would prefer to avoid being outside in "bad" weather (e.g., weather that would be a threat to falls).

2.7.2.5 One Size Does Not Fit All

Interviews with these participants revealed that it is unlikely that the way in which these factors influence physical activity maintenance is the same for everyone or in all instances. For example, while accessibility is paramount, older adults may choose not to engage in such physical activity programs due to an established routine or personal preferences. Both Juniper and Tabby acknowledged their accessibility of "doing some other things that won't cost [much money]" through *Silver Sneakers*, but because Juniper had a routine in place, and because Tabby claimed that "walking around a track was not as fun as walking [around convenience stores] and outdoors," this was not utilized. Furthermore, although Birdie has an accessible and convenient treadmill in her home basement, she prefers to walk outside, as she likes the scenery of the outdoors over "gray basement walls." On the other hand, Juliet also has access to a treadmill at a fitness center and will chose it over walking outside, as this allows her to read while being active. Additionally, several participants appreciate certain locations to be physically active because members of their social network also go to these locations, making them even more attractive areas in which to be active. Sam used to walk on a running track that was across the street from his wife's place of work so that she could join. However, Sam also used to exercise at

an inconvenient facility where his friends still frequent. He noted that while he missed them, it was not enough motivation to return.

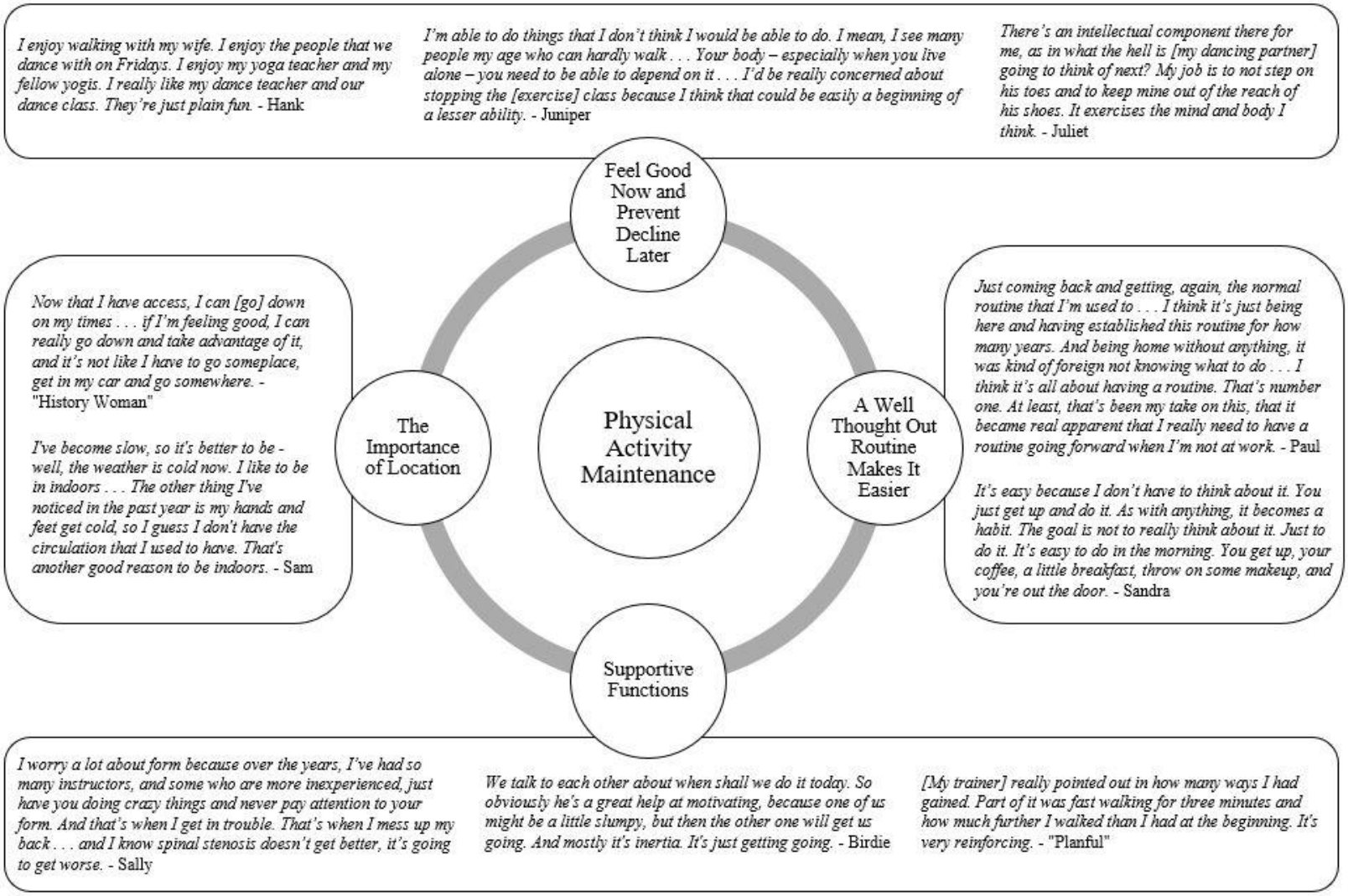

Figure 2.1. Study 2 themes and participant quotes.

2.8 Discussion

The overall purpose of this paper was to investigate beliefs related to physical activity maintenance among adults ages 60 years and older. Study 1 elicited modal, salient beliefs related to the maintenance of physical activity in older adults. Study 2 further investigated how beliefs identified in Study 1 influence older adults' experiences with maintaining their physical activity. Some beliefs appear more relevant to sustained engagement in physical activity, while others may be more helpful for re-engagement in physical activity after a setback. This is consistent with the health action process approach (Schwarzer, 1999, 2008) and self-efficacy theory (Bandura, 1997) that posit that efficacy beliefs should differ depending on whether the action is initiated, sustained, or recovered after its interruption.

The most frequently held behavioral beliefs related to the maintenance of physical activity were the improvement or preservation of muscular and motor fitness, and preventing physical decline was mentioned as a key motivator for maintaining physical activity. These are all instrumental for performing activities of the daily living – another behavioral belief endorsed by older adults. Those interviewed also mentioned that they had personally witnessed other older adults deteriorating in physical function, suggesting that inferential beliefs [i.e., beliefs formed when people observe the consequences (e.g., reduced capacity) produced by another person's (in)action (i.e., not maintaining physical activity; Fishbein & Ajzen, 2010)] may be particularly impactful for this population. Maula et al. (2019) reported similar qualitative findings. Additionally, our study found that witnessing physical declines in similar others was motivating for physical activity re-engagement as well, offering deeper insight as to when these beliefs may be markedly motivating for maintaining physical activity.

Older adults are also motivated to maintain physical activity for the experienced immediate emotional benefits. This is in line with the socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999) which posits that when time horizons grow shorter – which typically occurs as people age – people tend to prioritize the pursuit of goals that bring short-term emotional benefits (e.g., feeling energized and relaxed) and positive social experiences. This is also consistent with the temporal self-regulation theory (Hall, Fong, & Lowe, 2018) which theorizes that temporally immediate behavioral beliefs are weighted more heavily than those that are more distal. Thus, older adults who successfully maintain physical activity may experience more immediate emotional benefits (e.g., enjoyment of social

interactions, better mood) and fewer immediate costs (e.g., neck and joint pain, muscle soreness, fatigue) compared to older adults not maintaining physical activity. These findings agree with previous qualitative research (Brunet et al., 2013; Horne et al., 2012; Lee et al., 2007; Maula et al., 2019; Miller & Brown, 2017; Timmons et al., 2019; Wahlich et al., 2017).

Consistent with prior qualitative investigations (Brunet et al., 2013; Horne et al., 2012; Lee et al., 2007; Maula et al., 2019; Miller & Brown, 2017; Timmons et al., 2019; Wahlich et al., 2017), encouragement from others was reported to be useful for maintaining engagement in physical activity. Previous studies, however, did not elaborate on the nuances of the various support functions throughout the physical activity maintenance process. For instance, the older adults interviewed reported that encouragement from significant others can facilitate the maintenance of physical activity by inspiring them to participate in physical activity in a new way (e.g., by joining a new group exercise class). Furthermore, our results raise the hypothesis that instrumental support (e.g., having someone to go exercise with, having knowledgeable trainers who can provide advice on how to perform specific exercises, feedback on progress toward behavioral- or outcome- based goals) may be more salient for sustaining engagement in physical activity, whereas emotional support (e.g., spouse or peers providing encouragement) may be particularly helpful for re-engaging in physical activity after its interruption. This observation would not be definitive, however, but nonetheless suggests directions for additional research.

The ability to schedule (and stick to) a well thought out physical activity routine was supportive of sustained engagement in physical activity. By scheduling their physical activity (i.e., planning what, when, and where), it is easier for older adults to integrate physical activity into their day and thus maintain the behavior. Self-regulation has been theorized to play a key role in the health behavior maintenance process (Kwasnicka et al., 2016). This finding is consistent with those from studies conducted with older South Asian adults (Horne et al., 2012) and African American women (Price et al., 2013). Our qualitative investigation also highlights that returning to a set routine after time away (e.g., after holiday vacation, traveling) facilitates re-engagement in physical activity.

Nevertheless, French, Olander, Chisholm, and McSharry (2014) have hypothesized that older adults may find self-regulatory techniques either more cognitively difficult to use or less acceptable, while Warner, Wolff, Ziegelmann, Schwarzer, and Wurm (2016) conjectured that

committing to a written activity plan may be an ineffective strategy because it undermines older adults' feelings of autonomy. It is worth noting that the older adults interviewed conceded that being physically active was a part of their identities, and they enjoyed a structured approach to life. Thus, self-regulation may be more effective for people who tend to be more organized, conscientious, and like planning, or who have incorporated activity into their self-concepts. Establishing for whom self-regulation-based techniques may best promote maintenance would therefore constitute a pertinent research avenue.

Access to indoor and outdoor locations to do physical activity was believed to facilitate re-engagement in physical activity. Throughout the interviews, the convenience of certain locations and their helpful or fun amenities were further discussed as important features of the physical environment for physical activity maintenance. Weather was also found to act as both a barrier (e.g., when the weather is bad, indoor activity may be safer) and a facilitator (e.g., when the weather is good, outdoor activity may be chosen because the experience is more enjoyable) of physical activity. Bad weather has been previously reported as a barrier (Maula et al., 2019; Sweet et al., 2019; Wahlich et al., 2017), and convenient locations have been reported in previous literature as facilitators of older adults' physical activity maintenance (Maula et al., 2019). However, while accessibility to indoor or outdoor recreational facilities is essential, our findings suggest that it is likely not enough to promote physical activity maintenance. Importantly, the location should also meet individuals' unique needs and preferences so that the physical activity experience is a fun and pleasurable one. Recall Birdie who prefers walking outside because she enjoys the natural scenery over walking inside on a treadmill. Although walking on her treadmill would be a practical solution for physical activity when the weather is bad, this alternative is not perceived as enjoyable (e.g., boring atmosphere, no social interactions). Behavioral program developers should assess participants' location preferences and attempt to tailor their programs in order to foster long-term physical activity engagement, especially since research has found that older adults' preferred physical activity locations vary highly (Amireault, Baier, & Spencer, 2019).

2.9 Conclusion

What keeps them going, and what gets them back? Immediate emotional benefits and instrumental support appear more relevant to the sustained engagement in physical activity,

while emotional support may be more helpful for re-engagement in physical activity after a setback. Although having access to convenient physical activity locations was discussed as important for both sustaining and re-engaging in physical activity, older adults explicitly indicated that having access to those locations would facilitate re-engagement in physical activity after one week of inactivity. Self-regulation (i.e., scheduling, having a routine) and the expectation that maintaining physical activity will prevent physical declines appear important for both sustaining and re-engaging in physical activity.

The beliefs presented here are representative of three levels of influence: the intrapersonal level (physical and emotional benefits, self-regulation), the interpersonal level (support offered by significant others), and the physical environmental level (access to convenient indoor and outdoor physical activity locations). The 2018 Physical Activity Guidelines Advisory Committee suggested that one potent way to promote sustained physical activity is to target several levels of the socioecological framework within the same intervention (2018 Physical Activity Guidelines Advisory Committee). However, because the socioecological framework does not recommend specific constructs, identifying a parsimonious set of relevant targets for multilevel interventions can be challenging. Thus, our findings provide potential intervention targets that span the intrapersonal, interpersonal, and physical environment levels – along with highlighting the salience of older adults' physical activity preferences – that should be given priority in future efficacy testing of single techniques to determine how and for whom changes in these targets can be maximized in order to best support older adults' physical activity maintenance.

2.10 Conflict of Interest Disclosure Statement

Declarations of interest: None

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2.13 Appendix A.

List of the Open-Ended Questions for the Beliefs Elicitation Study

1. What do you see as the advantages for you to maintain regular engagement in one or more physical activities during your free time in the next 3 months?
2. What would you like or enjoy about you maintaining your regular engagement in one or more physical activities during your free time in the next 3 months?
3. What do you see as the disadvantages for you to maintain regular engagement in one or more physical activities during your free time in the next 3 months?
4. What would you dislike or hate about you maintaining your regular engagement in one or more physical activities during your free time in the next 3 months?
5. Please list the individuals or groups who would encourage you to maintain regular engagement in one or more physical activities during your free time in the next 3 months.
6. Please list the individuals or groups who would discourage you to maintain regular engagement in one or more physical activities during your free time in the next 3 months.
7. Please list any factors or circumstances that would make it easy or enable you to maintain regular engagement in one or more physical activities during your free time in the next 3 months.
8. Please list any factors or circumstances that would make it difficult or hard for you to maintain regular engagement in one or more physical activities during your free time in the next 3 months.
9. Please list any factors or circumstances that would make it easy or enable you to resume regular engagement in one or more physical activities during your free time after being completely inactive for one week (7 consecutive days).
10. Please list any factors or circumstances that would make it difficult or hard for you to resume regular engagement in one or more physical activities during your free time after being completely inactive for one week (7 consecutive days).

2.14 Appendix B.

Semi-Structured Interview Guide

1. Tell me about your current physical activity.
2. How do you know if you are maintaining your physical activity?
3. What would make you consider yourself inactive?
4. What motivates you to be active?

   Probe: When do you need this motivation the most?
5. How has any kind of social support helped you maintain physical activity?

   Probe: When is this social support the most helpful?

   Probe: How would you describe this social support?
6. How do you schedule your physical activity?

   Probe: Is having a set schedule important for you?

   Probe: How does scheduling help you maintain your physical activity?
7. How does having access to areas to *insert activities here* help you remain active?
8. How has your physical activity changed throughout your life?
9. Given that I am interested in helping people maintain physical activity, is there anything else you want to add?

CHAPTER 3. MAINTENANCE MOTIVES FOR PHYSICAL ACTIVITY AMONG OLDER ADULTS: A PROTOCOL FOR A SYSTEMATIC REVIEW AND META-ANALYSIS

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3.1 Abstract

Introduction: Physical activity (PA) is an important aspect for health and well-being, yet many older adults do not maintain their PA long-term. The identification of key factors that are associated with, and likely causally related to, older adults' PA maintenance is a crucial first step toward developing programs that are effective at promoting long-term PA behavior change. The purpose of this protocol is to outline a systematic review that will examine the relationship between four motives (i.e., satisfaction, enjoyment, self-determination, and identity) and older adults' PA maintenance. *Methods and analysis*: Studies that investigated PA maintenance with a sample mean age ≥ 55 years will be included. Five electronic databases (PubMed, CINAHL, SPORTDiscus, PsycINFO, and ProQuest Dissertations and Theses) were searched on April 6th, 2018 with no publication date limit (i.e., from inception). One reviewer screened 100% of titles and abstracts (k = 21,470) while a random sub-sample (20%) was screened independently by two reviewers. An update of the search was run on October 1st, 2019. All studies for which the full text was retrieved will be independently screened by two reviewers. Data pertaining to study sample, design, motives, PA (e.g., measurement validity evidence, study definition of maintenance), and essential bias domains (e.g., bias due to missing data) will be extracted. Study-level effect sizes will be calculated, and if the number of studies is ≥ 5, a random-effects meta-analysis will be performed using inverse-variance methods; a narrative synthesis will be performed otherwise. *Ethics and dissemination*: The university's Human Research Protection Program determined that the proposed study qualifies as exempt from IRB review under Exemption Category 4 (PROPEL #: 80047007). Results will be published in a peer-review journal, and the findings will help inform future interventions with older adults. PROSPERO Registration Number: CRD42018088161.

3.2 Introduction

The benefits of engaging in physical activity are well known and can be experienced across the lifespan. For example, physical activity has been linked to improved quality of life (1), prevention of cardiovascular disease and osteoporosis, management of chronic conditions (e.g., arthritis) (2), and reduced age-related physical and cognitive decline (3) for older adults. Although physical activity is a vital aspect for maintenance of human health and well-being, maintaining regular engagement in physical activity remains challenging for older adults (4,5). For instance, there is mixed evidence supporting the effectiveness of behavioral interventions regarding the maintenance of physical activity beyond program termination (6,7), and declines in physical activity levels are common for older adults after participation in such programs (8,9). This represents an important public health challenge because stopping or reducing physical activity can result in a significant reversal of initial health improvements (2,10,11). Collectively, this information highlights the need to devote special attention to the design of interventions that are more conducive of maintaining physical activity over time.

One of the first essential steps toward helping older adults maintain their physical activity behavior is to identify the most influential factors associated with, and likely causally related to, the maintenance of that behavior (12). The identification of such factors offers foundational insights into what needs to be modified in any future behavioral interventions and thus provides judicious guidance for selecting program components (e.g., behavior change techniques or strategies) that maximally promote the targeted behavior. Therefore, a knowledge synthesis of theory-based motives related to physical activity maintenance in older adults would represent one valuable tool that program developers and researchers could use to ultimately design evidence-based behavioral programs that are more effective for that population.

3.3 Theoretical Rationale

According to a recent framework synthesizing theoretical explanations for the maintenance of behavior change (13), maintenance can be conceptualized through five overarching themes: maintenance motives, self-regulation, resources, habit, and environmental and social influences. Maintenance motives are hypothesized to be different from those motives that underlie the initial adoption of a behavior. The maintenance motive theme consists of three concepts: satisfaction

with behavioral outcomes and enjoyment of the behavior, self-determination, and identity (see Table 3.1). Moreover, maintenance motives are the primary drivers for behavior; they influence priorities, decisions regarding the distribution of relevant resources, and decisions regarding self-regulation (13). Although this framework proposes that these motives are pertinent for all health behaviors and all populations, it is currently unknown if this review-level postulation can generalize to physical activity behavior or to the older adult population. Therefore, the main purpose of this proposed review is to examine if, and to what extent, the theorized maintenance motives are related to the maintenance of physical activity for older adults.

Table 3.1. Maintenance motives for behavior change maintenance.

Maintenance Motive	**Definition**	**Theoretical Basis for Maintenance**
Satisfaction with outcomes and behavioral enjoyment	An individual's positive self-assessment of the relative costs and benefits afforded by the behavior and the behavioral experiences	Satisfactory physical activity outcomes and experiences enhance the tendency to repeat the action by reinforcing the decision to engage in the behavior.
Self-determination	An individual's free choice to engage in a behavior	Physical activity is more likely to be maintained when it is personally relevant, valued, and autonomously chosen.
Identity	An individual's sense of self, including values, beliefs, and needs	The degree to which one's identity is congruent with physical activity fosters internalization and behavioral regulation.

Note. Adapted from Kwasnicka et al. (13).

In the physical activity literature, the term "maintenance" can refer to different behavioral contexts (14). First, maintenance of an intervention-induced change in physical activity refers to situations in which inactive individuals who increased their physical activity in response to participating in a behavioral intervention are still regularly active for a given period of time beyond program termination. Second, maintenance of self-initiated physical activity can refer to

situations in which inactive individuals increased their physical activity on their own (i.e., without participating in a physical activity program) and are still regularly active for a given period of time, as well as situations in which individuals have always been physically active (14). It is worth noting that people who try to maintain physical activity beyond program termination may form a more homogeneous group in terms of their experiences with physical activity behavior compared to those who try to maintain self-initiated physical activity (15). Therefore, these two maintenance contexts will be considered in sub-group analyses.

3.4 Previous Reviews of Correlates of Physical Activity Maintenance

Although many reviews exist examining correlates of physical activity behavior (e.g., see Bauman et al. (16) for a review of systematic reviews about the correlates of physical activity in children and adults), few have examined the correlates of physical activity maintenance specifically. Rhodes and Quinlan (17) and Amireault, Godin, and Vézina-Im (15) systematically reviewed studies of adults ages 18 to 64 and concluded that intention is a predictor of physical activity change and maintenance. Regarding older adults, a narrative review by Rhodes et al. (18) concluded that exercise history, self-efficacy, and social support were related to regular exercise; however, most included studies were cross-sectional. A later systematic review by van Stralen et al. (19) reported that outcome expectations and action planning were associated with physical activity initiation, while coping planning and outcome realization were associated with maintenance across studies for older adults. Additionally, these previous reviews investigated "correlates," "predictors," or "determinants," resulting in a broad scope of factors related to physical activity maintenance. To summarize, few reviews have assessed factors related to physical activity maintenance in the older adult population, and no review has yet to focus on the aforementioned theorized maintenance motives specifically.

The proposed review will expand upon these previous reviews in several ways. First, it will explicitly examine the factors of identity, self-determination, satisfaction, and enjoyment. Second, this review is designed to assess study-level effect sizes and perform meta-analyses rather than synthesize results using vote-counting procedures, as previous reviews of older adults have done (18–20). Third, the proposed review will target older adults ages 55 and older and conduct planned sub-group analyses to impart knowledge regarding for which sub-groups of the targeted population these maintenance motives are more or less influential. We will perform sub-

group analyses based on sample health status, as Amireault et al. (15) found support for health status (apparently healthy adults vs. adults with chronic disease or disability) as a potential moderating variable in their systematic review. Furthermore, Rhodes and Quinlan (17) have suggested that adults over the age of 64 may require separate reviews, and research has indicated that women and men may differ in some sources of motivation (e.g., general social support may be more influential for women's physical activity) (21); therefore, we plan to perform sub-group analyses to determine whether the relationships between the maintenance motives and physical activity vary as a function of sample mean age and percentage of females in the studied sample. Finally, we will perform a sub-group analysis based on study maintenance context (i.e., maintenance of self-initiated physical activity vs. maintenance of physical activity beyond program termination).

3.5 Objectives

The objective of the proposed systematic review is to evaluate the extent to which the maintenance motives are related to physical activity maintenance among older adults aged 55 and older. This review will address the following questions:

1. What maintenance motives are related to physical activity maintenance for older adults?
2. Which maintenance motives are most strongly related to physical activity maintenance for older adults?
3. Does the predictive capacity of the maintenance motives vary according to the following sample characteristics: (1) age, (2) gender distribution, (3) health status (e.g., cancer, diabetes), and/or (4) maintenance context?

3.6 Methods and Analysis

This systematic review protocol was registered in PROSPERO (International Prospective Register of Systematic Reviews; Registration Number: CRD42018088161). This protocol follows the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 guidelines for the description and reporting of systematic review protocols

(22). Any amendments to the protocol will be tracked and dated in PROSPERO. A copy of the PRISMA-P checklist is included in Appendix A.

3.6.1 Study Eligibility Criteria

Studies that investigated physical activity maintenance in an older adult population with a mean age of 55 or older were included. We acknowledge that defining the older adult population as 55 years or older is somewhat arbitrary; however, previous research has used this delineation, arguing that the age group of 55-64 serves as a point of reference marking the age-related decline in health (23).

The study designs that were included are longitudinal, experimental/randomized controlled trials, quasi-experimental, and one-group pre-test-post-test studies which assessed physical activity at least twice (including a follow up assessment for intervention studies) and at least one maintenance motive. No restrictions were placed on the length of the study, follow up, or type of intervention or control group. These types of study designs were purposefully included in order to assess the relationships between the motives and physical activity behavior within the two maintenance contexts (14). Cross-sectional and qualitative studies, books, and book chapters were excluded. No constraints were placed on the publishing year, country, or the language of the studies included.

Furthermore, although Kwasnicka et al. (13) consider enjoyment and satisfaction to be largely the same maintenance motive, from herein, we consider the two as different motives and thus will assess each separately. Although there may be overlap between the two, especially in the physical activity domain (24), it is possible that the studies we retrieve likewise consider them separately (e.g., enjoyment of *physical activity*, satisfaction with *physical activity experiences and outcomes*).

It is also worth mentioning that there is a lack of consensus throughout the literature regarding the conceptualization of maintenance and even some confusion concerning the difference between adherence and uptake (15,19,25). However, we assert that the maintenance of physical activity is not an unwavering continuation of behavior; it is a process that may include multiple episodes of sustained engagement in physical activity that can be discontinued for a short (lapse) or a longer (relapse) period of time and then resumed after a setback (recovery) (14,26–27). Thus, to capture our notion of maintenance while acknowledging others'

understanding and past use of the concept, study-specific assessments of physical activity maintenance were not restricted to a particular study design, follow up duration, or analysis method (e.g., difference scores, residual change scores, dichotomous change scores – relapse versus maintenance, within-person changes) in this review. The requirement is that the studies included must have assessed physical activity at least twice, thereby providing an indication of physical activity trajectories over time. Thus, we will include studies that are controlling, either statistically or by design, for past physical activity behavior – a potential confounding variable (13).

3.6.2 Information Sources and Search Strategies

An electronic databases (coverage period) search strategy was developed by the review team, including a database expert and health sciences information specialist, for PubMed (1946 – 2019), PsycINFO (EBSCO interface; 1887 – 2019), SPORTDiscus (EBSCO interface; 1800 – 2019), CINAHL (EBSCO interface; 1976 – 2019), and ProQuest Dissertations and Theses (1637 – 2019; full-text coverage: 1997 – 2019). For all databases, search terms for the maintenance motives, physical activity, and maintenance were used. Additionally, database-specific Index or Medical Subject Headings (MeSH) terms were used when available. The free text search terms remained constant across all databases, searching across title, abstract, and when available, keyword fields. The database-specific terms were updated for each database, where available, but were identified using the same concepts across all the databases. No date or language filters were used in any of the databases. Filters for resource type (Academic Journals or Dissertations) were used in two of the EBSCO databases (SPORTDiscus and PsycINFO) because of the indexing of periodicals in EBSCO. This option was not used for CINAHL because the filter was experiencing technical difficulties when the searches were run. Full details of an example electronic search for PubMed are presented in Appendix B. A hand search of the reference lists for all eligible full-text articles retrieved and relevant literature reviews (15,17–20) will also be performed to identify additional citations to assess for eligibility. All retrieved literature citation records, after removing duplicates, were uploaded to Rayyan QCRI Web application (28). Rayyan QCRI is a Web application that aids in the housing and screening of abstracts and titles. The results of the search will be reported in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow-chart (29).

3.6.3 Study Selection

The initial search was run on April 6th, 2018. Two reviewers (M.K.H and T.K.C.) independently screened titles and abstracts and excluded clearly irrelevant studies. Specifically, one reviewer (M.K.H.) independently screened 100% of the titles and abstracts (k = 21,470). The second reviewer (T.K.C.) independently screened 20% of the titles and abstracts. Reviewers were instructed to be over-inclusive at this stage of the screening process. If there was insufficient information to certainly conclude that a given citation should be excluded, the citation was retained and included in the full-text screening stage. The decisions were compared, and discrepancies among the two reviewers were resolved by discussion. At the end of this process, the reviewers disagreed on only one study (i.e., 0.023% of the titles and abstracts screened by the two reviewers). The review team concluded that there would likely be no added benefits – but additional time and cost constraints – of having a second reviewer independently screen the remaining 80% of titles and abstracts. Therefore, only one reviewer independently screened all 21,470 titles and abstracts. The full text of the articles decided for inclusion at the title and abstract screening stage were retrieved, and two reviewers (M.K.H. and S.A.) will independently assess the eligibility of each article; the results will be compared, and discrepancies between reviewers will be resolved by discussion. When no consensus can be reached, a third reviewer (J.B.R.) will help resolve the discrepancy. Note that the search was updated on October 1st, 2019 and resulted in two additional relevant articles to be included in the review.

3.6.4 Data Items and Data Extraction

Prior to data extraction, two reviewers (M.K.H. and S.A.) will independently pilot a purpose-built checklist with three randomly selected studies. The checklist will be designed to collect information on the characteristics of the study (e.g., sample size, maintenance context, year of publication, country in which the study was conducted), the maintenance motive measured (e.g., measurement instrument used, measurement validity evidence), the sample (e.g., mean age, percentage of women, ethnicity, level of education, retirement status, health status, marital status), and the physical activity assessed (main outcome; e.g., study definition of physical activity maintenance, measurement instrument used, measurement validity evidence);

specifically, reviewers will extract relevant information regarding all types of physical activity, which may include leisure time physical activity (e.g., walking), sport participation, and/or exercise. All physical activity units (frequency, duration, volume) will be considered, as well as assessments via objective measures (e.g., accelerometers) and self-report. In addition, data required for study-level effect size calculation (e.g., mean, correlation coefficient, odds ratio (OR), standard deviation, analyzed sample size, F-test, chi-square, and t-test values, and p-value) will be extracted. Following the pilot testing, the same reviewers will independently extract data from all included studies, compare results, and resolve any discrepancies through discussion. When no consensus can be reached, a third reviewer (J.B.R.) will help resolve the discrepancy. Authors of primary studies will be contacted (maximum of three email attempts over a maximum of five weeks) to obtain missing information. Relevant information pertaining to the risk of bias in primary studies (30) will be retrieved. More details regarding risk of bias are presented in the following section and in Appendix C.

3.6.5 Risk of Bias Appraisal

The assessment of the risk of bias in primary studies will be conducted using an adapted version of the Risk of Bias In Non-randomized Studies – of Interventions (ROBINS-I; (31)). Accordingly, the following relevant bias domains will be assessed: (*i*) bias due to confounding, (*ii*) bias in selection of participants into the study, (*iii*) bias in measurement of the outcome (i.e., physical activity), (*iv*) bias in the measurement of the exposure (i.e., maintenance motives), (*v*) bias due to missing outcome data, and (*vi*) bias in selection of the reported results. For each bias domain, a set of signaling questions will provide guidance for eliciting relevant information about each bias domain. Because our systematic review is considering observational studies, including the post-intervention features of intervention studies (i.e., follow-up from program termination), additional relevant signaling questions were drawn from a checklist for the assessment of the methodological quality of non-randomized studies of health care interventions (32). The response options for all signaling questions are: Yes; Probably yes; Probably no; No; No information. See Appendix C for the risk of bias tool that will be used. Free text boxes will also be available to the reviewers to provide justification responses in support of their answers to signaling questions and risk of bias judgements for each domain. Three qualitative ratings reflecting the risk of bias judgement will be assigned to each bias domain (33): *low risk of bias*

(plausible bias unlikely to seriously alter the results), *some concerns* (plausible bias that raises doubt about the results), and *high risk of bias* (plausible bias that seriously weakens confidence in the results). We will consider bias domains and their corresponding rating independently without making an overall risk of bias judgement for each primary study. Data will be compared between two reviewers (M.K.H. and S.A.), and discrepancies will be resolved by discussion until consensus is reached. When no consensus can be reached, a third reviewer (J.B.R.) will help resolve the discrepancy.

3.6.6 Data Analysis

Primary study characteristics (e.g., sample size, sample mean age, percentage of female participants, percentage of Caucasian/white participants, study publication year) will be reported for descriptive purposes in a summary table. The study-level effect size, such as odds ratios (OR) for dichotomous outcomes and standardized mean differences (SMD) or Pearson correlation coefficient (*r*) for continuous outcomes will be calculated and reported. The OR and SMD effect sizes will be converted to Pearson correlation coefficients to facilitate interpretation and to allow between-study comparison.

3.6.6.1 Quantitative Synthesis

If the number of included primary studies for a given maintenance motive is ≥ 5, a random-effects meta-analysis will be performed using Comprehensive Meta-Analysis software, version 3 (Biostat; Englewood, NJ, USA, 2014). The inverse-variance method will be used for all meta-analyses (34). Sub-group analyses will be performed according to the following variables: population (e.g., samples with or without health conditions), participant characteristics (sample mean age, percentage of females in the sample), and maintenance context (i.e., maintenance of self-initiated physical activity, maintenance of physical activity beyond program termination). If the ratio of number of studies for each key covariate ≥ 10, meta-regression analysis will be performed instead of sub-group analyses (35). Further variation in effect sizes will be examined with respect to risk of bias in primary studies.

3.6.6.2 Heterogeneity Inspection

Variation in the magnitude and direction of primary effect sizes will be assessed using both qualitative and quantitative criteria (36) by: describing the variation in study-level effect sizes; verifying the amount of overlap (none, minimal, or substantial) in 95% CI's; performing the Cochran *Q* chi-square test, which tests the hypothesis that all studies share a common effect size ($p < 0.10$); and reporting the percentage of total variation in estimated effects that is due to among-study variation rather than chance (I^2). An I^2 value of 25% is considered to reflect low heterogeneity, 50% moderate heterogeneity, and 75% high heterogeneity (37). If heterogeneity is substantial, the summary effect sizes will not be reported; a narrative synthesis will be done instead.

3.6.6.3 Narrative Synthesis

If there is a substantial difference in study sample, or heterogeneity in study-level effect size, a 3-step process will be used to synthesize the body of evidence for each maintenance motive. First, study-level effect sizes for each of the studied maintenance motives will be organized in a table based on the frequency at which a given maintenance motive was examined and study sample size. Second, sample characteristics (e.g., mean age, percentage of female participants, sample health status, maintenance context) will also be organized and displayed in a table. Third, visual inspection of the data displays using Box-and-Whisker plots for all maintenance motive study-level effect sizes will be used to informally examine whether the distribution of effects differs as a function of sample mean age, percentage of female participants, sample health status, risk of bias assessment ratings, maintenance context, and sample size. Within-study moderation or sub-group analysis findings with respect to these characteristics (gender, age, health status, and maintenance context) will also be noted.

3.6.6.4 Publication Bias

Assessment of publication bias will rely on the following assumptions. First, studies, irrespective of their sample size, reporting statistically significant results ($p < .05$) are more likely to be published compared to studies reporting non-statistically significant results. Second, small sample size studies – especially those reporting non-statistically significant results (*p*

≥ .05) – are at the greatest risk for being unpublished. Under such circumstances, small sample size studies reporting the strongest effects are therefore more likely to report statistically significant results (and get published). Conversely, smaller sample size studies reporting trivial, small, and even moderate effect sizes are more likely to remain unpublished. Taken together, the risk of publication bias in systematic reviews will likely increase as the number of small sample size studies included in the review increases (38–40). Therefore, overall likelihood of publication bias will be appraised when there are at least ten study-level effect sizes for the same maintenance motive (41). First, we will conduct a cumulative meta-analysis, where primary studies will be plotted from the most precise to least precise – larger studies will appear toward the top and smaller studies will appear toward the bottom of the forest plot. Publication bias will be suspected if the effects shift (either to the left or right) as we move toward the bottom of the forest plot (42). Second, discrepancy in findings between published studies and dissertation and thesis documents (unpublished studies) will be assessed. Finally, we will visually inspect the distribution of the funnel plot and use the Egger's regression test (38).

3.6.6.5 Quality of Evidence

The quality of evidence for each maintenance motive will be assessed across the domains of risk of bias, consistency of the results, precision and magnitude of the effect (if a meta-analysis is performed), and publication bias, using the GRADE approach (43).

3.7 Patient and Public Involvement

No patient involved.

3.8 Ethics and Dissemination Plan and Implications

The university's Human Research Protection Program determined that the proposed study qualifies as exempt from IRB review, under federal human subjects research regulations Exemption Category 4 (PROPEL #: 80047007). The results of this review will be published in a peer-reviewed journal and presented at relevant scientific conferences. In addition, results will be communicated to members of the target population (i.e., adults ages 55 or older) at relevant

community talks. Importantly, the conclusions of this review will help inform future interventions regarding how to maintain physical activity for older adults.

3.9 Authors' Contributions

All listed authors have contributed and will continue to contribute meaningfully to the protocol and proposed review. M.K.H. and S.A. conceived the proposed review. J.B.R., M.K.H., and S.A. developed the search strategy, and J.B.R. ran the pilot search as well as the final search. M.K.H. and T.K.C. are the two title and abstract reviewers, and M.K.H. and S.A. are the two full-text reviewers; J.B.R. will be the third reviewer that will help resolve any discrepancy. M.K.H. submitted the protocol to PROSPERO and is responsible for updating the registered protocol as needed. All authors read the final protocol manuscript and revised it for content; all also approved the final version.

3.10 Funding Statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

3.11 Conflicts of Interest

Declarations of interest: None

3.12 References

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3.13 Appendix A.

PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

Section and topic	Item No	Checklist item	Location in manuscript
ADMINISTRATIVE INFORMATION			
Title:			
Identification	1a	Identify the report as a protocol of a systematic review	Pages 53 and 57
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number	Pages 53 and 57
Authors:			
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author	N/A
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	Page 65
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	Page 58
Support:			
Sources	5a	Indicate sources of financial or other support for the review	Page 65
Sponsor	5b	Provide name for the review funder and/or sponsor	N/A
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	N/A
INTRODUCTION			
Rationale	6	Describe the rationale for the review in the context of what is already known	Pages 54-57
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	Page 57**
METHODS			
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review	Pages 58-59

Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage	Pages 59-60
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	Appendix B
Study records:			
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	Page 59
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)	Pages 60
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	Pages 60-61
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications	Pages 60-61
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	Pages 61
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	Pages 61-62
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised	Pages 62
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)	Pages 62-63
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)	Pages 62-64
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	Page 63
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)	Pages 63-64
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)	Page 64

*** It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.**

**** The 'comparators' component does not apply to this review. This review is examining the nature of the association between four motives and maintenance of physical activity. The design of studies reviewed is observational in nature (longitudinal design). Two contexts are considered: 1) the maintenance self-initiated physical activity and 2) the maintenance of physical activity beyond program termination.**

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647.

3.14 Appendix B.

Example of the database search for PubMed
((((((("exercise"[mh] OR "physical fitness"[mh])) OR (exercise[tiab] OR exercising[tiab] OR exercises[tiab] OR exerciser[tiab] OR exercised[tiab] OR "physical fitness"[tiab] OR "physical activity"[tiab] OR "physical activities"[tiab] OR "physically active"[tiab] OR walk[tiab] OR walking[tiab] OR walked[tiab] OR walker[tiab] OR walks[tiab] OR walkers[tiab] OR yoga[tiab]))) AND ((("motivation"[mh] OR "personal autonomy"[mh] OR "volition"[mh] OR "personal satisfaction"[mh] OR "social identification"[mh] OR "self concept"[mh] OR "pleasure"[mh] OR "happiness"[mh] OR "affect"[mh] OR "reward"[mh])) OR (motive[tiab] OR motivation[tiab] OR motivating[tiab] OR motives[tiab] OR motivated[tiab] OR autonomy[tiab] OR volition[tiab] OR volitional[tiab] OR satisfaction[tiab] OR satisfying[tiab] OR satisfies[tiab] OR satisfied[tiab] OR "social identity"[tiab] OR "social identities"[tiab] OR "social identification"[tiab] OR "group identification"[tiab] OR "group identities"[tiab] OR "group identity"[tiab] OR belonging[tiab] OR self-concept[tiab] OR self-perception[tiab] OR self-perceptions[tiab] OR self-esteem[tiab] OR pleasure[tiab] OR joy[tiab] OR enjoyment[tiab] OR fun[tiab] OR happiness[tiab] OR happy[tiab] OR affect[tiab] OR affective[tiab] OR reward[tiab] OR rewards[tiab] OR rewarded[tiab] OR rewarding[tiab] OR "body image"[tiab] OR "body images"[tiab] OR "body schema"[tiab] OR "body schemas"[tiab] OR "body representation"[tiab] OR "body representations"[tiab] OR "body dissatisfaction"[tiab] OR self-determined[tiab] OR self-determination[tiab] OR fulfillment[tiab] OR intrinsic[tiab] OR extrinsic[tiab] OR "external regulation"[tiab] OR "introjected regulation"[tiab] OR "integrated regulation"[tiab] OR "psychological needs"[tiab] OR identity[tiab] OR self-schema[tiab] OR self-schemata[tiab]))) AND ((adhere[tiab] OR adheres[tiab] OR adhered[tiab] OR adherence[tiab] OR maintenance[tiab] OR maintain[tiab] OR maintains[tiab] OR maintained[tiab] OR maintaining[tiab] OR continue[tiab] OR continues[tiab] OR continuing[tiab] OR continued[tiab] OR sustain[tiab] OR sustains[tiab] OR sustained[tiab] OR sustaining[tiab] OR sustainable[tiab] OR sustainability[tiab] OR relapsed[tiab] OR relapse[tiab] OR relapses[tiab] OR lapse[tiab] OR lapsed[tiab] OR lapses[tiab] OR engagement[tiab] OR engaging[tiab] OR engaged[tiab] OR engages[tiab] OR within-person[tiab] OR within-subject[tiab] OR longitudinal[tiab])))) NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))))

Note. To run this search properly, all text prior to NOT ("Animals"[Mesh] . . . can be copied and pasted into PubMed. After running that search, one should navigate to the advanced search and use the search builder to add the first part of the search; then, change the drop down box to "NOT" on line 2 and copy the remaining part of the search, beginning with ("Animals"[Mesh] . . .

3.15 Appendix C.

Bias in Selection of Study Participants Selection bias occurs when the study population does not represent the target population. It may occur during identification of the study population. The ideal study population is clearly defined, accessible, reliable, and at increased risk to develop the outcome of interest. When a study population is identified, selection bias occurs when the criteria used to recruit and enroll patients into study are inherently different.		
Items	**Guidance**	**Judgement**
1- Are the characteristics of the people included in the study clearly described?	Inclusion and/or exclusion criteria should be reported. Provide direct quote from the article:	Y / PY / PN / N / NI
2- Did the study apply the inclusion/exclusion criteria uniformly to all study participants?	If the answer to Q1 is "PN," "N," or "NI" the judgement for Q2 should be "NI."	Y / PY / PN / N / NI
3- Does the start of the follow up and the measure of the exposure (i.e., maintenance motives) coincide for most study participants?	If participants are not followed from the start of study (baseline), then a period of follow up has been excluded.	Y / PY / PN / N / NI
4- If "N/PN" to Q3: Were adjustment techniques used that are likely to correct for the presence of selection biases?	It is in principle possible to correct for selection biases, for example, by using inverse probability weights to create a pseudo-population in which the selection bias has been removed, or by modeling the distributions of the missing participants or follow up times and outcome events and including them using missing data methodology. However, such methods are rarely used, and the answer to this question will usually be "N."	Y / PY / PN / N / NI

Bias in Measurement of the Outcome (i.e., Physical Activity) Bias in measurement of the outcome (i.e., physical activity) is related to the measurement of the outcome(s) of interest.		
Items	**Guidance**	**Judgement**
5- Was the PA construct clearly defined?	Consider the level of detail describing the PA domain(s) (e.g., leisure-time, transportation), type (e.g., aerobic, resistance training), or behavior (e.g., walking).	Y / PY / PN / N / NI
6- Was the method of measuring the outcome inappropriate?	This question aims to identify methods of outcome measurement (data collection) that are unsuitable for the outcome they are intended to evaluate. Consider if reliability <u>and</u> validity evidence supporting the use and interpretation of the PA score (e.g., continuous/interval variable, dichotomous scores; e.g., *active* vs. *inactive*, measurement period; e.g., "last 7 days") of a particular instrument to assess PA is provided. Consider whether or not the instrument used to assess PA – as well as the interpretation of the PA score (operational definition) – matches the conceptual definition of PA provided in the article (see Q5). Answer 'Yes' or 'Probably yes' if the method of measuring the outcome is inappropriate, for example, because: (1) it is unlikely to be sensitive to change given the period (e.g. instrument asking participants to consider a "typical week" when answering PA questions) OR (2) the measurement instrument has been demonstrated to have poor validity.	Y / PY / PN / N / NI
7- Were the methods of outcome assessment comparable for all study participants?	Comparable assessment methods (i.e., data collection) would involve the same outcome detection methods and thresholds, same time point, same definition, and same measurements.	Y / PY / PN / N / NI

Bias in Measurement of the Exposure (i.e., Maintenance Motive) **Specify which maintenance motive is being assessed for risk of bias (circle one):** Identity Enjoyment Self-determination Satisfaction		
Items	**Guidance**	**Judgement**
8- Was the maintenance motive construct clearly defined/operationalized?	Consider whether a health behavior theory was used to provide rationale for the selection and measure of a given motive. Consider how confident you are that the items presented map onto the maintenance motive construct, if applicable.	Y / PY / PN / N / NI
9- Was the maintenance motive properly measured?	Consider if reliability evidence supporting the use and interpretation of the maintenance motive score (e.g., continuous/interval variable, dichotomous scores) of a particular instrument to assess that motive is provided. Consider whether or not the instrument used to assess the maintenance motive – as well as the interpretation of the maintenance motive score (operational definition) – matches the conceptual or theoretical definition of maintenance motive provided in the article (see Q8).	Y / PY / PN / N / NI
10- Were the methods of motive assessment comparable for all study participants?	Comparable assessment methods (i.e. data collection) would involve the same measurement methods and thresholds, same time point, same definition, and same measurements.	Y / PY / PN / N / NI

Bias in Selection of the Reported Outcome Results Bias in Selection of the Reported Results has been defined as the selection of a subset of the original outcome variables measured, on the basis of the results, for inclusion in publication. It arises from partial reporting of outcome variables that were measured and analyzed, preventing the outcome for a study being included in the review.		
Items	**Guidance**	**Judgement**
11- Was the PA outcome to be measured described in the introduction or methods sections of the article?	Selective outcome reporting is not possible if the outcome of interest has not been measured. Subsequent questions are unnecessary if the answer to this question is "No."	Y / PY / PN / N / NI
12- Is the numerical result being assessed likely to have been selected, based on the results from multiple eligible outcome measurements (e.g. scales, definitions, time points) within the outcome domain?	Answer 'Yes' or 'Probably yes' if there is clear evidence (usually through examination of a trial/study protocol or statistical analysis plan) that a domain was measured in multiple eligible ways, but data for only one measure or a subset of measures is fully reported (without justification), and the reported result is likely to have been selected based on the results. Selection based on the results can arise from a desire for findings to be newsworthy, sufficiently noteworthy to merit publication, or to confirm a prior hypothesis. For example, trialists who have a preconception or vested interest in showing that an experimental intervention is beneficial may be inclined to report outcome measurements selectively that are favorable to the experimental intervention. Answer 'No' or 'Probably no' if: (1) there is clear evidence (usually through examination of a trial/study protocol or statistical analysis plan) that all eligible reported results for the outcome domain correspond to all intended outcome measurements	Y / PY / PN / N / NI

	OR (2) there is only one possible way in which the outcome domain can be measured (hence there is no opportunity to select from multiple measures) OR (3) outcome measurements are inconsistent across different reports on the same trial, but the trialists have provided the reason for the inconsistency and it is not related to the nature of the results. Answer 'No information' if analysis intentions are not available, or the analysis intentions are not reported in sufficient detail to enable an assessment, and there is more than one way in which the outcome domain could have been measured. Partial or non-reporting conditional on statistical significance or practical significance is what gives rise to outcome reporting bias. Answers of "No" or "Probably no" should map to a judgement of low risk of bias. Answers of "Yes" or "Probably yes" should map to a judgement of high risk of bias.	
13- Is the numerical result being assessed likely to have been selected, based on the results, from multiple eligible analyses of the data?	A particular PA measurement may be analyzed in multiple ways (e.g., conversion of continuously scaled outcome to categorical data with different cut-points). Any analyses that had not been planned at the outset of the study should be clearly indicated.	Y / PY / PN / N / NI

Bias in Selection of the Reported "Exposure Variable"

Bias in Selection of the Reported "Exposure Variable" is defined here as the selection of a subset of the original exposure variable(s) measured, based on the results, for inclusion in publication. It arises from partial reporting of exposure variables that were measured and analyzed, preventing the exposure for a study being included in the review.

Specify which maintenance motives is being assessed for risk of bias (circle one):

Identity Enjoyment Self-Determination Satisfaction

Items	Guidance	Judgement
14- Was the maintenance motive to be measured described in the intro or methods sections of the article?	Selective "exposure" reporting is not possible if the exposure of interest has not been measured. Subsequent questions are unnecessary if the answer to this question is "No." Consider whether a health behavior theory was used to provide rationale for the selection and measure of a given maintenance motive (i.e., the exposure).	Y / PY / PN / N / NI
15- Is the numerical result being assessed likely to have been selected, on the basis of the results from multiple eligible outcome measurements (e.g. scales, definitions, time points) within the outcome domain?	Answer 'Yes' or 'Probably yes' if there is clear evidence (usually through examination of a trial/study protocol or statistical analysis plan) that a domain was measured in multiple eligible ways, but data for only one measure or a subset of measures is fully reported (without justification), and the reported result is likely to have been selected on the basis of the results. Selection based on the results can arise from a desire for findings to be newsworthy, sufficiently noteworthy to merit publication, or to confirm a prior hypothesis. For example, trialists who have a preconception, or vested interest in showing, that an experimental intervention is beneficial may be inclined to report outcome measurements selectively that are favorable to the experimental intervention. Answer 'No' or 'Probably no' if:	Y / PY / PN / N / NI

	(1) there is clear evidence (usually through examination of a trial/study protocol or statistical analysis plan) that all eligible reported results for the outcome domain correspond to all intended outcome measurements OR (2) there is only one possible way in which the outcome domain can be measured (hence there is no opportunity to select from multiple measures) OR (3) outcome measurements are inconsistent across different reports on the same trial, but the trialists have provided the reason for the inconsistency and it is not related to the nature of the results. Answer 'No information' if analysis intentions are not available, or the analysis intentions are not reported in sufficient detail to enable an assessment, and there is more than one way in which the outcome domain could have been measured. Partial or non-reporting conditional on statistical significance or practical significance is what gives rise to outcome reporting bias. Answers of "No" or "Probably no" should map to a judgement of low risk of bias. Answers of "Yes" or "Probably yes" should map to a judgement of high risk of bias.	
16- Is the numerical result being assessed likely to have been selected, on the basis of the results from multiple eligible	A particular maintenance motive measurement may be analyzed in multiple ways (e.g., conversion of continuously scaled outcome to categorical data with different cut-points). Any analyses that had not been planned at the outset of the study should be clearly indicated. Any analyses that had not been planned at the outset of the study should be clearly indicated.	Y / PY / PN / N / NI

analyses of the data?	If no retrospective unplanned subgroup analyses were reported, then answer "Yes."	

Confounding Variables Not controlling for certain variables may bias the results by invalidating any possible effect of the predictor variable(s) on the outcome of interest.		
Items	**Guidance**	**Judgement**
17- Were potentially confounding variables taken into account either in the study design or in statistical analysis?	Appropriate methods to control for measured confounders include stratification, regression, matching, standardization, and inverse probability weighting. They may control for individual variables or for the estimated propensity score. Inverse probability weighting is based on a function of the propensity score. Each method depends on the assumption that there is no unmeasured or residual confounding. For example, lack of adjustment in statistical analysis.	Y / PY / PN / N / NI
18- If Y/PY to Q17: Were confounding domains that were controlled for measured validly and reliably by the variables available in this study?	Appropriate control of confounding requires that the variables adjusted for are valid and reliable measures of the confounding domains. For some topics, a list of valid and reliable measures of confounding domains will be specified in the review protocol but for others such a list may not be available. Study authors may cite references to support the use of a particular measure. If authors control for confounding variables with no indication of their validity or reliability pay attention to the subjectivity of the measure. Subjective measures (e.g. based on self-report) may have lower validity and reliability than objective measures such as lab findings.	Y / PY / PN / N / NI

Bias Due to Missing Data High attrition presents a potential bias if subjects are systematically lost, thus creating unequal groups. Likewise, missing data can produce biased results and invalid conclusions.		
Issues	**Guidance**	**Response**
19- Were outcome data available for all or nearly all participants?	"Nearly all" should be interpreted as "enough to be confident of the findings," and a suitable proportion depends on the context. In some situations, availability of data from 95% (or possibly 90%) of the participants may be sufficient, provided that events of interest are reasonably common in both intervention groups. One aspect of this is that review authors would ideally try and locate an analysis plan for the study.	Y / PY / PN / N / NI
20- Were participants excluded due to missing data on the exposure variable (i.e., maintenance motive)?	Missingness for the maintenance motive may be a problem.	Y / PY / PN / N / NI
21- Were participants excluded due to missing data on other variables needed for the analysis?	This question relates particularly to participants excluded from the analysis because of missing information on confounders that were controlled for in the analysis.	Y / PY / PN / N / NI
22- If PN/N to Q19 or Y/PY to Q20 or Q21: Is a comparison made between full participants and those lost to follow up?	It is always possible that participants who dropped out of the study will differ in some way from those who remained part of the study throughout. A well-conducted study will attempt to identify any such differences between full and partial participants. Any unexplained differences should lead to the study results being treated with caution.	Y / PY / PN / N / NI
23- If PN/N to Q19, or Y/PY to Q20 or Q21: Is there evidence that results were robust to the presence of missing data?	Evidence for robustness may come from how missing data were handled in the analysis and whether sensitivity analyses were performed by the investigators, or occasionally from additional analyses performed by the systematic reviewers. It is important to assess whether assumptions employed in analyses are clear and	Y / PY / PN / N / NI

	plausible. Both content knowledge and statistical expertise will often be required for this. For instance, use of a statistical method such as multiple imputation does not guarantee an appropriate answer. Review authors should seek naïve (complete-case) analyses for comparison, and clear differences between complete-case and multiple imputation-based findings should lead to careful assessment of the validity of the methods used.	

CHAPTER 4. MAINTENANCE MOTIVES FOR PHYSICAL ACTIVITY AMONG OLDER ADULTS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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4.1 Abstract

The purpose of this systematic review was to examine if the motives of satisfaction with outcomes, enjoyment of behavior, self-determination, and identity are related to physical activity (PA) maintenance in older adults. We also explored whether the strength of these associations varies as a function of sample characteristics (i.e., age, gender, physical health status) and maintenance context. Five electronic databases (PubMed, PsycINFO, SportDiscus, CINAHL, and ProQuest Dissertations and Theses) were searched, and sixteen studies (*k*) with a sample mean age ≥ 55 years were included. When the number of studies was ≥ 5 for a given motive, a pooled correlation coefficient was calculated using the inverse-variance method under the random-effects model assumption. Self-determination was positively associated with PA maintenance [*r* (95% CI) = 0.189 (0.127, 0.249); *k* = 11]. This association was stronger and more homogeneous for samples described as having a physical health condition (*r* = 0.212; *k* = 6) and studies judged to be at risk of bias due to missing data (*r* = 0.223; *k* = 8). Few studies (< 5) investigated satisfaction with outcomes, enjoyment of behavior, and identity, which precludes any summary judgment for these three motives. Additional longitudinal research investigating the relationship between satisfaction with outcomes, enjoyment, and identity and older adults' PA maintenance is necessary to determine whether these motives are meaningful intervention targets for this population. PROSPERO Registration Number: CRD42018088161.

4.2 Introduction

Physical activity not only lengthens life, but it also enhances the health and quality of these later years for older adults (Piercy et al., 2018). Behavioral interventions can effectively increase physical activity in older adults (Chase, 2015; Conn, Valentine, & Cooper, 2002; O'Brien et al.,

2015); however, maintaining such changes beyond intervention completion proves difficult for this population (e.g., Hertogh, Vergouwe, Schuit, Peeters, & Monninkhof, 2010; Olson & McAuley, 2015). Habits (inactivity) that have been established for years may persist and interfere with a newly adopted behavior. This is evidenced by the fact that having a history of inactivity is one of the most frequently reported barriers to physical activity participation for older adults (Franco et al., 2015). This is a significant public health problem because the benefits brought on by physical activity are short-lived (Chodzko-Zajko et al., 2009; Mujika & Padilla, 2000a, 2000b). Moreover, because stopping or reducing physical activity can result in a significant reversal of initial health improvements, any behavioral intervention or exercise program that is not effective at promoting sustained physical activity will do little to reduce the burden of disease attributable to inactivity. Therefore, there is an urgent need to devote special attention to the creation of behavioral interventions for the older adult population that are more conducive to maintaining physical activity.

This study reviews the influence of theory-based motives for the maintenance of physical activity in older adults. One of the primary key steps in designing more effective behavioral interventions is to identify factors that are likely causally related to the targeted behavior (Aklin et al., 2020; Riddle, 2015; Sheeran, Klein, & Rothman, 2017). These factors represent potential mechanisms of action (i.e., reasons why an intervention should work). A focus on the maintenance motives provides "mechanistic insights" (Aklin et al., 2020) into physical activity maintenance and offers guidance for the selection of program components that are instrumental in driving such behavior. Therefore, this study provides information for researchers and program developers who aim to create new or refine existing behavioral interventions for the promotion of physical activity maintenance in older adults.

4.3 Maintenance Motives

Kwasnicka, Dombrowski, White, and Sniehotta (2016) conducted a systematic review of 100 health behavior theories and consulted with 25 health behavior theory experts to synthesize theoretical explanations for the maintenance of health behavior. They identified five main theoretical themes: maintenance motives, self-regulation, resources, habit, and environmental and social influences. Kwasnicka et al. (2016) hypothesized the motives to be the primary drivers of behavioral maintenance. Maintenance motives instigate volitional behavior by helping people

set goals, establish priorities, and allocate resources to carry out the intended action (Kwasnicka et al., 2016). As these motives represent theory-based mechanisms of action for health behavior maintenance, they will be the primary focus of this review. These motives consist of satisfaction with outcomes and enjoyment of behavior, self-determination, and identity.

4.3.1 Satisfaction with Outcomes and Enjoyment of Behavior

Physical activity is more likely to be maintained if it provides frequent, immediate, positive reinforcements, such as satisfaction with personally relevant outcomes (Aarts, Paulussen, & Schaalma, 1997; Baldwin & Sala, 2018; Nigg et al., 2008; Rothman, 2000) or enjoyment (Wankel, 1993). Perceived enjoyment reflects an assessment of the positive feelings (e.g., joy and pleasure) that occur during the performance of the behavior (Wankel, 1993). According to Baldwin and Sala (2018), perceived satisfaction reflects an overall assessment of both the positive *and* negative experiences, as well as the outcomes that result from engaging in the behavior. This feeling of satisfaction "indicates that the initial decision to change the behavior was correct, and furthermore, it sustains the effort people must put forth to monitor their behavior and minimize vulnerability to relapse" (Rothman, 2000, p. 66). Additionally, initial expectations serve as standards against which people repeatedly assess the outcomes of behavior change and determine whether it is worth continuing. From herein, we consider satisfaction with outcomes and enjoyment as separate maintenance motives.

4.3.2 Self-Determination

Physical activity should be maintained if it is considered relevant, is consistent with one's values, and is personally chosen – that is, if people's motivation is self-determined (Ryan & Deci, 2000). Specifically, people who are inclined to engage in physical activity out of personal interest or for the challenge of the experience (e.g., intrinsic motivation) are more likely to maintain the behavior compared to people who engage in physical activity for instrumental reasons (i.e., extrinsic motivation; Deci & Ryan, 2000).

4.3.3 Identity

Identities are cognitive generalizations about the self that people create from past experiences (Markus, 1977) and which are tinted by people's social and cultural landscapes (Stryker & Burke, 2000). People are biased to self-regulate their behavior to be in line with their held identity and therefore are more likely to maintain such behaviors. Thus, if older adults view themselves as people who keep physically active (i.e., they hold a physical activity identity), they should regularly engage in physical activity to demonstrate to themselves and others that their behaviors are congruent with this identity.

4.4 Previous Reviews of Correlates of Older Adults' Physical Activity Maintenance

Several reviews have investigated correlates of physical activity (e.g., demographic characteristics, socio-cognitive constructs) within the older adult population (Koeneman, Verheijden, Chinapaw, & Hopman-Rock, 2011; Notthoff, Reisch, & Gerstorf, 2017; Plonczynski, 2003; Rhodes et al., 1999; van Stralen, de Vries, Mudde, Bolman, & Lechner, 2009). Based on three studies with younger samples and three studies of older adults, Rhodes et al. (1999) and van Stralen et al. (2009) provided support for enjoyment as a correlate of physical activity maintenance. Although systematic reviews have examined the associations between self-determination (Rodrigues et al., 2018; Teixeira, Carraça, Markland, Silva, & Ryan, 2012), identity (Rhodes, Kaushal, & Quinlan, 2016), and physical activity, most of the evidence was derived from younger samples. No systematic review exists investigating the link between satisfaction with behavioral outcomes and physical activity.

The current systematic review expands upon previous knowledge syntheses in four ways. First, it explicitly reviews the literature surrounding the four motives of satisfaction with outcomes, enjoyment of behavior, self-determination, and identity, and older adults' physical activity maintenance. Prior reviews developed search strategies to investigate "correlates," "predictors," or "determinants," resulting in a wide-ranging selection of factors reviewed but potentially missing pertinent research on these specific motives (albeit, many were conducted prior to the integration of these motives into a maintenance theme). Second, rather than rely on subjective and potentially misleading rules (e.g., statistical significance vote counting procedures), the current systematic review integrates meta-analysis to summarize the strength of

effects under investigation. Third, the current systematic review considers the risk of bias of the reviewed studies. This information will be used to examine reasons for diversity in effect size and to rate the certainty of the synthesized evidence. Fourth, while it is important to ascertain if these motives are related to physical activity maintenance for the older population in general, it is also critical to determine for whom and under what conditions these relationships are stronger (Riddle, 2015; Sheeran et al., 2017). As such, this current systematic review assesses the relationship between study-level sub-group memberships or moderators (i.e., health status, age, gender, and maintenance context) and effect size.

4.5 Objective

The purpose of this systematic review is to evaluate the extent to which the maintenance motives are related to physical activity maintenance among adults aged 55 years and older. The specific aims of this review are to determine: 1) which of the four motives, if any, are related to physical activity maintenance, 2) which of the motives are most strongly related to physical activity maintenance, and 3) if the predictive capacity of the motives varies according to age, gender, health status (e.g., arthritis, cancer, cardiovascular disease, diabetes), and maintenance context (i.e., maintenance after an intervention or physical activity program or maintenance after self-initiated physical activity).

The protocol for this systematic review was registered in PROSPERO (International Prospective Register of Systematic Reviews; Registration Number: CRD42018088161) and has been published elsewhere (Huffman, Reed, Carpenter, & Amireault, 2020). Otherwise stated, no changes were made to the protocol. This review report follows the PRISMA guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009).

4.6 Methods

4.6.1 Study Eligibility Criteria

We included studies with a sample mean age of at least 55 years that assessed physical activity in the context of behavioral maintenance. Specifically, we included the following study designs: longitudinal, experimental/randomized controlled trials, quasi-experimental, and one-group pre-test-post-test.

Physical activity maintenance is conceptualized in this review as a process that includes multiple episodes of sustained engagement, as well as discontinuations of shorter (lapse) or longer (relapse) duration (Kahlert, 2015; Marcus et al., 2000; Sallis & Hovell, 1990). However, there is not an agreed upon conceptual definition of physical activity maintenance. To account for the varying definitions, no restriction was placed on study assessment or conceptualization of maintenance (e.g., dichotomously classifying participants as "maintainers" or "non-maintainers," assessing within-person changes, defining specific time restraints). All studies were required to have assessed physical activity at least twice in order to provide an indication of maintenance of physical activity over time. Importantly, (quasi-)experimental/randomized controlled trials were required to have assessed physical activity at a follow up assessment post-intervention; this requirement ensured any study included in the review that reported outcomes of a program or intervention also included an assessment of attempted maintenance beyond program completion. No restriction was placed on the length of the follow-up. Cross-sectional and qualitative studies, books, and book chapters were excluded.

Furthermore, all studies were required to have assessed either satisfaction, enjoyment, self-determination, identity, or a combination of these motives, at least once during the study and to have examined the association between the motive(s) and maintenance. No restrictions were placed on location, publishing year, or study language. This study qualified as exempt from Institutional Review Board review, under federal human subjects research regulations Exemption Category 4 (PROPEL #: 80047007).

4.6.2 Information Sources and Search Strategies

Five electronic databases [PubMed (1946-2019), PsycINFO (EBSCO interface; 1887-2019), SportDiscus (EBSCO interface; 1800-2019), CINAHL (EBSCO interface; 1976-2019), and ProQuest Dissertations and Theses (1637-2019; full-text coverage: 1997-2019)] were searched using a search strategy developed by the review team. An example search for PubMed is presented in Appendix A. Identified records were uploaded to Rayyan QCRI Web application (Ouzzani, Hammady, Fedorowicz, & Elmagarmid, 2016) to efficiently screen abstracts and titles and share decisions between two reviewers. The initial search was conducted on April 6th, 2018, and an updated search was performed on October 1st, 2019. Additionally, reference lists of included full-text articles and relevant literature reviews (Amireault, Godin, & Vézina-Im, 2013;

Koeneman et al., 2011; Rhodes et al., 1999; Rhodes & Quinlan, 2015; van Stralen et al., 2009) were also searched to identify any potentially eligible studies.

4.6.3 Study Selection

Duplicates were first removed from the records retrieved from the search. One reviewer (M.K.H.) independently screened 100% of the titles and abstracts, while a second reviewer (T.K.C.) independently screened 20%. The two reviewers met to compare their decisions, and after discussion, they disagreed on one study (0.02% of those screened by each). The same reviewer who screened 100% of the titles and abstracts resulting from the first search also screened all the titles and abstracts resulting from the updated search (2,916 records). The full text of the articles decided for inclusion were retrieved, and two reviewers independently screened these studies for eligibility. Full details are reported in Figure 4.1.

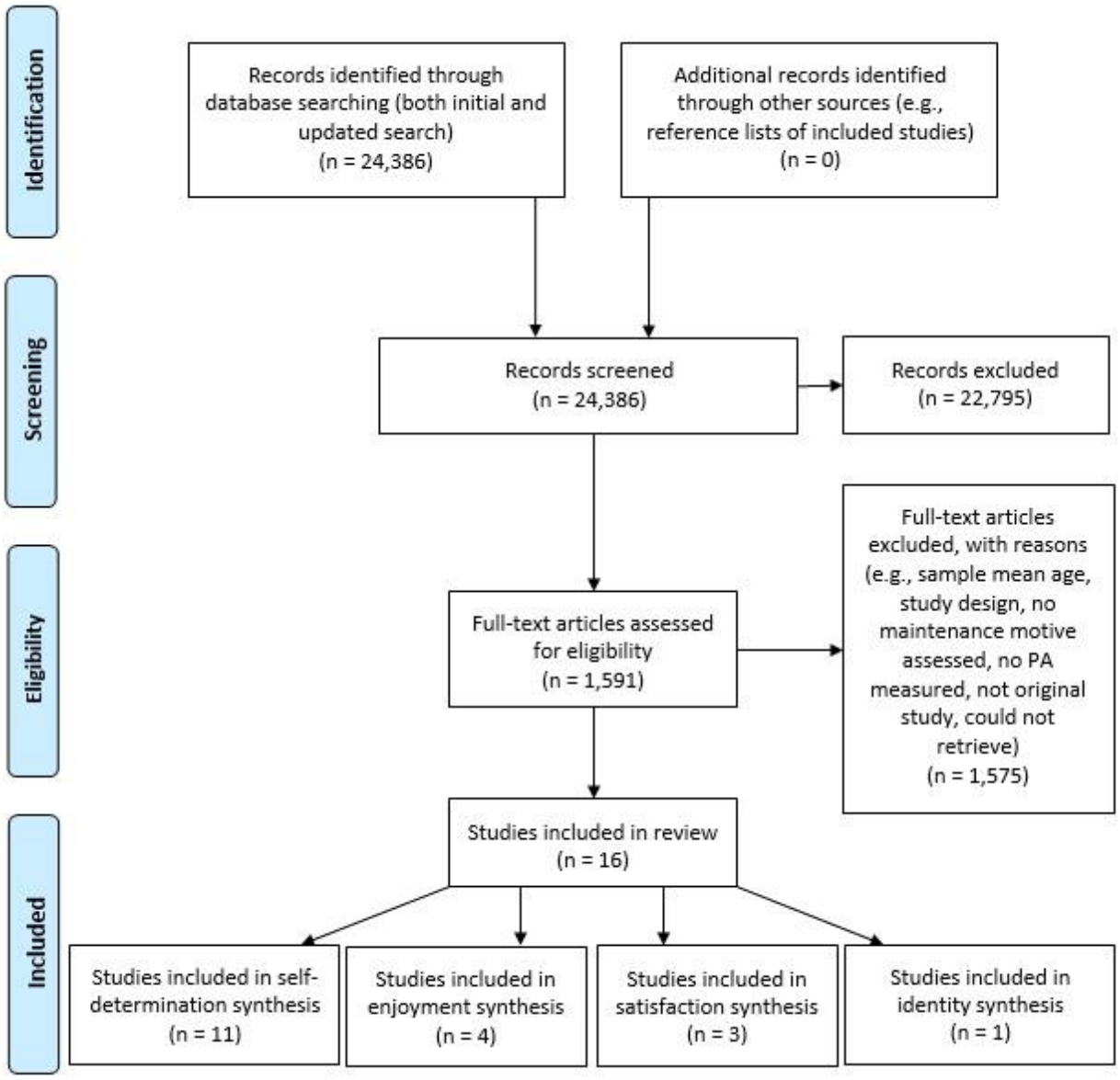

Figure 4.1. A flow diagram of study selection. Adapted from The PRISMA Group (2009).

Note. The sum of studies included for the self-determination, enjoyment, satisfaction with outcomes, and physical activity identity exceeds 16 because three studies examined two motives. PA: Physical Activity.

4.6.4 Data Extraction

Prior to data extraction, two reviewers (M.K.H. and S.A.) independently piloted a checklist developed to extract pertinent study information. The same two reviewers independently extracted information on characteristics of the study (e.g., sample size,

maintenance context), the maintenance motive (e.g., measurement instrument used), characteristics of physical activity (e.g., type of physical activity, measurement instrument used), characteristics of the sample (e.g., mean age, percentage of women in the sample), and study-level effects and descriptions of the relationship between the maintenance motive and physical activity (e.g., odds ratio, regression coefficient). When necessary, authors of primary studies were contacted to confirm the sample mean age of the study. Five authors were contacted to obtain sample mean age information, of which four replied within a five-week span. Three authors were contacted to obtain further relevant statistical information so that study-level effect sizes could be readily calculated. One granted us access to the data from the original analysis (Rahman, Hudson, Thøgersen-Ntoumani, & Doust, 2015). The two reviewers (M.K.H. and S.A.) met to compare extracted data, and any disagreements were resolved through discussion.

4.6.5 Risk of Bias Appraisal

Risk of bias was assessed using signaling questions from an adapted version of the Risk of Bias In Non-randomized Studies – of Interventions (ROBINS-I; Sterne et al., 2016), with additional signaling questions adapted from a checklist for the assessment of quality of non-randomized studies of healthcare interventions (Downs & Black, 1998). Relevant bias domains assessed were: bias due to confounding, bias in selection of participants into the study, bias in measurement of the physical activity, bias in the measurement of the motive(s), bias due to missing data, and bias in the selection of the reported results. Two review authors (M.K.H. and S.A.) independently answered the signaling questions for each bias domain for each included study and met to compare decisions; all discrepancies were solved through discussion. Based on the answers to the signaling questions, three qualitative ratings were then assigned to each bias domain (Higgins, Altman, & Sterne, 2011): *low risk of bias* (plausible bias unlikely to seriously alter the results), *some concerns* (plausible bias that raises some doubt about the results), and *high risk of bias* (plausible bias that seriously weakens confidence in the results). A fourth rating (*no information*) was also applied to the domain of bias in the selection of study participants, as it was decided that if information was not sufficiently reported regarding inclusion and exclusion criteria, we could not make an appropriate assessment as to whether the study had a high or low risk of bias for this domain. Risk of bias information was used to examine whether diversity in

primary study effect sizes could be explained by risk of bias and to rate the certainty of our conclusions. The risk of bias for each study and each domain is presented in Appendix B.

4.6.6 Data Analysis

4.6.6.1 Quantitative Synthesis

A meta-analysis was conducted using Comprehensive Meta-Analysis software, version 3 (Biostat; Englewood, NJ, USA, 2014) for motives with ≥ 5 included studies. A summary effect size (*r*) and the accompanying 95% confidence interval (95% CI) was calculated using the inverse-variance method under the random-effects model assumption. Pre-planned random-effects meta-regressions were conducted based on sample mean age, percentage of female participants in the study, whether the participants of the study had a specific health condition, and the maintenance context. Moreover, risk of bias judgment (*low risk* vs. *some concerns/high risk*) for all bias domains were entered in separate meta-regression analyses to assess whether the judged risk influenced the findings.

4.6.6.2 Heterogeneity Inspection

We conducted a visual inspection of the forest plot to appraise the variation in study-level effect sizes and the amount of overlap in the 95% confidence intervals. We performed the Cochran *Q* test to determine if all studies shared a common effect size ($\alpha = 0.10$). Additionally, we considered the percentage of total variation in estimated effects due to between-study variation (I^2); a value of 25% was considered to reflect low heterogeneity, 50% to reflect moderate heterogeneity, and 75% to reflect high heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003).

4.6.6.3 Narrative Synthesis

Our original protocol (Huffman et al., 2020) proposed a visual inspection of box-and-whisker plots for the studies of the motives that did not meet our meta-analysis criterion (i.e., < 5 studies). However, we determined that such a visual inspection would not be an effective representation of study findings. Rather, harvest plots (Ogilvie et al., 2008) were constructed,

and findings from these studies are narratively described along with a tabular display of study characteristics.

4.6.6.4 Publication Bias

The likelihood of publication bias was appraised when there were at least 10 study-level effect sizes for a given maintenance motive (Sutton, Duval, Tweedie, Abrams, & Jones, 2000). First, we conducted a cumulative meta-analysis where primary studies were plotted according to sample size on a forest plot and used Trim and Fill method (Borenstein, Hedges, Higgins, & Rothstein, 2009). Publication bias was suspected if the effects shifted away from the center toward the bottom of the plot. Second, we conducted a visual inspection of the distribution of the funnel plot of meta-analyzed studies and performed the Egger's test ($\alpha = 0.10$) of the intercept (Egger, Smith, Schneider, & Minder, 1997). Third, discrepancies in findings between published studies and dissertation and thesis documents (unpublished studies) were assessed, if at least one published and one unpublished study was included for a given motive.

4.6.6.5 Quality of Evidence

The quality of evidence for each maintenance motive was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework (Schünemann et al., 2019).

4.7 Results

The search resulted in 24,386 potentially relevant records (Figure 4.1). A total of 15 peer-reviewed articles and 1 doctoral dissertation were included in the review. Listed in Table 4.1 are the study characteristics of the primary studies included in the systematic review. These studies span over 20 years of research (1997 to 2018) and were conducted in nine different countries. Only three studies assessed more than one motive (Kuroda, Sato, Ishizaka, Yamakado, & Yamaguchi, 2012; Sincharoen, 2005; Williams et al., 2008). Given the number of primary studies investigating the association between theory-based motives for the maintenance of physical activity, a quantitative synthesis was conducted for self-determination, whereas a qualitative synthesis was conducted for satisfaction with outcomes, enjoyment, and identity.

Table 4.1. Sample characteristics of studies examining the association between maintenance motives and physical activity in older adults.

Author (year)	Country	Sample characteristics	Maintenance motive(s)	Measure(s) of physical activity	Maintenance context	Length of follow-up
Boyette, Sharon, & Brandon (1997)	United States	*N* = 46 adults Mean age (SD): 71.3 (4.6) years 71.7% ♀	Perceived satisfaction: changes in satisfaction with exercise routine	Physical Exercise Profile (self-report)	Intervention-induced maintenance	6 months
Floegel et al. (2015)	United States	*N* = 24 adults Mean age (SD): 65.0 (8.8) years 87.5% ♀	Self-determination: changes in motivation to exercise (Exercise Motivation Scale)	Godin-Shephard Leisure-Time Exercise Questionnaire (self-report)	Intervention-induced maintenance	14 months
Frensham, Parfitt, & Dollman (2018)	Australia	*N* = 91 cancer survivors Mean age (SD): 65.6 (9.3) years 51.6% ♀	Self-determination: changes in motivation to be physically active (Physical Activity Maintenance Assessment)	Pedometer	Intervention-induced maintenance	3 months
Kekäläinen, Kokko, Tammelin, Sipilä, & Walker (2018)	Finland	*N* = 104 adults Mean age (SD): 68.5 (2.8) years 54.9% ♀	Self-determination: changes in motivation to be physically active and to resistance train (Exercise Self-Regulation Questionnaire)	Telephone interview (self-report)	Intervention-induced maintenance	12 months

Table 4.1 continued

Knittle, de Gucht, Hurkmans, Vleiland, & Maes (2016)	Netherlands	*N* = 78 rheumatoid arthritis patients Mean age (SD): 62.8 (11.8) years 66.7% ♀	Self-determination: motivation to be physically active (Treatment Self-Regulation Questionnaire items)	Short Questionnaire to Assess Health-Enhancing Physical Activity (self-report)	Intervention-induced maintenance	26 weeks
Kuroda, Sato, Ishizaka, Yamakado, & Yamaguchi (2012)	Japan	*N* = 385 adults Mean age (SD): 55.0 (10.9) years 40.0% ♀	Enjoyment: changes in enjoyment of physical activity (The Physical Activity Enjoyment Scale) Self-determination: changes in motivation to exercise (Self-Determined Exercise Motivation Scale)	Stage-based exercise questions (self-report)	Self-initiated maintenance	3 months
Meunier et al. (2016)	Canada	*N* = 295 adults with type 2 diabetes Mean age (SD): 59.4 (10.8) years 49.8% ♀	Self-determination: motivation to exercise (Treatment Self-Regulation Questionnaire)	Summary of Diabetes Self-Care Activities – Revised (self-report)	Self-initiated maintenance	11 months

Table 4.1 continued

Rahman, Hudson, Thøgersen-Ntoumani, & Doust (2015)	Wales	*N* = 389 adults with heart disease Mean age (SD): 64.0 (9.0) years 34.3% ♀	Self-determination: changes in motivation to exercise (Behavioral Regulation in Exercise Questionnaire-2)	Baecke's Questionnaire of Habitual Physical Activity (self-report)	Intervention-induced maintenance	6 months
Russell & Bray (2009)	Canada	*N* = 68 adults with heart disease Mean age (SD): 64.9 (8.9) years 13.0% ♀	Self-determination: motivation to exercise (Behavioral Regulation in Exercise Questionnaire-2)	7-Day Physical Activity Recall (self-report)	Intervention-induced maintenance	6 weeks
Sincharoen (2005)[1]	United States	*N* = 282 adults Mean age (SD): 74.0 (7.8) years 68.4% ♀	Enjoyment: interest in physical activity Identity (adapted Exercise Identity Scale)	Stage-based physical activity questions (self-report)	Self-initiated maintenance	5 months
Slovinec D'Angelo, Pelletier, Reid, & Huta (2014)	Canada	*N* = 801 adults with heart disease Mean age (SD): 61.4 (10.0) years 24.6% ♀	Self-determination: motivation to exercise (Physical Activity Regulation Scale)	Godin-Shephard Leisure-Time Exercise Questionnaire (self-report)	Self-initiated maintenance	12 months

Table 4.1 continued

Ungar, Wiskemann, & Sieverding (2016)	Germany	*N* = 67 cancer patients Mean age (SD): 55.5 (12.6) years 52.2% ♀	Enjoyment: current and changes in enjoyment of physical activity	Modified Short Questionnaire to Assess Health-Enhancing Physical Activity (self-report)	Intervention-induced maintenance	14 weeks
Van Roie, Bautmans, Coudyzer, Boen, & Delecluse (2015)	Belgium	*N* = 56 adults Mean age (SD): 68.0 (5.0) years 53.6% ♀	Self-determination: motivation to participate in resistance exercise (Behavioral Regulation in Exercise Questionnaire-2)	Interview (self-report)	Intervention-induced maintenance	24 weeks
van Stralen, de Vries, Mudde, Bolman, & Lechner (2011)	Netherlands	*N* = 1,971 adults Mean age (SD): 64.0 (8.6) years % ♀ Not reported	Self-determination: changes in motivation to be physically active	Dutch Short Questionnaire to Assess Health-Enhancing Physical Activity (self-report)	Intervention-induced maintenance	6 months
Williams et al. (2008)	United States	*N* = 205 adults Mean age: ≥ 55 years[2] 83.9% ♀	Enjoyment: enjoyment of physical activity (The Physical Activity Enjoyment Scale) Perceived satisfaction: expectancy violation	7-Day Physical Activity Recall (self-report)	Intervention-induced maintenance	6 months

Table 4.1 continued

Williams et al. (2016)	United States	*N* = 123 prediabetic adults Mean age (SD): 59.5 (5.4) years 74.0% ♀	Perceived satisfaction: changes in **s**atisfaction with the outcomes of resistance training	Timeline follow back calendars (self-report)	Intervention-induced maintenance	6 months

Notes. [1]*Doctoral dissertation.* [2]*Personal contact with the corresponding author confirmed that the sample mean age was ≥ 55 years.*

4.7.1 Quantitative Synthesis

4.7.1.1 Self-determination

Eleven studies examined the association between self-determination and physical activity maintenance. The mean age of the samples ranged from 55.0 to 68.5 years, and sample sizes at study onset ranged from 24 to 1,971. The percentage of females within each sample ranged from 13% to 87.5%, and eight studies examined the maintenance of physical activity beyond program completion (length of the follow up ranged from six weeks to 14 months). The length of the observational studies ranged from three to 12 months. Five studies focused on apparently healthy older adults, while the remaining studies focused on patients with rheumatoid arthritis (Knittle, De Gucht, Hurkmans, Vlieland, & Maes, 2016), cancer survivors (Frensham, Parfitt, & Dollman, 2018), patients with type 2 diabetes (Meunier et al., 2016), and cardiac patients (Rahman et al., 2015; Russell & Bray, 2009; Slovinec D'Angelo, Pelletier, Reid, & Huta, 2014). In most studies, self-determination was measured either with the Behavioral Regulation in Exercise Questionnaire-2 or with the Treatment Self-Regulation Questionnaire. Physical activity (e.g., minutes/week) or frequency of resistance training (e.g., number of training sessions/week) were assessed by means of self-report instruments, except for Frensham et al.'s (2018) study, which used pedometers to record step count.

4.7.1.2 Data Preparation

Before computing summary effects for the self-determination analyses, some raw data needed to be transformed or estimated. Rationale and details underlying the conversion and estimation of data are reported in Appendix C.

4.7.1.3 Meta-Analysis

Data for the self-determination and physical activity maintenance association includes 11 independent samples, totaling 3,738 older adults (see Figure 4.2). The pooled analysis revealed a positive association between self-determination and physical activity maintenance [r (95% CI) = 0.189 (0.127, 0.249)]. Three sensitivity analyses, reported in Appendix C, consistently revealed similar positive associations.

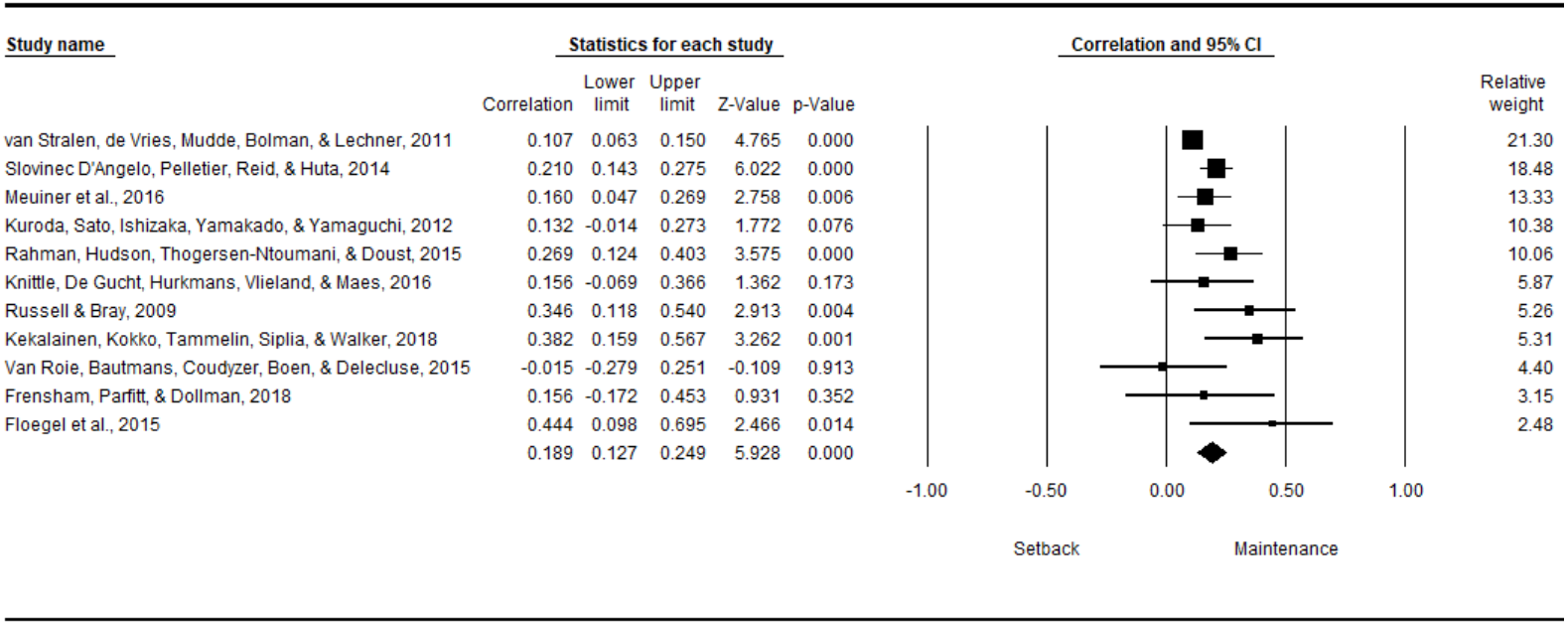

Figure 4.2. Self-determination and the maintenance of physical activity in older adults – forest plot.

Note. Study-level effect size data for Van Roie et al.'s (2015) study were unreported in the article. Data were obtained from the corresponding author.

4.7.1.4 Heterogeneity Inspection

The study-level effect sizes ranged from -0.015 to 0.444. There was minimal overlap in the calculated study-level confidence intervals, the Cochran's Q (10) = 20.77; p = 0.02, and the I^2 statistic = 51.86%. Taken together, there is converging evidence that the effect sizes for the self-determination vary, and this between-study variation is of moderate magnitude.

4.7.1.5 Publication Bias

Only published peer-reviewed articles were included in the meta-analysis; thus, it was not possible to compare findings from published studies and unpublished studies (i.e., dissertation and thesis documents). The inspection of the forest plot of the cumulative meta-analysis (see Figure 4.3) revealed a slight shift toward favoring maintenance of physical activity as sample sizes decreased, notably from the study with the largest sample size (N = 1,971) to the next largest one (N = 801). The Egger's test of the intercept provided a t value (9) equal to 1.20 (1-tailed p = 0.04). The visual inspection of the funnel plot depicted in Figure 4.4 is suggestive of asymmetry at the bottom. Nonetheless, using Trim and Fill method, the imputed point estimate [r (95% CI)] is 0.182 (0.120, 0.243), which is close to the pooled estimate from the primary meta-analysis [0.189 (0.127, 0.249)]. Therefore, even if there is evidence of publication bias, its impact is likely modest. In other words, if we had been able to retrieve other unpublished studies, results from the Trim and Fill method suggest that these additional studies may have altered the effect numerically, but the practical significance would remain the same.

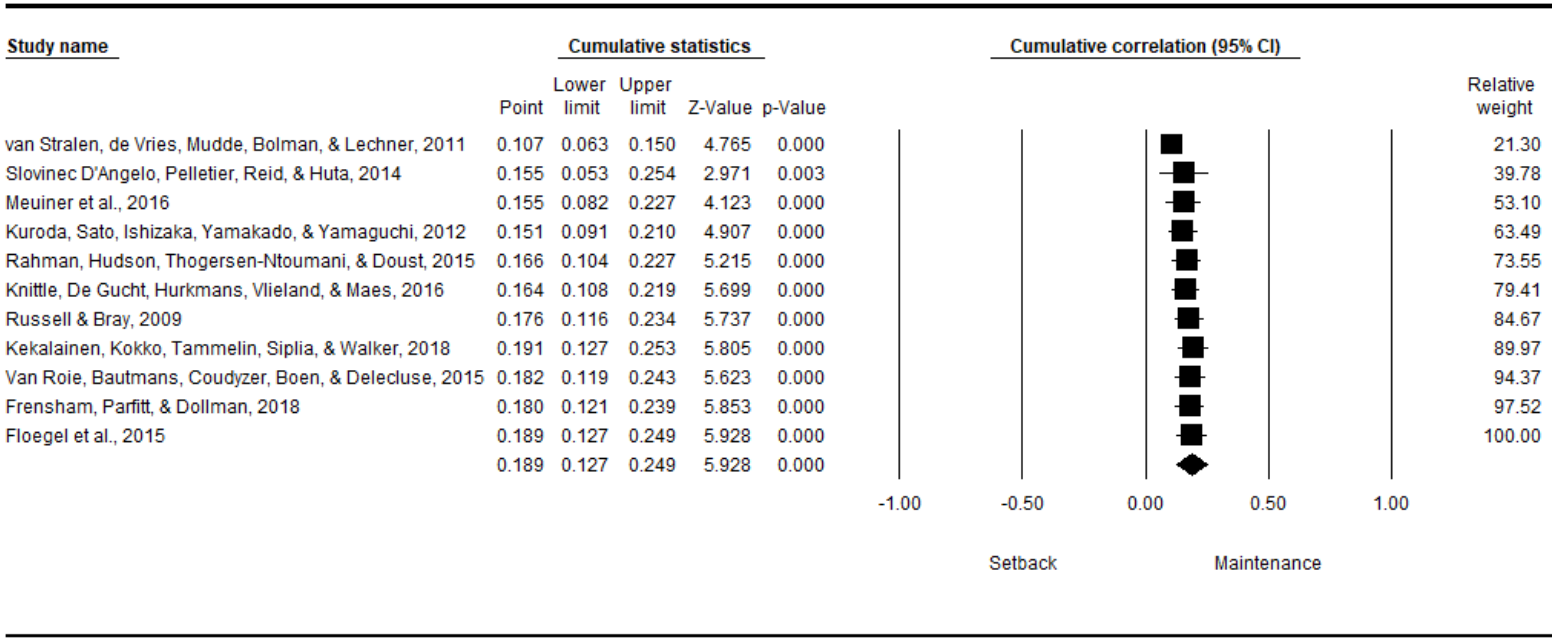

Figure 4.3. Self-determination and the maintenance of physical activity in older adults – cumulative random-effects meta-analysis.

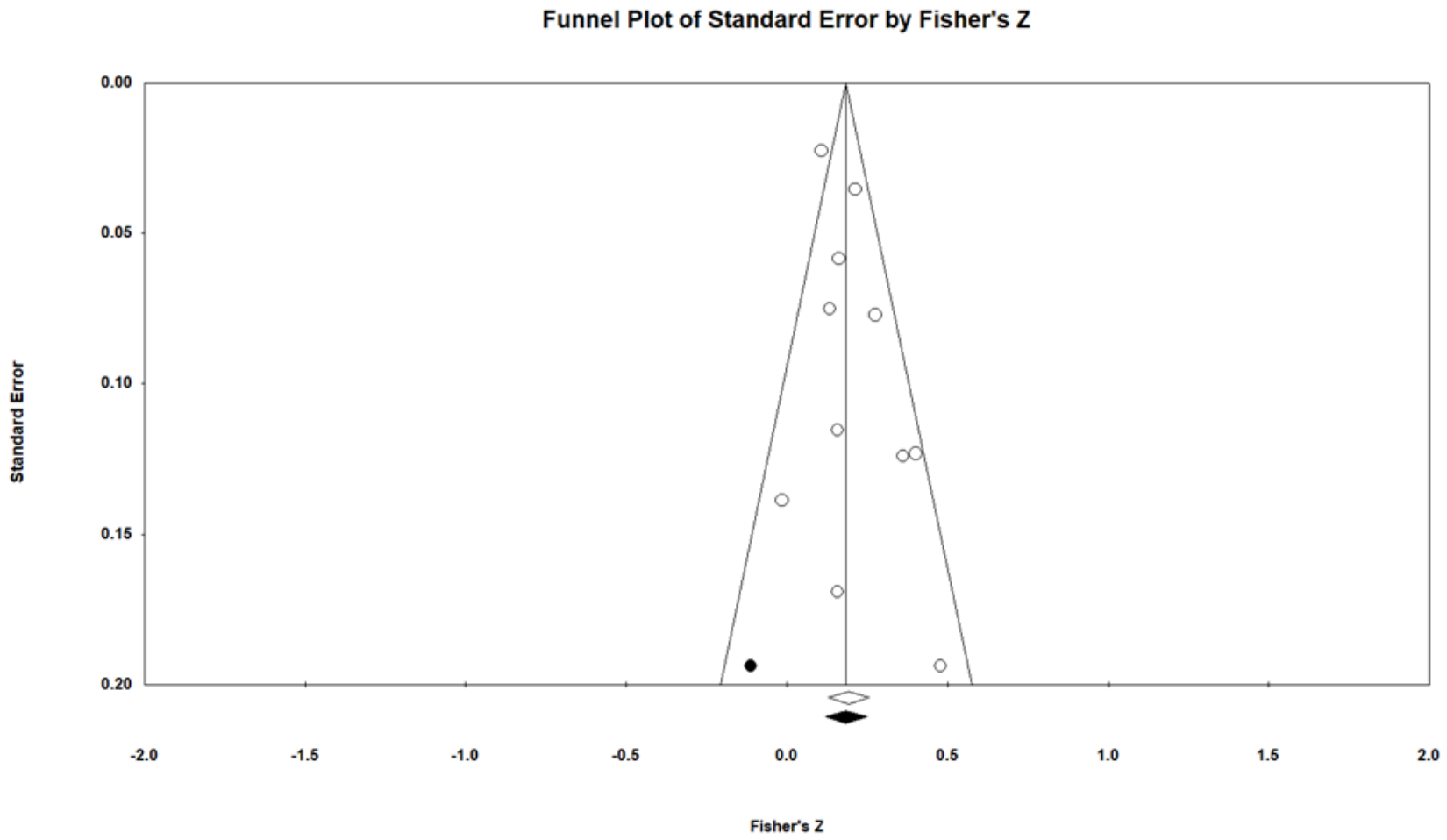

Figure 4.4. Self-determination and the maintenance of physical activity in older adults – funnel plot with imputed (bold) studies.

4.7.1.6 Meta-Regression

There was insufficient evidence for variation in self-determination effects as a function of sample mean age ($p = 0.41$), maintenance context ($p = 0.65$), or percentage of females in the study sample ($p = 0.80$). However, the effect tended to be stronger and more homogeneous for studies with samples described as having a physical health condition (i.e., arthritis, cancer, type 2 diabetes, and cardiovascular disease; $p = 0.25$). The summary effect was 0.212 (0.139, 0.283); Q (5) = 3.21, $p = 0.67$, $I^2 = 0\%$ for studies conducted with older adults known to have a physical health condition ($k = 6$; $N = 1{,}451$), whereas it was 0.148 (0.066, 0.229); Q (4) = 9.93, $p = 0.04$, $I^2 = 60\%$ for studies conducted with apparently healthy older adults ($k = 5$; $N = 2{,}287$).

Notably, eight (72.7%) and seven studies (63.6%) were at high risk of bias (or some concerns) due to missing data or to the measurement of physical activity, respectively. Risk of bias due to missing data was associated with study effects ($p = 0.001$). The summary effect was 0.223 (0.172, 0.273); Q (7) = 7.52, $p = 0.38$, $I^2 = 7\%$ for studies that were at high risk ($k = 8$; $N = 1{,}417$), whereas it was 0.111 (0.068, 0.154); Q (2) = 1.59, $p = 0.45$, $I^2 = 0\%$ for studies that were at low risk of bias due to missing data ($k = 3$; $N = 2{,}321$). The R^2 analogue was 0.98, indicating that 98% of the between-study variance in effect sizes (i.e., $I^2 = 51.86\%$) could be explained by this risk of bias. There was insufficient evidence for variation in self-determination effects as a function of the other bias domains ($p > .05$).

4.7.2 Qualitative Synthesis

4.7.2.1 Satisfaction with Outcomes

Three studies assessed the association between satisfaction with outcomes and physical activity maintenance. The sample mean ages for two of the studies were 59.5 (Williams et al., 2016) and 71.3 (Boyette, Sharon, & Brandon, 1997). The baseline sample sizes ranged from 46 to 205, and the majority of participants were female in all studies. One study targeted prediabetic adults (Williams et al., 2016).

The harvest plot (Figure 4.5; Panel A) illustrates the distribution of evidence, which converges to a positive association between satisfaction with outcomes and the maintenance of physical activity. Boyette, Sharon, and Brandon (1997) reported that the percentage of people satisfied with their resistance training routine increased from 44% to 81% among those who

ended up maintaining their exercise; in contrast, the percentage of satisfied people decreased from 43% to 36% for those who did not. Likewise, Williams et al. (2016) reported that positive changes in satisfaction with outcomes were correlated with more frequent resistance training six months after program completion (Cohen's $f^2 = 0.40$). Williams et al. (2008) reported that perceived satisfaction correlated with physical activity maintenance [odds ratio (95% CI) = 1.95 (0.93, 4.06)]. Notably, all studies were at high risk of bias for missing data.

4.7.2.2 Enjoyment of Behavior

Four studies assessed the association between enjoyment and physical activity maintenance. The sample mean age of these studies ranged from 55.0 to 74.0 years, and baseline sample sizes ranged from 67 to 385. Three of the four samples primarily consisted of females (Sincharoen, 2005; Ungar, Wiskemann, & Sieverding, 2016; Williams et al., 2008). Three studies reported information on apparently healthy older adults, while Ungar et al. (2016) focused on cancer patients.

The harvest plot (Figure 4.5; Panel B) illustrates the distribution of evidence for the associations between enjoyment and physical activity maintenance. Sincharoen (2005) reported positive associations between enjoyment and physical activity maintenance (odds ratio = 1.79 and 2.02 for two models with a different set of variables). Similarly, Williams et al. (2008) reported that enjoyment was positively associated with physical activity [odds ratio (95% CI) = 1.71 (1.26, 2.32)]; this effect was reported to be the same for those who were adopting and maintaining physical activity. Kuroda et al. (2012) reported a decrease in enjoyment for individuals who maintained or improved their physical activity as well as for those who relapsed. Ungar et al. (2016) concluded that both enjoyment (pre-program level, regression coefficient = -0.05) and change in enjoyment (pre-post program change, regression coefficient = 0.11) were not associated with the maintenance of physical activity. Two out of four studies were at high risk of bias for missing data.

4.7.2.3 Identity

One study assessed the association between physical activity identity and physical activity maintenance among apparently healthy older adults (Sincharoen, 2005; see the harvest

plot, Figure 4.5; Panel C). The mean age of the sample (N = 282) was 74.0 years (68.4% female). Physical activity identity was positively associated with physical activity maintenance [odds ratio (95% CI) = 2.00 (1.02, 4.01)].

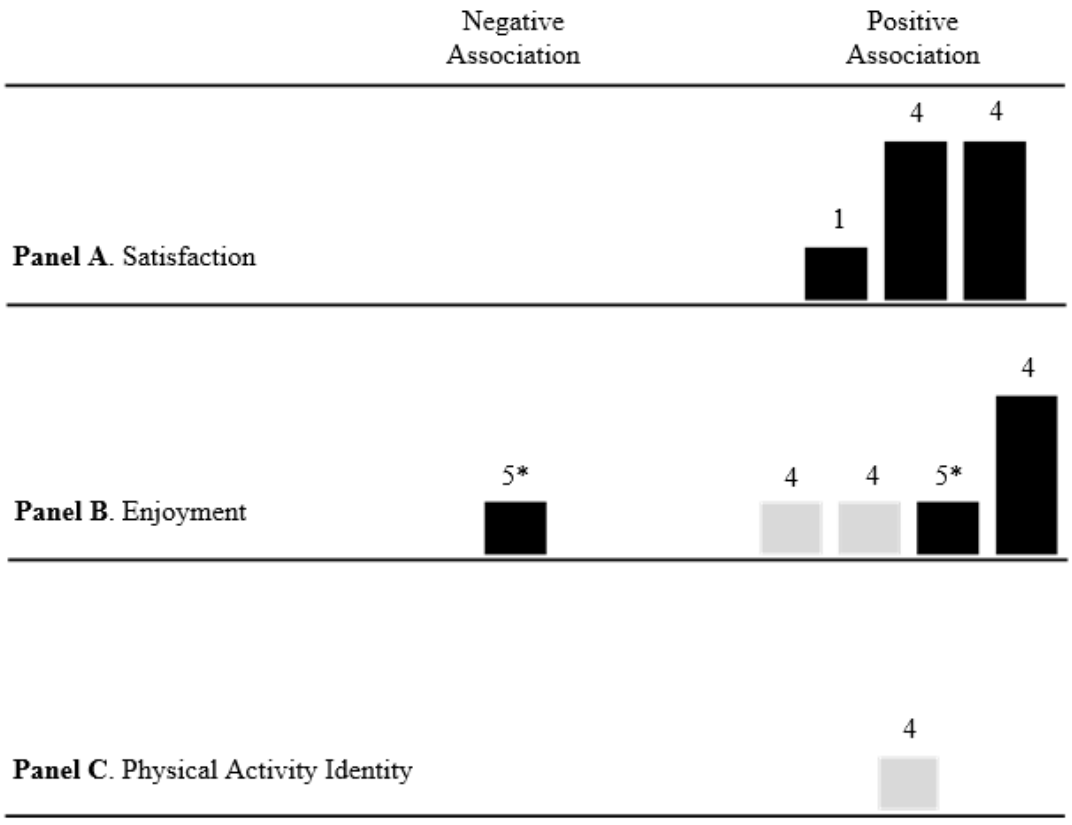

Figure 4.5. Evidence for the direction of the association between theory-based motives and the maintenance of physical activity in older adults – harvest plots.

*Notes. Each study is represented by a mark in each row for which that study had reported relevant results. Studies examining maintenance of physical activity in response to participating in a behavioral intervention are indicated with full-tone (black) bars, and studies examining self-initiated maintenance of physical activity are indicated with half-tone (gray) bars. The height of the bar relects the risk of bias due to the measurement of physical activity – lower bar: high risk; middle bar: some concerns; higher bar: low risk. Each bar is annotated with the number of other methodological criteria (maximum five) that were judged to be at low risk for that study. *One study provided evidence for both a negative association (for baseline [T1] enjoyment score) and a positive association (for a change [T1-T2] in enjoyment score) between enjoyment and the maintenance of physical activity.*

4.7.3 Quality of Evidence

Listed in Table 4.2 are the summary of findings of this systematic review. The GRADE framework was used for grading the quality (or certainty) of evidence and presenting the findings (Schünemann et al., 2019).

Table 4.2. Summary of findings: Systematic review of theory-based motives for the maintenance of physical activity in older adults.

Population: adults aged 55 years and over

Outcome: maintenance of physical activity

Contexts: (1) maintenance after an intervention/program or (2) self-initiated maintenance (without an intervention component)

Maintenance Motives	Estimated Effect (95% CI)	*N* (studies)	Certainty of the evidence (GRADE)	Comments
Enjoyment of physical activity	Not estimable	724 (4 studies)	Not estimable[a]	[a]There is plausible bias due to the measurement of physical activity and missing data.
Satisfaction with the outcomes of physical activity	Not estimable	273 (3 studies)	Not estimable[b]	[b]There is plausible bias due to missing data.
Self-determination	r = 0.189 (0.127 to 0.249)	3,738 (11 studies)	⨁⨁⨀⨀ low[c,d] The true effect might be markedly different from the estimated effect.	[c]Study design and statistical controls (i.e., adjustment for past physical activity behavior and experience) likely reduce confounding bias. Therefore, the certainty of evidence was not downgraded for the lack of randomization. [d]There is plausible bias due to the measurement of physical activity (i.e., self-report instrument with unknown psychometric properties, inappropriate recall period). The bias due to missing data is likely to affect the interpretation of the results (downgraded by two levels).
Physical activity identity	Not estimable	282 (1 study)	Not estimable[a]	[a]There is plausible bias due to the measurement of physical activity and missing data.

Note. Certainty of evidence ratings: high – the authors have a lot of confidence that the true effect is similar to the estimated effect; moderate – the authors believe that the true effect is probably close to the estimated effect; low – the true effect might be markedly different from the estimated effect; very low – the true effect is probably markedly different from the estimated effect. CI: confidence interval. N: sample size. r: correlation coefficient.

4.8 Discussion

This study reviewed the influence of theory-based motives on the maintenance of physical activity among older adults. The following inferences can be drawn from this knowledge synthesis.

First, the motive of self-determination is positively related to the maintenance of physical activity in older adults. This finding is consistent with results from past systematic reviews of studies in younger populations in the context of physical activity (Rodrigues et al., 2018; Teixeira et al., 2012). This suggests that older adults who participate in physical activity due to valuing or appreciating the inherent nature of the behavior and who are physically active out of their own choosing are also those who tend to sustain their engagement in physical activity over time. Compared to zero-order correlations typically reported in meta-analyses (Sheeran et al., 2017), our pooled estimated effect (r = 0.189) is more reflective of a partial correlation between self-determination and the maintenance of physical activity. The current systematic review was conceived such that all included studies controlled for past physical activity either by design (e.g., investigating people who have completed a physical activity intervention) or explicitly within the statistical analyses conducted. Therefore, our estimate is less likely to be inflated by the effects of past behavior and may in fact underestimate the effect of self-determination on physical activity (Weinstein, 2007). Additionally, many of the reviewed studies accounted for other known physical activity correlates within their analyses, such as self-efficacy (Frensham et al., 2018; Slovinec D'Angelo et al., 2014; Van Roie, Bautmans, Coudyzer, Boen, & Delecluse, 2015; van Stralen, de Vries, Mudde, Bolman, & Lechner, 2011). Heterogeneity of results, imprecision of results, indirectness of evidence, and publication bias did not represent serious limitations. However, high risk of bias due to the measurement of physical activity and missing data yielded a *low* rating for certainty of evidence.

Second, the predictive capacity of self-determination may be stronger (and more homogeneous) among samples of older adults described has having a physical health condition (i.e., rheumatoid arthritis, cardiovascular diseases, type 2 diabetes, cancer). While insightful, pre-planned sub-group analyses in the context of this meta-analysis best serve as hypothesis generating, as opposed to hypothesis testing. This is a valuable hypothesis to test in a new study, as the majority of older adults live with one or more chronic conditions (Centers for Disease Control and Prevention, 2020). If this observation is replicated in original studies, future physical

activity programs for older adults with physical health conditions may benefit from employing strategies that foster self-determination (e.g., increasing autonomy through providing a sense of choice and freedom; promoting competence through detailed, informational feedback; Ryan & Deci, 2000). Although speculative, this association may be stronger for this sub-group by nature of their underlying health issues. Identified regulation is a type of self-determined motivation that reflects valuing a behavior for its important outcomes or benefits (Deci & Ryan, 2000). By understanding and accepting the utility of the behavior within the context of their health conditions, afflicted older adults' self-determined motivation may be more facilitating of physical activity maintenance. It is worth noting that of the six studies that were conducted with samples with physical health conditions, only one study investigated intrinsic motivation specifically (Rahman et al., 2015). The remaining studies used a composite autonomous motivation variable (Knittle et al., 2016; Meunier et al., 2016; Russell & Bray, 2009; Slovinec D'Angelo et al., 2014) or a general motivation variable that was based on self-determination theory (Frensham et al., 2018).

Third, no judgment could be made regarding satisfaction with outcomes, enjoyment, or physical activity identity. While there is converging evidence supportive of a positive association between satisfaction and the maintenance of physical activity, this relies on a small number of studies that were at high risk of bias for missing data. Past knowledge syntheses of factors related to older adults' physical activity have concluded that enjoyment is a correlate of exercise adherence and physical activity maintenance (Rhodes et al., 1999; van Stralen et al., 2009). Given the number of studies retrieved and study-level findings synthesized in the current systematic review, there is not enough evidence to conclude that enjoyment is associated with the maintenance of physical activity in older adults. Of note, two of the studies included in the current review measured enjoyment with the original (18 items) Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991). This scale may not be a suitable instrument for use with older adults, and the modified PACES-8 should be used instead (Mullen et al., 2011). Regarding physical activity identity, Rhodes, Kaushal, and Quinlan (2016) have remarked that the physical activity identity literature is "blemished by mostly modest to low quality studies . . . cross-sectional designs, college student samples, and self-reported physical activity outcomes" (p. 218). The lack of studies retrieved for the current review illustrates that the state of the literature has not advanced over the past four years, particularly concerning longitudinal designs

with older samples. In summary, the small number of studies included for these motives precludes any definitive conclusions as to their association with older adults' physical activity maintenance.

Our risk of bias assessment highlights the critical need for future research to pay careful attention to the issues of physical activity measurement and missing data. High attrition can produce biased conclusions. For instance, results of our meta-regression analysis indicated that the effect of self-determination was stronger for studies judged to be at high risk of bias. Future research should incorporate strategies to better retain older adults in research studies (e.g., continuously assess study satisfaction and address participant concerns; Mody et al., 2008) and use appropriate analytical methods for dealing with missing data (e.g., maximum likelihood estimation and multiple imputation; Graham, 2009). Future research should also carefully consider which instrument(s) should be used to measure physical activity (Kowalski, Rhodes, Naylor, Tuokko, & MacDonald, 2012; Nigg et al., 2020; Rikli, 2000). For self-reported or interviewer administered questionnaires, it is recommended to measure physical activities that are relevant to older adults (e.g., walking, dancing, gardening/yard work) over a relatively short period of time (e.g., past 7 days) to minimize reporting errors (Nigg et al., 2020; Rikli, 2000). For research questions related to physical activity trajectories over time, the selected instruments should be responsive to "true" changes in physical activity; the CHAMPS may represent an appropriate option in this case (Stewart et al., 2001). Arguably, device-based measures are more sensitive to changes in physical activity relative to subjective measures. When these measures are used, population-specific backend calculations and decisions (e.g., accelerometer cut-points and metabolic costs for older adults; Cleland et al., 2020; Kowalski, Rhodes, Naylor, Tuokko, & MacDonald, 2012) should be considered. Ideally, a combination of both subjective (questionnaire) and device-based (e.g., accelerometry) measures should be used to provide a comprehensive assessment of physical activity in older adults.

Our review was only able to address two of our three research questions for the motive self-determination. Future research should therefore be devoted to conducting high quality studies (e.g., studies that appropriately measure physical activity over time, adequately retain participants, and accurately account for missing data) to investigate the relationship between satisfaction with outcomes, enjoyment, and identity and older adults' physical activity maintenance and determine under what conditions these motives are most relevant for

maintenance. Kwasnicka et al. (2016) hypothesize that at least one motive is necessary for behavioral maintenance. Thus, it is relevant to determine how many motives, or which combination of motives, best facilitate maintenance. Finally, it remains unclear whether these motives directly or indirectly influence (e.g., through self-regulation) physical activity maintenance, whether they become irrelevant over time (e.g., through habit development), or how they interact with the social or physical environment to influence maintenance. Future research should further clarify how the motives operate within Kwasnicka et al.'s (2016) entire behavioral maintenance framework.

4.8.1 Review-Level Limitations and Strengths

Several study-level effects for the motive of self-determination were estimated and transformed prior to conducting the meta-analyses, which may have affected the precision of the calculated pooled estimates. Because the reported effect sizes were within the range of ± 0.50 units (Peterson & Brown, 2005), the use of these estimations and conversions was deemed more appropriate than restricting the meta-analysis to a subset of studies or not performing a meta-analysis at all. Second, given only 11 studies were included in the primary meta-analysis, we were unable to examine the impact of multiple covariate and moderator variables on the relationship between study-level effects for self-determination (e.g., including both risk of bias due to missing data and sample health condition in the same meta-regression model). Third, we were unable to perform any meta-analyses or use the GRADE framework for the motives of satisfaction with outcomes, enjoyment, and physical activity identity due to the low number of primary studies examining these motives. Fourth, our classification of samples with health conditions were deemed so by the individual studies' descriptions. Thus, there may have been some participants in the "healthy" samples that were indeed afflicted by a health condition. Finally, our operationalization of physical activity maintenance was not based on any time criteria or thresholds. As a result, we were unable to determine or speculate whether the motives are more relevant in the beginning of the maintenance process or exert their influence in the longer term.

Several steps were taken to limit the risk of bias due to missing results in the systematic review. We searched for gray literature (one doctoral dissertation was included in the review; Sincharoen, 2005), included studies written in non-English languages, and contacted primary

authors to confirm study eligibility (Williams et al., 2008) and obtain study-level information needed for inclusion in the primary meta-analysis (Rahman et al., 2015; Van Roie et al., 2015). As a result, all studies retrieved that assessed self-determination were included in the primary meta-analysis. We acknowledge that many observational studies do not have written protocols and are exploratory in nature. It is possible that at least some of them have selectively reported results for a given outcome based on *p*-value. Nonetheless, only two out of the 16 studies (12.5%) included in the systematic reviewed were at high risk of bias for the selection of reported physical activity outcomes. Lastly, another strength of our review includes the collaborative creation of a search strategy between subject matter and database experts.

4.8.2 Conclusion

We concluded that self-determination is positively related to older adults' physical activity maintenance. This association may be stronger for individuals with physical health conditions. There was not enough information to determine whether satisfaction with outcomes, enjoyment, or physical activity identity influence maintenance for this population. An implication of the findings is that self-determination could be a relevant putative target for behavioral programs that aim to promote the maintenance of physical activity in older adults. However, the certainty of evidence was rated as *low*. Therefore, the next research priority should be to confirm this finding in studies that appropriately account for missing data and measure physical activity in accordance with the population and research questions.

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4.10 Appendix A.

Table 4.A.1. Database search example.

Example of the database search for PubMed
((((((("exercise"[mh] OR "physical fitness"[mh])) OR (exercise[tiab] OR exercising[tiab] OR exercises[tiab] OR exerciser[tiab] OR exercised[tiab] OR "physical fitness"[tiab] OR "physical activity"[tiab] OR "physical activities"[tiab] OR "physically active"[tiab] OR walk[tiab] OR walking[tiab] OR walked[tiab] OR walker[tiab] OR walks[tiab] OR walkers[tiab] OR yoga[tiab]))) AND ((("motivation"[mh] OR "personal autonomy"[mh] OR "volition"[mh] OR "personal satisfaction"[mh] OR "social identification"[mh] OR “self concept”[mh] OR "pleasure"[mh] OR "happiness"[mh] OR "affect"[mh] OR "reward"[mh])) OR (motive[tiab] OR motivation[tiab] OR motivating[tiab] OR motives[tiab] OR motivated[tiab] OR autonomy[tiab] OR volition[tiab] OR volitional[tiab] OR satisfaction[tiab] OR satisfying[tiab] OR satisfies[tiab] OR satisfied[tiab] OR "social identity"[tiab] OR "social identities"[tiab] OR "social identification"[tiab] OR "group identification"[tiab] OR "group identities"[tiab] OR "group identity"[tiab] OR belonging[tiab] OR self-concept[tiab] OR self-perception[tiab] OR self-perceptions[tiab] OR self-esteem[tiab] OR pleasure[tiab] OR joy[tiab] OR enjoyment[tiab] OR fun[tiab] OR happiness[tiab] OR happy[tiab] OR affect[tiab] OR affective[tiab] OR reward[tiab] OR rewards[tiab] OR rewarded[tiab] OR rewarding[tiab] OR "body image"[tiab] OR "body images"[tiab] OR "body schema"[tiab] OR "body schemas"[tiab] OR "body representation"[tiab] OR "body representations"[tiab] OR "body dissatisfaction"[tiab] OR self-determined[tiab] OR self-determination[tiab] OR fulfillment[tiab] OR intrinsic[tiab] OR extrinsic[tiab] OR "external regulation"[tiab] OR "introjected regulation"[tiab] OR "integrated regulation"[tiab] OR "psychological needs"[tiab] OR identity[tiab] OR self-schema[tiab] OR self-schemata[tiab]))) AND ((adhere[tiab] OR adheres[tiab] OR adhered[tiab] OR adherence[tiab] OR maintenance[tiab] OR maintain[tiab] OR maintains[tiab] OR maintained[tiab] OR maintaining[tiab] OR continue[tiab] OR continues[tiab] OR continuing[tiab] OR continued[tiab] OR sustain[tiab] OR sustains[tiab] OR sustained[tiab] OR sustaining[tiab] OR sustainable[tiab] OR sustainability[tiab] OR relapsed[tiab] OR relapse[tiab] OR relapses[tiab] OR lapse[tiab] OR lapsed[tiab] OR lapses[tiab] OR engagement[tiab] OR engaging[tiab] OR engaged[tiab] OR engages[tiab] OR within-person[tiab] OR within-subject[tiab] OR longitudinal[tiab])))) NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh])))

Note. To run this search properly, all text prior to NOT (“Animals”[Mesh] . . . can be copied and pasted into PubMed. After running that search, one should navigate to the advanced search and use the search builder to add the first part of the search; then, change the drop down box to “NOT” on line 2 and copy the remaining part of the search, beginning with (“Animals”[Mesh] . .

4.11 Appendix B.

Table 4.B.1. Risk of bias in individual bias domains for studies examining the association between maintenance motives and physical activity in older adults.

	Bias Domains						
Author (year)	Selection of Participants	Measurement of PA	Measurement of Motives	Selection of Reported PA	Selection of Reported Motives	Confounding	Missing Data
Boyette, Sharon, & Brandon (1997)	No information	High	High	High	Low	High	High
Floegel et al. (2015)	Low	High	Low	Low	Low	Some concerns	High
Frensham, Parfitt, & Dollman (2018)	No information	Low	High	Low	Some concerns	Low	High
Kekäläinen, Kokko, Tammelin, Sipilä, & Walker (2018)	Low	High	Low	Low	Low	Low	High
Knittle, de Gucht, Hurkmans, Vleiland, & Maes (2016)	Low	High	High	Low	Low	Some concerns	High

Kuroda, Sato, Ishizaka, Yamakado, & Yamaguchi (2012)	High	High	Low	Low	Low	Low	High
Meunier et al. (2016)	No information	Low	Low	Low	Low	Low	Low
Rahman, Hudson, Thøgersen-Ntoumani, & Doust (2015)	No information	High	Low	Low	Low	Low	High
Russell & Bray (2009)	Low	Low	Low	Low	Low	Low	High
Sincharoen (2005)	No information	High	Low	Low	Low	Low	Some concerns
Slovinec D'Angelo, Pelletier, Reid, & Huta (2014)	Low	High	Low	Low	Low	Low	Some concerns
Ungar, Wiskemann, & Sieverding (2016)	Low	High	Low	High	Low	Low	Low
Van Roie, Bautmans, Coudyzer, Boen, & Delecluse (2015)	Some concerns	High	Low	Low	Low	Low	Low

van Stralen, de Vries, Mudde, Bolman, & Lechner (2011)	No information	Low	High	Low	Some concerns	Low	Low
Williams et al. (2008)	Low	Low	Low (enjoyment) High (satisfaction)	Low	Some concerns (enjoyment) Low (satisfaction)	Low	High
Williams et al. (2016)	No information	Low	Low	Low	Low	Low	High

Notes. PA: Physical Activity. Risk of bias was considered either: low (plausible bias unlikely to seriously alter the results), some concerns (plausible bias that raises some doubt about the results), high (plausible bias that seriously weakens confidence in the results), or no information (information insufficiently reported).

4.12 Appendix C.

Two studies presented findings as differences in means between active and inactive groups for which the standard error of the difference was calculated by assuming the population standard deviations were the same and pooling information from both groups (Floegel et al., 2015; Kekäläinen, Kokko, Tammelin, Sipilä, & Walker, 2018). Kuroda, Sato, Ishizaka, Yamakado, and Yamaguchi (2012) presented findings as mean differences but did not provide the standard deviations for the two groups. Here, the standard error of the difference was calculated by dividing the difference in means by the estimated *t* value. Six studies provided regression coefficients that were transformed into correlation coefficients based on Peterson and Brown's (2005) formula. For one of these studies (van Stralen, de Vries, Mudde, Bolman, & Lechner, 2011), the provided regression coefficient needed to be transformed further prior to converting it into a correlation coefficient. van Stralen et al.'s (2011) study presented findings as intervention changes; thus, the standard deviation of the change from baseline was calculated by imputing correlations from other studies (Higgins & Green, 2011) used in the meta-analysis. For another study (Rahman, Hudson, Thøgersen-Ntoumani, & Doust, 2015), the authors' interpretation of the study findings (i.e., a positive association) did not match the sign of the regression coefficient reported in the published article (negative). Personal correspondence with the primary author indicated that the standardized regression coefficient reported in the paper was opposite of the true effect found (i.e., 0.219 instead of -0.219). This was corrected for the purposes of this meta-analysis.

Additionally, one study reported more than one physical activity outcome (van Stralen et al., 2011), and another reported more than one intrinsic motivation predictor (Kekäläinen et al., 2018). van Stralen et al. (2011) reported evidence pertaining to the weekly frequency (days/week) and duration (minutes/week) of physical activity and found that the two interventions they tested were effective in increasing the weekly frequency of physical activity, but not duration. Consequently, data pertaining to the weekly frequency of physical activity were chosen for the primary meta-analysis, as this was more consistent with the concept of maintaining an increase in physical activity beyond intervention completion (Marcus et al., 2000). Kekäläinen et al. (2018) reported evidence pertaining to physical activity- and resistance training-specific intrinsic motivation. The resistance training-specific measure of self-determined motivation was chosen for the primary meta-analysis, as this measure reflects an assessment of

motivation for the targeted behavioral outcome in the study. To explore the degree to which the quantitative synthesis was affected by changes in the data used from the primary studies, four random-effects meta-analyses (i.e., one for each of the four different combinations of study-level effect sizes, accounting for the choices made regarding van Stralen et al.'s (2011) and Kekäläinen et al.'s (2018) data), were conducted. The results were consistent across the different analyses. The forest plot for the primary meta-analysis is reported in the main text; the forest plots for the additional three analyses are displayed below in Figure 4.C.1.

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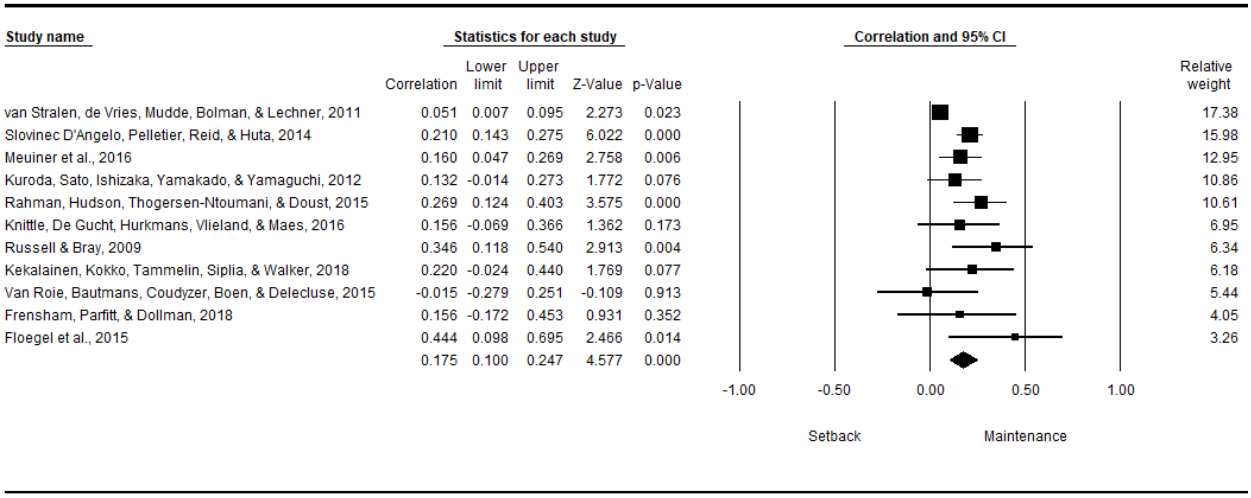
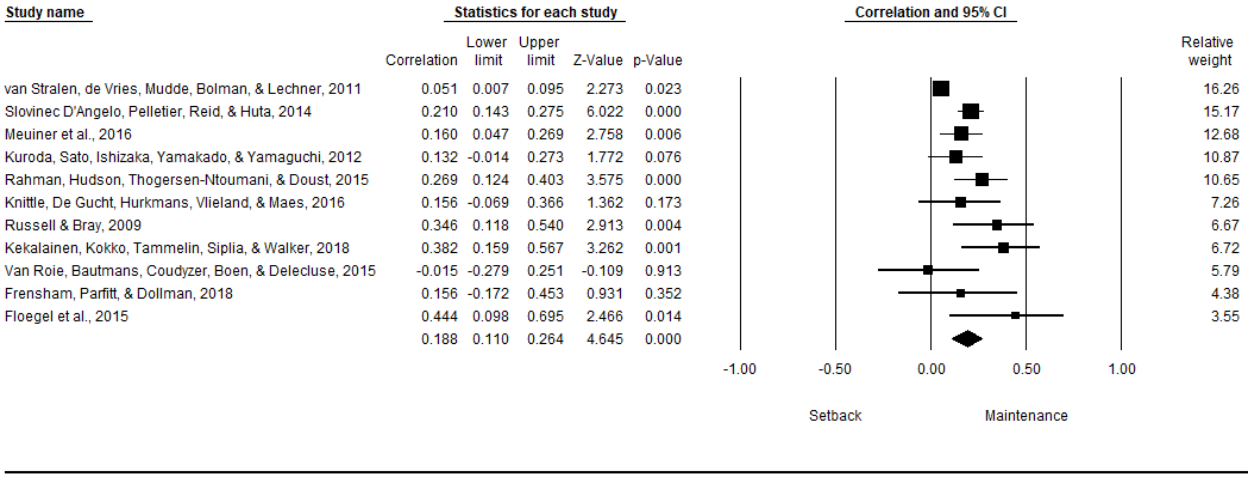
Panel A.



Panel B.



Panel C.

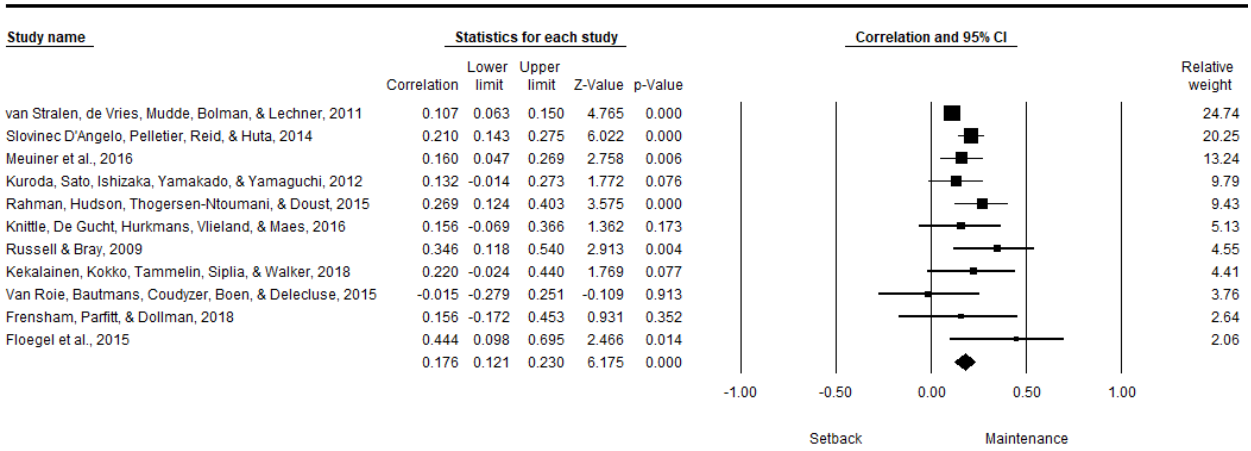


Figure 4.C.1. Self-determination and the maintenance of physical activity in older adults – forest plots of three sensitivity analyses.

Notes. Panel A: Meta-analysis results utilizing minutes/week data from van Stralen et al.'s (2011) study and physical activity-specific intrinsic motivation data from Kekäläinen et al.'s (2018) study. Panel B: Meta-analysis results utilizing minutes/week data from van Stralen et al.'s (2011) study and resistance training-specific intrinsic motivation data from Kekäläinen et al.'s (2018) study. Panel C: Meta-analysis results utilizing frequency/week data from van Stralen et al.'s (2011) study and physical activity-specific intrinsic motivation data from Kekäläinen et al.'s (2018) study.

4.13 Appendix D.

References for Studies Included in the Systematic Review

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CHAPTER 5. ARE CURRENT MEASURES OF PHYSICAL ACTIVITY REGULATORY STYLES AND PHYSICAL ACTIVITY IDENTITY ROBUST FOR THE OLDER ADULT POPULATION?

This chapter is derived in part from an article that has been submitted for publication to the *Journal of Sport and Exercise Psychology*.

5.1 Abstract

Are measures of physical activity regulation and identity that were originally developed on primarily young adult samples equally valid for use with older adults? We address this question by examining measurement invariance, convergent, and divergent validity for modified versions of the Behavioral Regulation in Exercise Questionnaire and the Exercise Identity Scale for older adults. Participants (N = 314; age ≥ 55 years) completed an online questionnaire twice across four weeks. Using a structural equation modeling framework, a two-factor model of identity representing *role identity* and *physical activity beliefs* provided the best fit. Both instruments were invariant across genders and time. Identity dimensions and autonomous regulatory styles were positively related to each other and to physical activity. Physical activity beliefs was more strongly related to introjected regulation than was role identity. These modified scales are robust measures of physical activity regulation and two dimensions of physical activity identity for older adults.

5.2 Introduction

Motives for physical activity that emanate from one's sense of self are theorized to support sustained engagement in physical activity (Burke, 2006; Kwasnicka et al., 2016; Ryan & Deci, 2000; Stryker & Burke, 2000). Specifically, highly self-determined regulatory styles (e.g., integrated regulation) and self-representation as a physically active person (e.g., holding a physical activity identity) can support continued engagement in physical activity by aligning personal core values, goals, and expectations affixed to a physical activity identity with congruent physically active behaviors. These motives are posited to be malleable and therefore may represent putative targets for future interventions designed to promote physical activity (Rhodes et al., 2016; Ryan & Deci, 2000). However, having interpretable scales that measure

these constructs within the population of interest is critical to understanding how they relate to the focal behavior, how they change in response to intervention strategies, and how they associate with other relevant constructs. Too often, the adequacies of common measures are taken for granted and erroneously applied to dissimilar contexts (Hagger & Chatzisarantis, 2009). Therefore, the overall purpose of this study is to examine the robustness of current scales measuring physical activity regulatory styles and physical activity identity in the older adult population.

Measurement invariance is of particular importance in this regard. Measurement invariance reflects the psychometric equivalence of a construct between subgroups of the population of interest or across time (Putnick & Bornstein, 2016). An invariant measure between different subgroups of respondents suggests that the meaning and interpretation of the underlying construct is similar across the members of each subgroup. Scores resulting from the measure can thus be directly compared between groups. Similarly, a longitudinally invariant measure suggests that the meaning and interpretation of the underlying construct is the same when respondents are measured across different occasions. The possibility that changes in the test scores are due to fluctuating interpretations of the scale items rather than real changes in the score levels can therefore be ruled out. When measures are assumed to be invariant – but actually vary across groups or time – researchers may estimate inaccurate direct and indirect (i.e., mediation) effects (Xu et al., 2020). Therefore, determining whether instrument interpretation is equivalent between relevant subgroups of the population of interest (e.g., males and females) and across measurement occasions (i.e., time) is a prerequisite for drawing valid inferences from research testing relationships involving the theory-based constructs under study.

Moreover, evidence for convergent validity is accumulated when measures of constructs that are theorized to be related – either positively or negatively – are shown to be strongly correlated (Campbell & Fiske, 1959). Evidence for divergent validity is accumulated when measures of constructs that are not theorized to be related are shown to be weakly correlated (Campbell & Fiske, 1959). Together, evidence for measurement invariance, convergent, and divergent validity reinforces the robustness of a given instrument within a specific population.

5.3 Regulatory Styles

The organismic integration theory (OIT) within self-determination theory describes several different and distinct types of regulatory styles that have been conceptualized as lying along a continuum of relative autonomy (or self-determination; Ryan & Deci, 2000). The two ends of this continuum are *amotivation* and *intrinsic motivation*. Amotivation represents a state of non-regulation in which people lack intention to act. In contrast, intrinsic motivation represents a regulatory style in which individuals are motivated to engage in a behavior due to fun, interest, challenge, or inherent enjoyment (i.e., intrinsic regulation). OIT also describes four types of extrinsic motivation: *external, introjected, identified,* and *integrated regulation*. External and introjected regulation are characterized by participation in a behavior to obtain external rewards and to avoid shame or guilt, respectively. These regulatory styles are considered controlled forms of motivation. Individuals who value the outcomes or benefits of a particular behavior are said to have identified regulation, and those who have internally endorsed the behavior as part of the self are said to have integrated regulation. These regulatory styles and intrinsic motivation are considered autonomous or more self-determined forms of motivation. Autonomous motivation has consistently been found to be related to better well-being, positive affect, and greater persistence as compared to controlled motivation (Deci & Ryan, 2008).

The Behavioral Regulation in Exercise Questionnaire (BREQ) was developed to measure regulatory styles for exercise-related contexts and has been used extensively in research (see Rodrigues et al., 2018; Teixeira et al., 2012). Mullan et al. (1997) first created the BREQ to assess four of the regulatory styles (i.e., external, introjected, and identified regulation and intrinsic motivation) in a sample with a mean age of 30.11 years, and this four-factor measure was found to be invariant between males and females in a sample with a mean age of 37.56 years. Markland and Tobin (2004) added an amotivation subscale to the BREQ, which demonstrated a good fit to data provided by physically active middle aged and older adults. Wilson et al. (2006) created a measure of integrated regulation and added it to Mullan et al.'s (1997) original instrument. These authors found that identified and integrated regulation were more strongly and positively correlated with physical activity (both $r = 0.53$) than external and introjected regulation ($r = -0.05$ and 0.39, respectively) for a sample of undergraduate students. Consistent with theory (Ryan & Connell, 1989), these studies found that regulatory styles nearer each other on the continuum of relative autonomy generally had larger positive correlations than

those farther apart. Except for the study by Markland and Tobin (2004), this literature has relied primarily or exclusively on younger adults.

5.4 Physical Activity Identity

According to identity theory, identities are self-meanings situated in the context of a role that are created from prior personal and social experiences (Burke, 1980; Stryker & Burke, 2000). Well-developed identities direct future behavior such that individuals will typically act in accordance with their self-beliefs and resist information counter to their identity (Rhodes & Yao, 2015). The identity-to-behavior connection is more likely to be maintained because behavior that matches a person's identity leads to positive emotions (Stryker & Burke, 2000), while behavior that does not match leads to negative affect, dissonance, and motivation to change behavior to reduce the incongruence (Burke, 2006). Therefore, a person with a physical activity identity should be inclined to display and reaffirm this identity through being physically active.

Anderson and Cychosz (1994) developed the Exercise Identity Scale to investigate the relationship between exercise identity and exercise behaviors among university students. The nine items of this scale were found to reflect a one-factor model of identity, and exercise identity was positively related to exercise behaviors (Anderson & Cychosz, 1994). Past research has provided support for partial gender invariance of the Exercise Identity Scale (i.e., some items were not interpreted the same way between genders; Vlachopoulos et al., 2008). Additionally, Ennigkeit and Hänsel (2018) provided evidence in support of longitudinal invariance (two weeks) for a German version of the scale but could not provide support for invariance between males and females, as their analyses delivered inconclusive results. However, Wilson and Muon (2008) found that the Exercise Identity Scale more appropriately reflects a two-factor model of identity consisting of dimensions that have been labeled *role identity* (e.g., how the behavior has been integrated with one's identity) and *exercise beliefs* (e.g., perceptions about the behavior itself). The superior fit of this two-factor model has been subsequently verified among Greek adults (ages 18 to 64 years; Vlachopoulos et al., 2011; Zafeiridou et al., 2014).

Notably, Whaley and Ebbeck (2002) qualitatively explored the formation of exercise identities of older adults and concluded that some prefer to describe themselves as "physically inclined" or one "who keeps physically active" instead of as an "exerciser" (Whaley & Ebbeck, 2002, p. 254). Researchers have since modified the Exercise Identity Scale for older adults (e.g.,

changing “exercise” to “physical activity,” Strachan et al., 2010). Using this modified scale, Strachan et al. (2010) found support for a single factor model for a sample of older adults and concluded that physical activity identity was related to both past physical activity frequency (r = 0.33) and strength of intentions to be physically active (r = 0.40). Results of a two-factor model assessment were not reported in Strachan et al.’s (2010) study.

5.5 Objectives

This study aims to test the robustness of modified versions of the Exercise Identity Scale and the BREQ by examining measurement invariance and convergent and divergent validity among an older adult sample. This study expands upon prior research in two meaningful ways. First, the Exercise Identity Scale and the BREQ were initially designed to measure psychological constructs specific to *exercise* behavior. However, many older adults prefer the more inclusive term *physical activity* to refer to their activities and self-descriptions (Whaley & Ebbeck, 2002). Therefore, the wording of both instruments was changed in this study to reflect physical activity rather than exercise. Since exercise refers to planned, structured, and repetitive activities performed for the purpose of enhancing physical fitness (Caspersen et al., 1985), this study provides validity evidence for the use of these scales measuring a broader set of physical activity behaviors. Second, there is limited validity evidence supporting the use of these scales in the older adult population. This study provides evidence of measurement invariance between males and females and across two measurement occasions (four weeks) and convergent and divergent validity evidence among a sample of adults ≥ 55 years.

Our validation hypotheses were drawn from complementary theoretical statements from OIT and identity theory (Soenens & Vansteenkiste, 2011; Strachan et al., 2013). We expect physical activity identity and more self-determined regulatory styles (i.e., identified regulation, integrated regulation, and intrinsic motivation) to be positively related to physical activity ($r \geq$ 0.33; Strachan et al., 2010) and amotivation to be negatively related to physical activity. We expect physical activity identity to have (*i*) stronger positive relations with more self-determined regulatory styles, with the relation between identity and integrated regulation being the strongest, and (*ii*) weaker relations with less self-determined regulatory styles.

5.6 Methods

5.6.1 Participants and Procedures

Participants for this study were recruited from ResearchMatch (www.researchmatch.org), which is a U.S. National Institutes of Health-supported online health research volunteer registry. Eligibility criteria included being at least 55 years old, having no indication of cognitive impairment, and being able to read and understand English. These eligibility criteria were entered into ResearchMatch's filtering system, and an initial invitation message was sent to randomly selected individuals meeting these criteria. We additionally filtered on sex in order to recruit equal numbers of both males and females. A total of 5,750 males and females were sent the invitation message. Recipients of the initial invitation were asked if they were interested in participating in the study, and if so, they were emailed a link to an online Qualtrics survey. Four weeks later, those who provided their informed consent and answered at least one question from the first survey received a second link to an identical survey. The final sample was comprised of 410 participants at baseline and 314 participants at follow up. See Figure 5.1 for a participant flow chart. All participants were compensated with a $10 Amazon gift card. This study was approved by the Purdue University Institutional Review Board (IRB Protocol #: 1906022325).

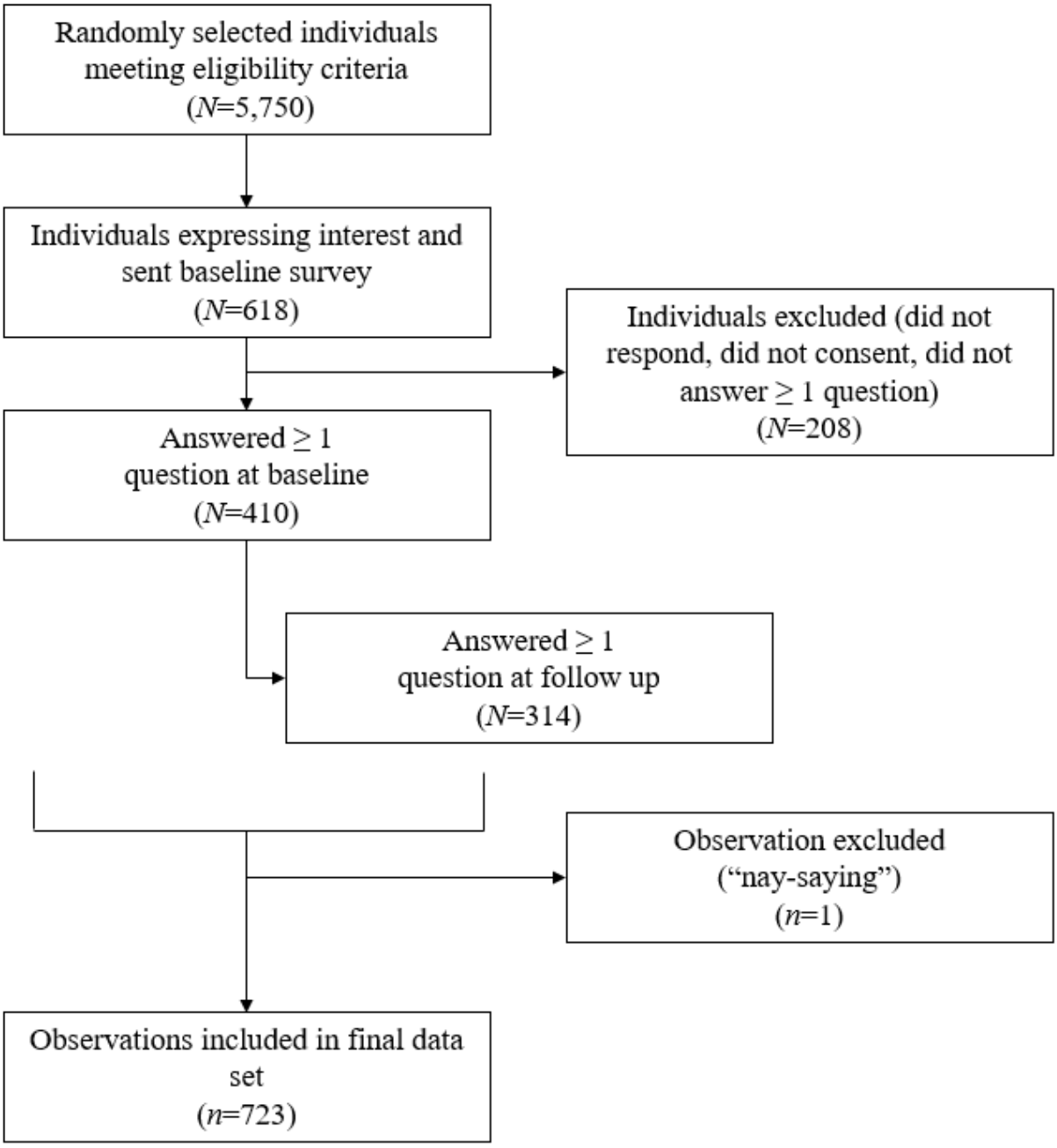

Figure 5.1. Participant flow chart.

Notes. Individuals were recruited from ResearchMatch. N: individual respondents. n: observations. Because observations with missing data were excluded from the analyses, n ranged from 700 to 708 for all analyses, which included 403 to 406 individuals for all analyses.

5.6.2 Measures

5.6.2.1 Modified Behavioral Regulation in Exercise Questionnaire (BREQ; Regulatory Styles)

All six regulatory styles were measured using latent variables (confirmatory factor analysis). The BREQ instrument (Markland & Tobin, 2004; Mullan et al., 1997; Wilson et al., 2006) used in this study consists of 24 items (four items per regulatory style) that ask about reasons why the respondents engage in exercise on a scale from 1 (*not true for me*) to 5 (*always true for me*). This instrument was modified to replace "exercise" with "physical activity" or its closest derivative (e.g., "I am physically active because other people say I should"). The full measure is presented in Appendix A.

5.6.2.2 Modified Exercise Identity Scale (Physical Activity Identity)

Physical activity identity was measured using latent variables. The Exercise Identity Scale (Anderson & Cychosz, 1994) consists of nine items (e.g., "When I describe myself to others, I usually include my involvement in physical activity;" "I would feel a real loss if I were forced to give up being physically active") that are answered with responses ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). The scale was modified by replacing the word "exercise" with "physical activity" or its closest derivative. The full measure is presented in Appendix B.

5.6.2.3 Leisure Time Physical Activity

Physical activity was assessed with one item. Participants were first presented with the following definition of leisure time physical activity: "Physical activity refers to activities that get your body moving. Doing such activities would result in noticeable increases in breathing, heart rate, or sweating." This definition was followed by examples of relevant activities for older adults (e.g., gardening, walking; Amireault et al., 2019). Participants were asked how often in the past month, ranging from 1 (*never*) to 7 (*4 days or more per week*), they had been physically active for ≥ 30 minutes in a single day, not including activities that were part of their job, volunteering, or caretaker duties (Gionet & Godin, 1989). This one item has validity evidence supporting its use and interpretation among adults (Gionet & Godin, 1989; Godin et al., 1986)

and mitigates the measurement error associated with the reporting of physical activity, as it does not ask about intensity or duration of activities (Nigg et al., 2020; Rikli, 2000).

5.6.2.4 Demographics and Health Characteristics

Age, gender, race/ethnicity, employment status, relationship status, education, self-rated health, weight, height, and chronic conditions experienced were reported by the participants. Body mass index (BMI; kg/m^2) was calculated from self-reported weight and height.

5.6.3 Data Analysis

Data were first screened for duplicate respondents, out-of-range values, missing data, and non-normal distributions using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and Stata version 16 (StataCorp LLC, College Station TX, USA). Missing gender information was imputed based on gender reported at one occasion (i.e., either baseline or at follow up), if available. Responses to the identity items were visually inspected, which revealed that some distributions were negatively skewed. Similarly, the distributions of BREQ items were found to be skewed (negatively for the identified regulation and integrated regulation items, positively for the amotivation and external regulation items). A comparison between completers (i.e., those who answered both surveys) and dropouts (i.e., those who answered only at baseline) was made (see Appendix C). Finally, one respondent's baseline answers were removed from the analyses due to evidence of "nay-saying" (i.e., answering the lowest response possible for all scales).

Means and standard deviations of the scale items were calculated. Measurement invariance was then tested using structural equation modeling (Bollen, 1989). First, the measurement models (latent variables) were assessed for fit using confirmatory factor analysis. Second, the forms of the models were tested for males and females and across the two measurement occasions, allowing parameter estimates to be different between groups and over time, to determine if the general structure (e.g., number of factors or dimensions) of the model was invariant. Third, factor loadings were constrained to be equal between groups and across time, and Lagrange multiplier tests were conducted to determine if the factor loadings were invariant ($\alpha = 0.01$). These analyses were conducted using Stata version 16.

To maximize sample size, observations (i.e., individual respondents' answers at baseline and at follow up) were pooled from both surveys, and observations with missing data were excluded from the analyses. Clustered bootstrapping with 500 replications and the robust cluster estimator were used for the analyses to calculate standard errors, correcting for non-normal outcomes, and to account for the clustering of repeated measures within respondents of the pooled sample. Multiple model fit criteria were considered when assessing the fit of the models: the chi-square test (χ^2; $p > 0.05$ for acceptable fit), the Tucker-Lewis Index (TLI; ≥ 0.90 for acceptable fit), the comparative fit index (CFI; ≥ 0.90 for acceptable fit), the root mean square error of approximation (RMSEA; < 0.10 for acceptable fit), the coefficient of determination (CD; ≥ 0.90 for acceptable fit), the standardized root mean square residual (SRMR; < 0.08 for acceptable fit), item factor loadings, and item reliability values. The reliability values represent a structural equation approach to item reliability and are interpreted as the proportion of variance in an item due to the underlying latent variable (Bollen, 1989). Values ≥ 0.70 were considered strong, values between 0.40 and 0.70 were considered moderate, and values ≤ 0.40 were considered weak. Finally, the latent variables represented by the measurement models were correlated with each other and with the one item measure of physical activity.

5.7 Results

At baseline, about half of the respondents were female (48.9%) and on average 66.29 years (*SD* = 7.06) of age. The majority were white/Caucasian (88.0%), retired (54.3%), and educated (71.9% with a bachelor's degree or higher). Participants' average BMI was 27.91 (*SD* = 5.64), 69.9% reported having at least one chronic condition (e.g., asthma, cancer), and 49.1% considered themselves to be in "excellent" or "very good" health. On average, participants reported being physically active between two and three days per week over the previous month, with 44.5% reporting that they were active four days or more per week. The means and standard deviations of the scale items at each time point are presented in Appendix D.

5.7.1 Measurement Invariance

5.7.1.1 Modified Behavioral Regulation in Exercise Questionnaire

5.7.1.1.1 Initial Confirmatory Factor Analysis

One-factor models for each of the six regulatory styles assessed by the BREQ were specified separately. Global model fit statistics for the models are displayed in the top panel of Table 5.1. Item reliability values ranged from 0.56 to 0.78 (amotivation), 0.40 to 0.63 (external), 0.46 to 0.59 (introjected), 0.31 to 0.75 (identified), 0.47 to 0.85 (integrated), and 0.68 to 0.86 (intrinsic). All factor loadings for all subscales were statistically significant and in the same direction. Based on all fit criteria, it was concluded that the amotivation, introjected, identified, and intrinsic four-item subscales were acceptable. The external and integrated subscales required further refinement prior to invariance testing. Two items of the external regulation subscale ask respondents if they are active because others "say [they] should" be. It is likely that the frames of reference used to respond to these items are similar; therefore, the error covariances of these items were allowed to correlate. This resulted in improved model fit (see top panel of Table 5.1), and this model was retained for the invariance analyses. Similarly, two of the integrated regulation subscale items ask about physical activity being part of "[your] identity" and "a fundamental part of who [you are]." Again, as these items ask respondents to consider similar frames of reference, the error covariances were allowed to correlate. This resulted in improved model fit (see top panel of Table 5.1), and this model was also retained for the invariance analyses.

Table 5.1. Global model fit indices for the six subscales of the BREQ.

Regulation Subscale	χ^2	**TLI**	**CFI**	**RMSEA**	**SRMR**	**CD**
Initial Confirmatory Factor Analyses						
Amotivation	0.367	1.003	1.000	0.000 (0.000, 0.043)	0.003	0.905
External	46.596*	0.876	0.959	0.178 (0.136, 0.224)	0.037	0.842
Introjected	9.674*	0.974	0.991	0.074 (0.032, 0.123)	0.018	0.816
Identified	3.643	0.996	0.999	0.034 (0.000, 0.089)	0.011	0.875
Integrated	119.475*	0.814	0.938	0.289 (0.246, 0.334)	0.053	0.925
Intrinsic	12.209*	0.988	0.996	0.085 (0.044, 0.134)	0.010	0.944
External (revised)	7.921*	0.961	0.994	0.099 (0.044, 0.168)	0.014	0.835
Integrated (revised)	10.012*	0.971	0.995	0.113 (0.057, 0.181)	0.009	0.879
Gender Analyses						
Amotivation	3.614	1.001	1.000	0.000 (0.000, 0.077)	0.006	0.904
External (revised)	9.572*	0.958	0.993	0.104 (0.045, 0.174)	0.015	0.829
Introjected	12.214*	0.972	0.991	0.077 (0.030, 0.128)	0.020	0.816
Identified	4.534	0.999	1.000	0.020 (0.000, 0.085)	0.012	0.875
Integrated (revised)	12.351*	0.967	0.995	0.122 (0.063, 0.191)	0.010	0.882
Intrinsic	13.170*	0.989	0.996	0.081 (0.035, 0.131)	0.010	0.944
Longitudinal Analyses						
Amotivation	7.151	0.994	0.998	0.047 (0.000, 0.103)	0.012	0.906
External (revised)	8.682*	0.964	0.994	0.097 (0.038, 0.168)	0.014	0.827
Introjected	13.371*	0.969	0.990	0.082 (0.036, 0.132)	0.022	0.816
Identified	3.973	1.000	1.000	0.000 (0.000, 0.080)	0.012	0.875
Integrated (revised)	11.249*	0.971	0.995	0.115 (0.056, 0.184)	0.010	0.881
Intrinsic	13.309*	0.989	0.996	0.081 (0.036, 0.132)	0.010	0.943

*Notes. *p < 0.05. BREQ: Behavioral Regulation in Exercise Questionnaire. TLI: Tucker-Lewis Index. CFI: comparative fit index. RMSEA: root mean square error of approximation. SRMR: standardized root mean square residual. CD: coefficient of determination. The two revised models were re-specified such that select error covariances were allowed to correlate (i.e., items 1 and 2 for the external regulation subscale and items 2 and 3 for the integrated regulation subscale).*

5.7.1.1.2 Gender Invariance

The models (i.e., the initial amotivation, introjected, identified, and intrinsic subscales and the revised external and integrated subscales) were tested for males and females

simultaneously, allowing all estimates to vary across gender, to determine whether the same model form was valid for both groups. All models fit well for both males and females (see Table 5.1, middle panel, for global fit indices; factor loading information is presented in Appendix E). Therefore, the forms of the models were considered the same for both genders. Item reliability values were moderate to strong for all items for all subscales except for the first item of the external regulation scale (0.34 and 0.30 for males and females, respectively) and for the last item of the identified regulation scale (0.34 and 0.29 for males and females, respectively). Next, factor loadings were constrained to be equal between gender, and Lagrange multiplier tests indicated that factor loadings were the same for males and females for all subscales, indicating measurement invariance for the relationships between the constructs and the scale items across genders (Appendix E).

5.7.1.1.3 Longitudinal Invariance

The forms of the models were also tested across time to determine whether the measurement models were the same across four weeks. All models fit well at both measurement occasions (see Table 5.1, bottom panel, for global fit indices; factor loading information is presented in Appendix E). Therefore, the forms of the models were considered equivalent over time. Item reliability values were again moderate to strong for all items with the exception of the first item of the external regulation scale (0.36 at baseline and 0.25 at follow up) and the last item of the identified regulation scale (0.27 at baseline and 0.36 at follow up). Lagrange multiplier tests indicated that factor loadings were stable over time when constrained to be equal for all six subscales, indicating measurement invariance for the relationships between the constructs and the scale items over time (Appendix E).

5.7.1.2 Modified Exercise Identity Scale

5.7.1.2.1 Initial Confirmatory Factor Analysis

A one-factor model of physical activity identity was assessed first. This model represents the unidimensional factor model originally proposed by Anderson and Cychosz (1994) and later confirmed by Strachan et al. (2010). However, this conceptualization did not represent a well-fitting model for the data collected for this study. Although all factor loadings were significant

and in expected directions, two reliability values were weak (0.36 and 0.39), and global model fit indices indicated poor fit [χ^2 = 421.691, *df* = 27, *p* = 0.000; TLI = 0.859; CFI = 0.894; RMSEA = 0.144, 90% CI: (0.132, 0.156); CD = 0.923; SRMR = 0.055]. Thus, the model was re-specified. The two-factor model determined by Wilson and Muon (2008) was assessed, representing two dimensions of *role identity* and *physical activity beliefs*. All factor loadings for this model were again significant and in expected directions. Only one item reliability value was weak (0.37, item seven), with the remainder ranging from moderate to strong. Global model fit was improved [χ^2 = 194.087, *df* = 26, *p* = 0.000; TLI = 0.938; CFI = 0.955; RMSEA = 0.096, 90% CI: (0.083, 0.108); CD = 0.974; SRMR = 0.042]. Because these two models were not nested, Akaike's information criteria (AIC) and Bayesian information criteria (BIC) were also investigated. AIC and BIC values were smaller for this second model (21088.83 and 21216.58, respectively) compared to the first model (21314.43 and 21437.62, respectively), indicating improved fit for the second model. Therefore, given the superior fit of the two-factor model, as well as previous theoretical and empirical support (e.g., Stryker & Burke, 2000; Wilson & Muon, 2008), this model was retained for the invariance analyses.

5.7.1.2.2 Gender Invariance

The form of the two-factor model was tested for males and females to determine whether it was the same for both genders. Appendix E displays factor loading information for both gender groups. The global model fit was acceptable [χ^2 = 234.928, *df* = 52, *p* = 0.000; TLI = 0.933; CFI = 0.951; RMSEA = 0.100, 90% CI: (0.087, 0.113); CD = 0.975; SRMR = 0.046]. Therefore, the form of the model was considered invariant between genders. For both groups, item seven had the weakest reliability value (0.34 for males, 0.41 for females). Otherwise, item reliability values ranged from moderate to strong. Factor loadings were constrained to be equal between groups, and results of the Lagrange multiplier tests indicated that all factor loadings were equal for males and females (see Appendix E).

5.7.1.2.3 Longitudinal Invariance

Invariance of form was also tested across time. Appendix E displays factor loading information at baseline and follow up. The global fit indices indicated a good fit [χ^2 = 230.672, *df*

= 52, p = 0.000; TLI = 0.934; CFI = 0.952; RMSEA = 0.099, 90% CI: (0.086, 0.112); CD = 0.974; SRMR = 0.045]. The form was thus considered longitudinally invariant over four weeks. Item reliability values ranged from moderate to large (with the exception of the value for the seventh item at baseline, 0.35). Lagrange multiplier test results indicated that factor loadings were equal over time (see Appendix E).

5.7.2 Convergent and Divergent Validity

The latent variables, along with the measure of physical activity frequency, were combined into three larger models (see Figures 5.2, 5.3, and 5.4). Consistent with identity theory, the correlations between both factors of physical activity identity and physical activity frequency were strong and positive (see Figure 5.2). Amotivation was negatively related to physical activity (see Figure 5.3). The three more self-determined regulatory styles were strongly positively related to behavior, in accordance with theory, and external and introjected regulation were weakly correlated with physical activity frequency. Additionally, the regulatory styles posited to be more similar with respect to their relative level of autonomy (i.e., more controlled versus more self-determined) generally had larger positive correlations than those less similar (see correlation matrix, Appendix F). Finally, Figure 5.4 illustrates the correlations between identity dimensions and regulatory styles. As hypothesized, role identity and physical activity beliefs were both most strongly related to integrated regulation. Introjected regulation was positively related to physical activity beliefs.

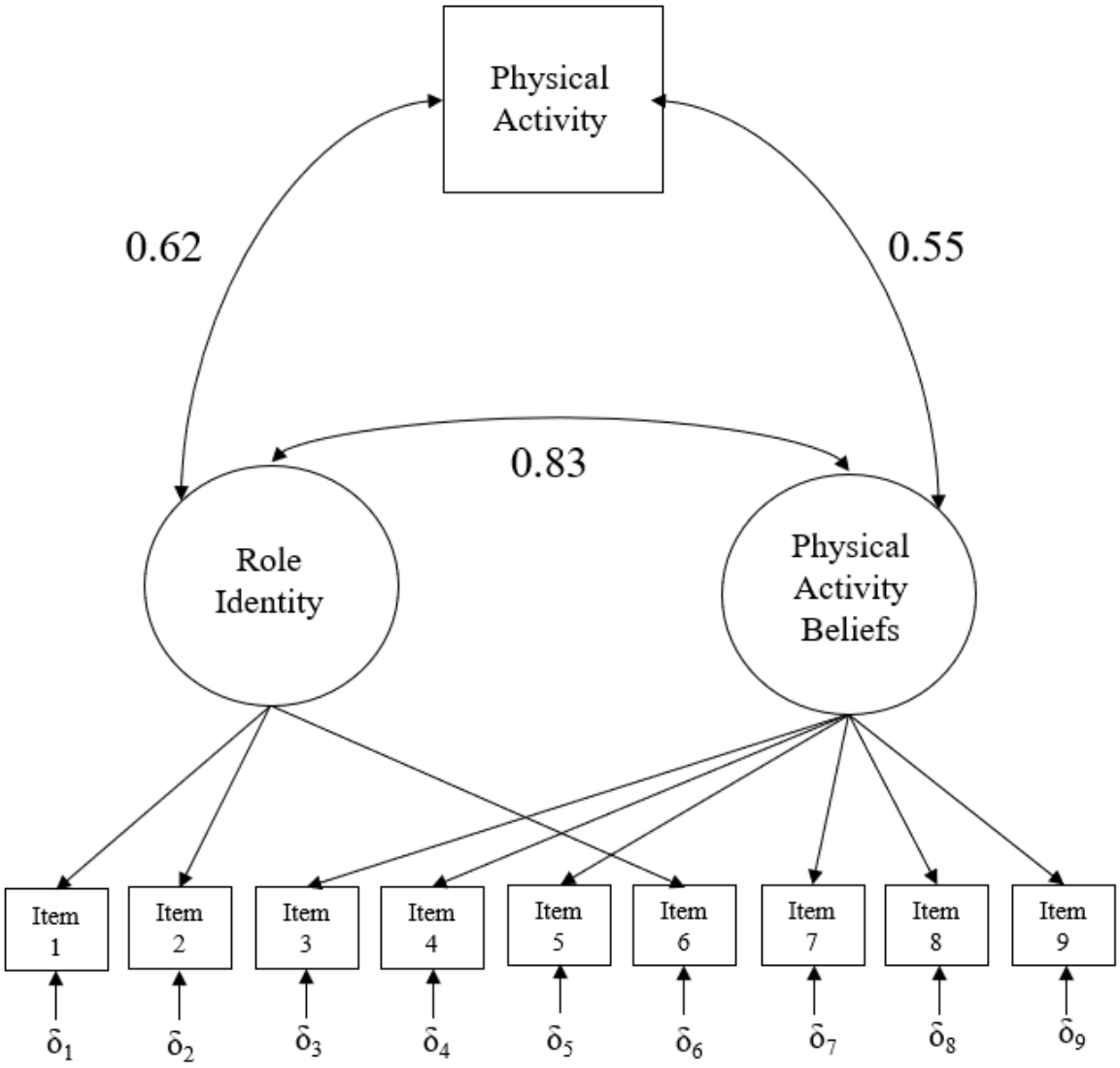

Figure 5.2. Relations between role identity, physical activity beliefs, and physical activity behavior.

Notes. δ denotes item errors. All correlations depicted are statistically significant ($p < 0.05$).

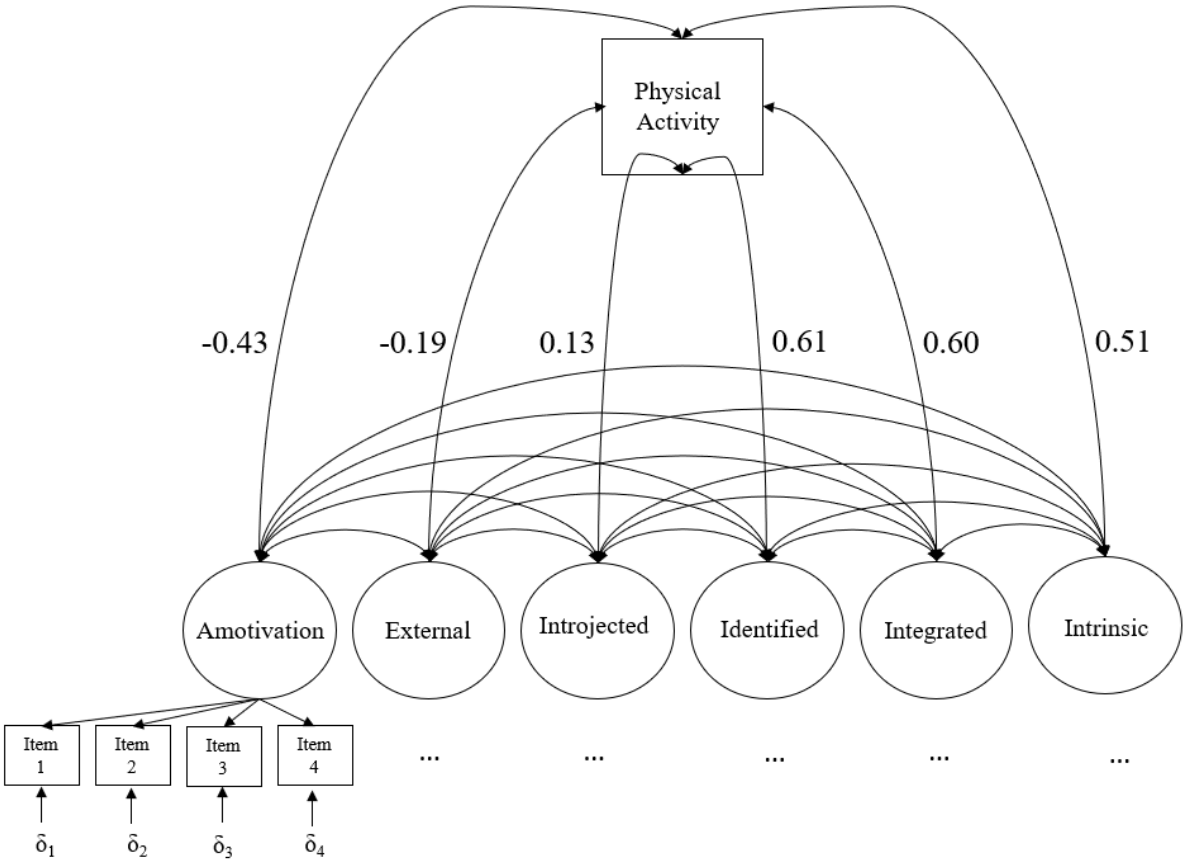

Figure 5.3. Relations between regulatory styles and physical activity behavior.

Notes. Correlations between the regulatory styles are not shown for simplicity. The ellipses indicate that each regulatory style subscale is likewise measured by four items, although the external regulation subscale and the integrated regulation subscale each have a pair of correlated errors. δ denotes item errors. All correlations depicted are statistically significant ($p < 0.05$) except for the correlation between physical activity and introjected regulation ($p = 0.05$).

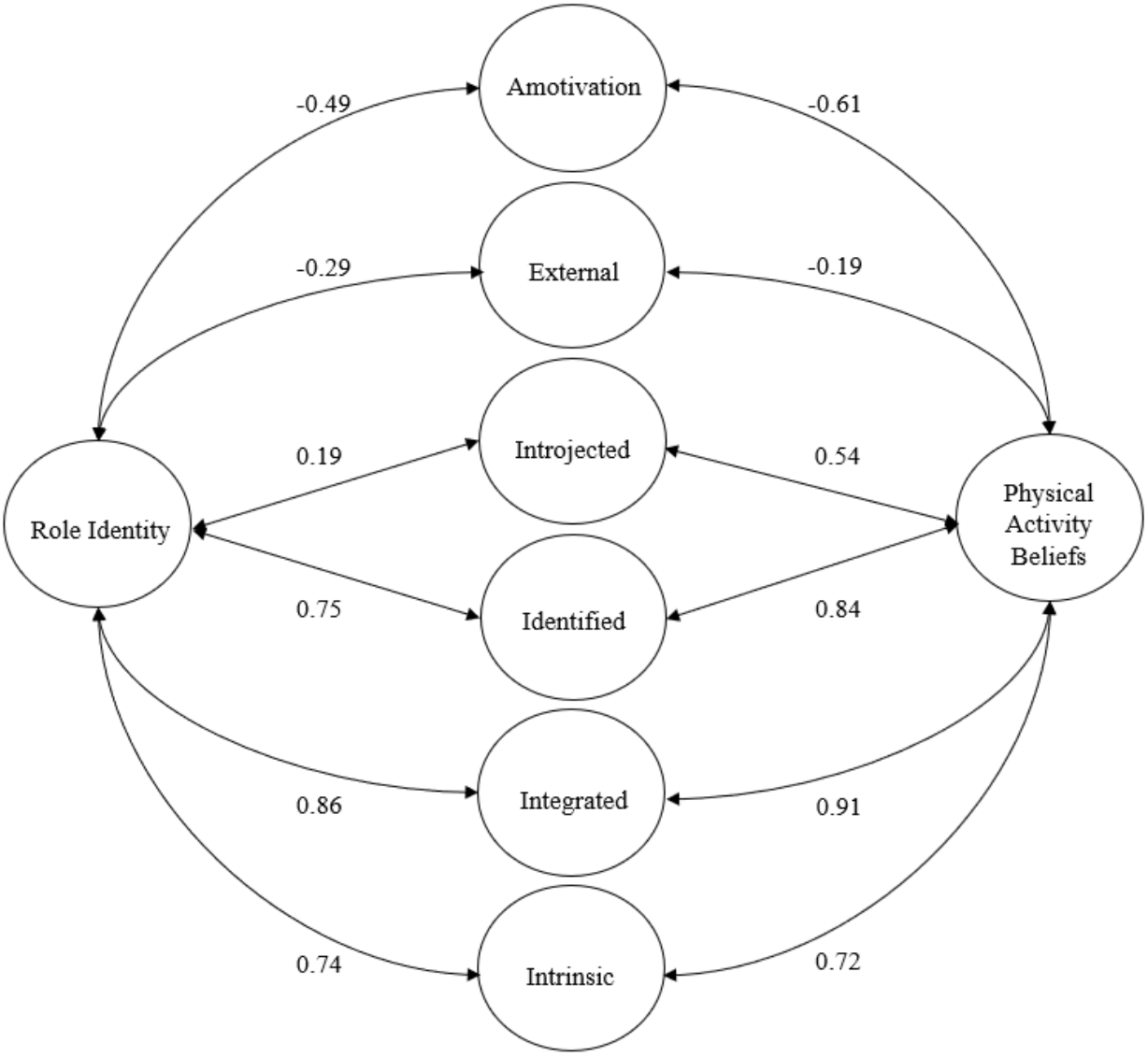

Figure 5.4. Relations between identity dimensions and regulatory styles.

Note. All correlations depicted are statistically significant ($p < 0.05$).

5.8 Discussion

The purpose of this study was to test the robustness of modified versions of the Exercise Identity Scale and the BREQ by examining measurement invariance and convergent and divergent validity among a sample of older adults. Overall, the findings from this study reveal that these instruments measuring two dimensions of physical activity identity and physical

activity regulatory styles are invariant between males and females and across four weeks for the older population. Furthermore, the latent variables relate to each other and to physical activity in ways that are consistent with the theoretical frameworks from which they were derived.

A substantial finding from this study was that the initial confirmatory factor analysis for the modified Exercise Identity Scale did not support a one-factor model, as has previously been suggested by Anderson and Cychosz (1994) and subsequently verified in a sample of older adults (Strachan et al., 2010). Rather, a two-factor model representing *role identity* and *physical activity beliefs* as two dimensions of physical activity identity demonstrated a better fit. This two-factor model reflecting exercise identity has been previously supported and used in past research (Ennigkeit & Hänsel, 2018; Ntoumanis et al., 2018; Vlachopoulos et al., 2011; Wilson & Muon, 2008; Zafeiridou et al., 2014). While both dimensions of identity were strongly and positively related to each other, to physical activity, and to more self-determined regulatory styles, only physical activity beliefs was strongly positively related to introjected regulation ($r = 0.54$). This relationship warrants future investigation. Higher levels of introjected regulation are associated with short-term engagement in physical activity (Deci & Ryan, 2008), as well as poorer psychological outcomes, such as anxiety and the inability to cope with failures (Ryan & Deci, 2000). Thus, if targeting physical activity beliefs leads to an introjected regulatory style, behavioral scientists may wish to instead focus on the role identity dimension of identity to promote sustained engagement in physical activity among older adults.

Additionally, item scores are often consolidated into one measure of the underlying construct (e.g., by taking an average). Should the items of this scale be averaged together into one measure of physical activity identity, the score may be primarily influenced by physical activity beliefs due to the larger number of scale items for this factor. To this point, given that role identity is measured with fewer items, it may also be more pragmatic (as well as more beneficial in the long-term due to its weaker association with introjected regulation) to measure role identity only in future physical activity studies.

The first item of the external regulation subscale of the modified BREQ ("I am physically active because other people say I should") had lower reliability. External regulation represents a regulatory style where people engage in activities due to peripheral, controlling factors; however, the degree to which someone perceives an external source as controlling is of importance for determining the ultimate motivational impact (Deci & Ryan, 2008). Thus, the degree to which

this item represents a controlling situation should be investigated in future studies. The last item of the identified regulation subscale ("I get restless if I'm not physically active regularly") also had low reliability. This item has posed problems for other researchers when attempting to validate the BREQ (e.g., Cid et al., 2018; Wilson et al., 2006). In fact, this item was removed from Markland and Tobin's (2004) validation study due to an unspecified "error." This item may more appropriately load onto introjected regulation (Cid et al., 2018), as it conveys an anxiousness that is possibly associated with the desire to avoid inactivity-related guilt (Mullan et al., 1997). Additional research should confirm which regulatory style this item best reflects for older adults – or consider removing the item from the BREQ, as there is evidence supporting its omission for adults approximately 55 years of age (Markland & Tobin, 2004).

This study has limitations that should be acknowledged. First, older adults were recruited from an online health research registry of individuals living in the United States, and therefore findings may not generalize to the wider population of older adults. Additionally, respondents were mostly white/Caucasian, educated, and in relatively good health, which also limits the generalizability of the study. Finally, data were gathered via self-report, which may be subject to social desirability bias and shared method variance inflating the correlations between the scale constructs and physical activity.

5.8.1 Conclusion

Physical activity regulatory styles and physical activity identity are potential putative targets for interventions designed to help older adults engage in physically active behaviors. High quality measures of these constructs are required to draw reliable conclusions regarding how they relate to the focal behavior, how they change in response to intervention strategies, and how they associate with other relevant constructs. The modified BREQ measuring distinct physical activity regulatory styles and the modified Exercise Identity Scale measuring physical activity beliefs and role identity were found to be invariant across four weeks and between males and females for a sample of older adults. The latent variables measured by these scales related to each other and to physical activity frequency in ways consistent with their theoretical frameworks. Importantly, the dimension of physical activity beliefs was found to be more strongly related to introjected regulation than was role identity. This finding emphasizes the implication that a one-factor model of identity should not be considered the default, especially

among the older population. To conclude, these measures are robust for adults aged 55 and older and should therefore be used to good advantage in future research investigating these constructs among this population.

5.9 References

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5.10 Appendix A.

Modified BREQ Scale Items

Using the scale below, please indicate to what extent each of the following items is true for you. Please note that there are no right or wrong answers and no trick questions. We simply want to know how you personally feel about physical activity.

		Not true for me	Rarely true for me	Some-times true for me	Often true for me	Always true for me
1.	It's important to me to be physically active regularly	1	2	3	4	5
2.	I don't see why I should have to be physically active	1	2	3	4	5
3.	I am physically active because it's fun	1	2	3	4	5
4.	I feel guilty when I'm not physically active	1	2	3	4	5
5.	I am physically active because it is consistent with my life goals	1	2	3	4	5
6.	I am physically active because other people say I should	1	2	3	4	5
7.	I value the benefits of being physically active	1	2	3	4	5
8.	I can't see why I should bother being physically active	1	2	3	4	5
9.	I enjoy my physical activity sessions	1	2	3	4	5
10.	I feel ashamed when I miss a physical activity session	1	2	3	4	5
11.	I consider physical activity part of my identity	1	2	3	4	5
12.	I take part in physical activity because my friends/family/partner say I should	1	2	3	4	5
13.	I think it is important to make the effort to be physically active regularly	1	2	3	4	5
14.	I don't see the point in being physically active	1	2	3	4	5

15. I find physical activity a pleasurable activity	1	2	3	4	5
16. I feel like a failure when I haven't been physically active in a while	1	2	3	4	5
17. I consider physical activity a fundamental part of who I am	1	2	3	4	5
18. I am physically active because others will not be pleased with me if I'm not	1	2	3	4	5
19. I get restless if I'm not physically active regularly	1	2	3	4	5
20. I think being physically active is a waste of time	1	2	3	4	5
21. I get pleasure and satisfaction from being physically active	1	2	3	4	5
22. I would feel bad about myself if I was not making time to be physically active	1	2	3	4	5
23. I consider physical activity consistent with my values	1	2	3	4	5
24. I feel under pressure from my friends/family to be physically active	1	2	3	4	5

Notes. Items 2, 8, 14, and 20 correspond to items 1, 2, 3, and 4 of the amotivation subscale. Items 6, 12, 18, and 24 correspond to items 1, 2, 3, and 4 of the external regulation subscale. Items 4, 10, 16, and 22 correspond to items 1, 2, 3, and 4 of the introjected regulation subscale. Items 1, 7, 13, and 19 correspond to items 1, 2, 3, and 4 of the identified regulation subscale. Items 5, 11, 17, and 23 correspond to items 1, 2, 3, and 4 of the integrated regulation subscale. Items 3, 9, 15, and 21 correspond to items 1, 2, 3, and 4 of the intrinsic motivation subscale.

5.11 Appendix B.

Modified Exercise Identity Scale Items

1. I consider myself a physically active person.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

2. When I describe myself to others, I usually include my involvement in physical activity.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

3. I have numerous goals related to physical activity.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

4. Physical activity is a central factor to my self-concept.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

5. I need to be physically active to feel good about myself.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

6. Others see me as someone who is physically active.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

7. For me, being a physically active person means more than just being physically active.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

8. I would feel a real loss if I were forced to give up being physically active.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

9. Being physically active is something I think about often.

Strongly Disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree

5.12 Appendix C.

Missing Observation Evaluation

Table 5.C.1. Demographic information and scale item comparisons at baseline for completers (two completed waves) and dropouts (only baseline completed).

Variable	**Completers (*n* = 314)**	**Dropouts (*n* = 96)**	**Effect Size**
	Mean (SD)		**SMD (95% CI)**
Age (years)	66.40 (7.21)	65.97 (6.51)	0.06 (-0.17, 0.30)
BMI (kg/m^2)	28.04 (5.81)	27.45 (4.96)	0.11 (-0.12, 0.35)
Physical activity	5.54 (1.81)	5.81 (1.47)	-0.18 (-0.41, 0.05)
Education	5.20 (1.53)	5.11 (1.46)	0.06 (-0.18, 0.30)
Amotivation (item 3)	1.24 (0.63)	1.43 (0.83)	-0.24 (-0.48, 0.01)
External regulation (item 1)	1.86 (1.03)	2.06 (1.11)	-0.19 (-0.42, 0.04)
Introjected regulation (item 2)	2.44 (1.20)	2.25 (1.00)	0.18 (-0.05, 0.42)
Identified regulation (item 2)	4.35 (0.88)	4.13 (0.98)	0.23 (0.00, 0.47)
Integrated regulation (item 4)	3.92 (1.12)	3.72 (1.10)	0.19 (-0.05, 0.42)
Intrinsic motivation (item 3)	3.62 (1.07)	3.43 (0.92)	0.20 (-0.03, 0.43)
Exercise Identity Scale (item 2)	4.03 (1.79)	3.66 (1.80)	0.21 (-0.03, 0.44)
	Percentage		**OR (95% CI)**
White/Caucasian	92.8%	86.8%	0.51 (0.24, 1.08)
Married/partnership	65.7%	61.5%	0.84 (0.52, 1.36)
Retired	55.4%	60.0%	1.21 (0.75, 1.95)
"Excellent" or "very good" self-rated health	48.9%	57.1%	1.40 (0.87, 2.24)

Notes. BMI: body mass index. SD: standard deviation. SMD: standardized mean difference. OR: odds ratio. CI: confidence interval. Education (highest degree received) was considered continuous for this analysis and ranged from 1 (some high school, no diploma) to 8 (doctorate). Items with the largest differences between completers and dropouts are displayed.

5.13 Appendix D.

Scale Item Descriptive Statistics

Table 5.D.1. Means and standard deviations of scale items at baseline and follow up.

Scale Item	T_1 Mean (SD)	T_2 Mean (SD)
Modified BREQ Items		
Amotivation		
Item 1	1.33 (0.72)	1.43 (0.86)
Item 2	1.25 (0.77)	1.43 (0.82)
Item 3	1.29 (0.69)	1.34 (0.75)
Item 4	1.27 (0.70)	1.26 (0.68)
External		
Item 1	1.91 (1.05)	1.85 (1.00)
Item 2	1.72 (0.96)	1.63 (0.88)
Item 3	1.40 (0.75)	1.34 (0.65)
Item 4	1.67 (0.96)	1.57 (0.89)
Introjected		
Item 1	3.40 (1.17)	3.45 (1.09)
Item 2	2.40 (1.16)	2.37 (1.22)
Item 3	2.70 (1.24)	2.81 (1.29)
Item 4	3.23 (1.18)	3.17 (1.23)
Identified		
Item 1	4.08 (1.03)	4.05 (1.08)
Item 2	4.31 (0.89)	4.27 (0.91)
Item 3	4.27 (0.90)	4.22 (0.99)
Item 4	3.20 (1.18)	3.20 (1.21)
Integrated		
Item 1	3.75 (1.20)	3.69 (1.23)
Item 2	3.22 (1.34)	3.14 (1.39)
Item 3	3.35 (1.34)	3.28 (1.41)
Item 4	3.88 (1.11)	3.78 (1.18)
Intrinsic		
Item 1	3.23 (1.13)	3.19 (1.15)
Item 2	3.64 (0.98)	3.59 (1.08)
Item 3	3.59 (1.03)	3.55 (1.08)
Item 4	3.88 (1.02)	3.72 (1.07)
Modified Exercise Identity		
Scale Items		
Active Person	4.88 (1.72)	4.75 (1.81)
Self-description	3.96 (1.79)	3.82 (1.81)
PA Goals	4.65 (1.65)	4.48 (1.70)
Self-concept	4.51 (1.83)	4.49 (1.80)
PA Need	5.06 (1.64)	4.92 (1.63)
Others' Description	4.61 (1.73)	4.54 (1.83)
Meaning	4.96 (1.49)	4.97 (1.50)
Feel Loss	5.73 (1.61)	5.59 (1.62)
PA Thoughts	5.16 (1.52)	5.07 (1.48)

Notes. BREQ: Behavioral Regulation in Exercise Questionnaire. T_1: baseline. T_2: four-week follow up. The modified BREQ items range from 1 (not true for me) to 5 (always true for me). The modified Exercise Identity Scale items range from 1 (strongly disagree) to 7 (strongly agree). PA: physical activity. SD: standard deviation.

5.14 Appendix E.

Component Fit Indices and Lagrange Multiplier Results

Table 5.E.1. Unconstrained factor loadings, standard errors, and 95% confidence intervals associated with the test of invariant form between gender and across time for the BREQ items.

Item	**Factor Loading**		**Standard Error**		**95% Confidence Interval**	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
Amotivation						
Item 1	1 (constrained)					
Item 2	0.99*	1.02*	0.07	0.13	(0.85, 1.13)	(0.76, 1.28)
Item 3	0.77*	0.82*	0.11	0.08	(0.56, 0.98)	(0.67, 0.98)
Item 4	0.85*	0.63*	0.08	0.10	(0.69, 1.02)	(0.44, 0.82)
External (revised)						
Item 1	1 (constrained)					
Item 2	1.33*	1.00*	0.13	0.11	(1.06, 1.59)	(0.78, 1.22)
Item 3	0.99*	0.88*	0.10	0.12	(0.79, 1.18)	(0.63, 1.12)
Item 4	1.41*	1.25*	0.17	0.18	(1.09, 1.74)	(0.89, 1.60)
Introjected						
Item 1	1 (constrained)					
Item 2	1.04*	1.06*	0.10	0.12	(0.84, 1.25)	(0.82, 1.31)
Item 3	1.17*	1.21*	0.11	0.12	(0.95, 1.38)	(0.97, 1.45)
Item 4	1.11*	0.94*	0.10	0.10	(0.91, 1.30)	(0.74, 1.14)
Identified						
Item 1	1 (constrained)					
Item 2	0.83*	0.81*	0.06	0.06	(0.71, 0.96)	(0.69, 0.93)
Item 3	0.77*	0.82*	0.07	0.06	(0.63, 0.92)	(0.70, 0.94)
Item 4	0.69*	0.79*	0.07	0.08	(0.54, 0.83)	(0.62, 0.95)
Integrated (revised)						
Item 1	1 (constrained)					
Item 2	1.09*	1.06*	0.08	0.09	(0.93, 1.25)	(0.88, 1.23)
Item 3	1.19*	1.06*	0.08	0.13	(1.03, 1.34)	(0.82, 1.31)
Item 4	1.09*	1.04*	0.08	0.07	(0.93, 1.24)	(0.90, 1.18)
Intrinsic						
Item 1	1 (constrained)					
Item 2	1.04*	0.98*	0.05	0.05	(0.94, 1.14)	(0.88, 1.07)
Item 3	1.04*	1.04*	0.06	0.05	(0.93, 1.16)	(0.96, 1.13)
Item 4	0.97*	0.97*	0.07	0.05	(0.84, 1.09)	(0.87, 1.08)
	Time 1	*Time 2*	*Time 1*	*Time 2*	*Time 1*	*Time 2*
Amotivation						
Item 1	1 (constrained)					
Item 2	1.07*	0.93*	0.09	0.08	(0.90, 1.23)	(0.77, 1.10)
Item 3	0.84*	0.74*	0.07	0.11	(0.71, 0.97)	(0.53, 0.96)
Item 4	0.81*	0.70*	0.10	0.08	(0.62, 1.00)	(0.54, 0.85)

External (revised)						
Item 1	1 (constrained)					
Item 2	1.08*	1.36*	0.12	0.15	(0.85, 1.31)	(1.06, 1.66)
Item 3	0.91*	1.02*	0.10	0.14	(0.70, 1.11)	(0.74, 1.29)
Item 4	1.19*	1.60*	0.14	0.21	(0.91, 1.47)	(1.19, 2.02)
Introjected						
Item 1	1 (constrained)					
Item 2	1.02*	1.11*	0.09	0.11	(0.84, 1.20)	(0.90, 1.32)
Item 3	1.13*	1.30*	0.10	0.11	(0.93, 1.32)	(1.08, 1.51)
Item 4	1.01*	1.02*	0.09	0.08	(0.83, 1.18)	(0.86, 1.18)
Identified						
Item 1	1 (constrained)					
Item 2	0.81*	0.84*	0.06	0.07	(0.70, 0.93)	(0.70, 0.97)
Item 3	0.73*	0.86*	0.07	0.06	(0.59, 0.87)	(0.74, 0.99)
Item 4	0.68*	0.78*	0.07	0.06	(0.54, 0.83)	(0.66, 0.90)
Integrated (revised)						
Item 1	1 (constrained)					
Item 2	1.09*	1.11*	0.07	0.09	(0.94, 1.23)	(0.93, 1.28)
Item 3	1.12*	1.19*	0.08	0.10	(0.96, 1.29)	(0.98, 1.39)
Item 4	1.05*	1.14	0.07	0.07	(0.91, 1.18)	(1.00, 1.28)
Intrinsic						
Item 1	1 (constrained)					
Item 2	0.96*	1.06*	0.04	0.05	(0.87, 1.04)	(0.97, 1.16)
Item 3	1.01*	1.09*	0.05	0.05	(0.91, 1.11)	(0.99, 1.19)
Item 4	0.95*	1.00*	0.05	0.06	(0.84, 1.05)	(0.89, 1.12)

*Notes. *p < 0.05. BREQ: Behavioral Regulation in Exercise Questionnaire. Standard errors presented are bootstrap standard errors. The two revised models were re-specified such that select error covariances were allowed to correlate.*

Table 5.E.2. Unconstrained factor loadings, standard errors, and 95% confidence intervals associated with the test of invariant form between gender and across time for the identity items.

Item	**Factor Loading**		**Standard Error**		**95% Confidence Interval**	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
1. Active Person	1 (constrained)					
2. Self-description	0.92*	0.81*	0.06	0.05	(0.80, 1.04)	(0.70, 0.92)
6. Others' Description	0.97*	0.98*	0.04	0.04	(0.89, 1.06)	(0.90, 1.06)
3. PA Goals	1 (constrained)					
4. Self-concept	1.20*	1.33*	0.07	0.12	(1.05, 1.34)	(1.10, 1.56)
5. PA Need	0.94*	0.98*	0.09	0.11	(0.77, 1.11)	(0.77, 1.19)
7. Meaning	0.69*	0.81*	0.07	0.08	(0.55, 0.82)	(0.65, 0.96)
8. Feel Loss	1.02*	0.99*	0.08	0.12	0.86, 1.19)	(0.76, 1.23)
9. PA Thoughts	0.86*	0.80*	0.08	0.07	(0.70, 1.02)	(0.67, 0.94)
	Time 1	*Time 2*	*Time 1*	*Time 2*	*Time 1*	*Time 2*
1. Active Person	1 (constrained)					
2. Self-description	0.89*	0.82*	0.05	0.05	(0.80, 0.98)	(0.73, 0.91)
6. Others' Description	0.96*	0.99*	0.03	0.03	(0.90, 1.03)	(0.92, 1.05)
3. PA Goals	1 (constrained)					
4. Self-concept	1.26*	1.28*	0.08	0.09	(1.11, 1.40)	(1.10, 1.47)
5. PA Need	0.97*	0.95*	0.08	0.08	(0.81, 1.13)	(0.79, 1.11)
7. Meaning	0.73*	0.78*	0.06	0.07	(0.60, 0.85)	(0.65, 0.91)
8. Feel Loss	1.00*	1.02*	0.08	0.09	(0.85, 1.16)	(0.85, 1.19)
9. PA Thoughts	0.86*	0.80*	0.07	0.06	(0.72, 1.00)	(0.68, 0.91)

*Notes. *p < 0.05. PA: physical activity. Standard errors presented are bootstrap standard errors. Items are not presented in the same order as the scale in Appendix A. Items 1, 2, and 6 load onto the latent construct of role identity and are presented first. Items 3, 4, 5, 7, 8, and 9 load onto the latent construct of physical activity beliefs and are presented as the last six items.*

Table 5.E.3. Results of the Lagrange multiplier tests associated with the test of invariant factor loadings between gender and across time for the BREQ items.

Item	χ^2 **Gender Analysis**	χ^2 **Longitudinal Analysis**
Amotivation		
Item 1	0.15*	2.25*
Item 2	0.79*	0.36*
Item 3	0.54*	0.05*
Item 4	4.40*	0.39*
External (revised)		
Item 1	1.63*	2.39*
Item 2	2.10*	0.52*
Item 3	0.09*	1.12*
Item 4	0.40*	2.07*
Introjected		
Item 1	0.18*	0.82*
Item 2	0.18*	0.01*
Item 3	0.64*	1.41*
Item 4	2.69*	0.28*
Identified		
Item 1	0.07*	1.10*
Item 2	0.40*	0.19*
Item 3	0.29*	1.61*
Item 4	1.02*	0.50*
Integrated (revised)		
Item 1	0.41*	0.81*
Item 2	1.08*	0.38*
Item 3	1.43*	0.28*
Item 4	0.00*	0.82*
Intrinsic		
Item 1	0.14*	2.30*
Item 2	2.71*	1.26*
Item 3	0.51*	0.06*
Item 4	0.26*	0.09*

*Notes. *p > 0.01. BREQ: Behavioral Regulation in Exercise Questionnaire. The two revised models were re-specified such that select error covariances were allowed to correlate.*

Table 5.E.4. Results of the Lagrange multiplier tests associated with the test of invariant factor loadings between gender and across time for the identity items.

Item	χ^2 **Gender Analysis**	χ^2 **Longitudinal Analysis**
1. Active Person	0.53*	0.01*
2. Self-description	3.62*	2.07*
6. Others' Description	0.49*	1.03*
3. PA Goals	0.37*	0.00*
4. Self-concept	1.95*	0.21*
5. PA Need	0.01*	0.15*
7. Meaning	1.50*	0.33*
8. Feel Loss	0.89*	0.07*
9. PA Thoughts	1.44*	0.91*

*Notes. *p > 0.01. PA: physical activity. Items are not presented in the same order as the scale in Appendix A. Items 1, 2, and 6 load onto the latent construct of role identity and are presented first. Items 3, 4, 5, 7, 8, and 9 load onto the latent construct of physical activity beliefs and are presented as the last six items.*

5.15 Appendix F.

Regulatory Style Associations

Table 5.F.1. Correlations between latent variable regulatory styles.

Variable	1	2	3	4	5	6
Amotivation	-					
External	0.26*	-				
Introjected	-0.35*	0.17*	-			
Identified	-0.79*	-0.23*	0.46*	-		
Integrated	-0.62*	-0.28*	0.41*	0.92*	-	
Intrinsic	-0.54*	-0.23*	0.28*	0.75*	0.77*	-

*Note. *p < 0.05.*

CHAPTER 6. ENJOYMENT OF AND SATISFACTION WITH PHYSICAL ACTIVITY: A ROBUSTNESS CHECK OF MEASUREMENT INSTRUMENTS FOR OLDER ADULTS

This chapter is derived in part from an article that has been submitted for publication to the *Journal of Aging and Physical Activity*.

6.1 Abstract

Enjoyment of and satisfaction with physical activity (PA) have been proposed as two actionable mechanisms for enhancing PA maintenance among older adults. Accurate conclusions regarding these mechanisms are contingent on having robust measures. This study examines convergent validity and measurement invariance (across time and between males and females) of the Physical Activity Enjoyment Scale-8 and a novel satisfaction measure among a sample of older adults (M_{age} = 66.25 years). Participants answered an online questionnaire twice across four weeks. Measurement invariance was assessed within a structural equation modeling framework; convergent validity was assessed by correlating the latent variables with each other and with PA. Both measures were invariant between gender and across time. Enjoyment and satisfaction were related to each other (r = 0.72) and to PA (r = 0.48 and 0.64, respectively). Results support the robustness of these measures as tools to assess PA enjoyment and satisfaction among older adults.

6.2 Introduction

Physical activity is vital for healthy aging, yet many older adults struggle to continue engaging in this behavior once it has been initiated (e.g., Olson & McAuley, 2015). To develop and refine more effective behavioral interventions, there is a fundamental need to identify theoretical constructs that could serve as potential actionable mechanisms of behavior change and maintenance and delineate the conditions under which these mechanisms are and are not related to physical activity (Sheeran et al., 2017). According to behavioral maintenance theories (Kwasnicka et al., 2016; Rothman, 2000), enjoyment of and satisfaction with physical activity are two constructs that play an essential role in motivating and supporting one's decision to sustain physical activity participation over time. Moreover, there is emerging evidence that these

factors are related to older adults' physical activity maintenance (Huffman et al., 2020; van Stralen et al., 2009). Accurate conclusions from research pertaining to these constructs, however, rely on the use of measurement instruments that adequately assess them within the population – and subgroups of the population – of interest. The ability of a given measure to perform without failure under a wide range of conditions (henceforth, *robustness*) is often mistakenly taken for granted in the exercise psychology domain (Hagger & Chatsizarantis, 2009). The overall purpose of this study is to test the robustness of a current measure of enjoyment of physical activity and a new approach to the measurement of satisfaction with physical activity among a sample of English-speaking older adults living in the United States.

Measurement invariance is one fundamental aspect related to the robustness of a measure. Measurement invariance assesses the psychometric equivalence of a given construct between subgroups of respondents or across measurement occasions (Putnick & Bornstein, 2016). Evidence for measurement invariance indicates that the measured construct has the same structure or meaning between groups or across time and can therefore be assessed in the same way. Without evidence for measurement invariance, observed differences between groups or changes in a construct over time may unknowingly be due to the instrument rather than true differences in the same construct. Importantly, if a measure varies across groups of interest but is used as if it were invariant, estimated direct and indirect effects may be inaccurate (Xu et al., 2020). Specifically, this study investigates the measurement invariance of these instruments between males and females and across four weeks. Furthermore, this study examines the convergent validity of the enjoyment and satisfaction measures based on relations between the two constructs, as well as between these constructs and physical activity frequency. Together, evidence for measurement invariance and convergent validity reinforces the robustness of a given instrument for use in the targeted population.

6.3 Enjoyment of Physical Activity

Enjoyment of physical activity has been defined as a positive affective state brought about by engaging in the behavior itself (Rhodes et al., 2009; Wankel, 1993) or as an optimal psychological state that leads one to perform an activity primarily for its own sake (Kimiecik & Harris, 1996). When physical activity is perceived as personally meaningful and psychologically

beneficial, people are more likely to choose to participate in it during their discretionary or leisure time (Wankel, 1993).

The 18-item Physical Activity Enjoyment Scale (PACES) was developed and validated with samples of adults ages 18 to 65 (Kendzierski & DeCarlo, 1991). Adapted versions of the PACES have been assessed for invariance among children and adolescents (Dunton et al., 2009; Jekauc et al., 2013; Moore et al., 2009), with Moore et al. (2009) acquiring evidence for non-invariant factor loadings between American boys and girls. However, research has concluded that the PACES does not represent a well-fitting one-factor model for older adults (M_{age} = 66.43 years; Mullen et al., 2011). Thus, the PACES-8 was subsequently developed and has been found to be invariant between two exercise groups (walking and flexing-toning-balance) and across time (six months) for this population (Mullen et al., 2011). Correlations between physical activity and the PACES-8 were reported (r = 0.16 and 0.17). A Portuguese version of the PACES-8 has also been found to be invariant across younger (18 to 66 years) males and females (Teques et al., 2020).

6.4 Satisfaction with Physical Activity

Satisfaction with physical activity reflects a global assessment of the positive and negative experiences and outcomes derived from the behavior (Baldwin & Sala, 2018; Rothman, 2000; Rothman et al., 2004). If more positive experiences (e.g., quality experiences with friends, feeling better during the activity) are perceived than negative ones (e.g., pain, fatigue), and if actual outcomes are similar to those initially expected and desired (e.g., improved functioning), motivation to continue physical activity is reinforced (Kwasnicka et al., 2016; Rothman, 2000). It is worth noting that enjoyment and satisfaction are overlapping yet distinct constructs (Baldwin & Sala, 2018; Chmielewski et al., 2016).

In the physical activity literature, satisfaction has often been measured with a single item (e.g., "In general, how satisfied are you with what you have experienced as a result of exercising?") on a rating scale that ranges from "*extremely*" or "*very dissatisfied*" to "*extremely*" or "*very satisfied*" (Baldwin et al., 2013; Chmielewski et al., 2016; Fleig et al., 2011). Although this single item closely reflects the underlying satisfaction construct, it is likely a sub-optimal measure for three main reasons. First, respondents tend to more frequently use the midpoint or positive (satisfied) end of the scale as compared to the negative (dissatisfied) end (Baldwin et al.,

2013). It is unclear if this is because the wording of the question (i.e., "how *satisfied* are you…?") leads respondents to focus only on satisfaction, or because of people's tendency to provide positive ratings when answering questions on satisfaction (Choi & Pak, 2005), or both. Second, this single item has been reported as having poor psychometric properties, including evidence of weak test-retest reliability and validity (Chmielewski et al., 2016). Third, perceived satisfaction is theorized as a multifaceted construct (Baldwin & Sala, 2018), which may not be adequately appraised using one question. Therefore, in an attempt to appropriately capture the entirety of the construct and to safeguard against reporting issues, a new approach to the measurement of satisfaction has been developed and tested in this study.

6.5 Objectives

The purpose of this study is to test the robustness of the PACES-8 and a novel measure of satisfaction in a sample of adults ages 55 and older. Accordingly, this study examines measurement invariance between males and females and across four weeks, as well as convergent validity based on relations with other variables. This study contributes to the physical activity and gerontology literature in several ways. First, this study reports the development and validity of a new approach to the measurement of satisfaction with physical activity. This approach was developed with members of the older population to create a measure that better represents the multifaceted nature of the satisfaction construct, thus surpassing the shortcomings of the previously used one-item measure. Second, this study replicates Mullen et al.'s (2011) validity assessment of the PACES-8 for older adults. This is particularly necessary, as the rejection of the original PACES and creation of the PACES-8 was decided within the same sample (Mullen et al., 2011). Finally, this study further establishes the robustness of the instruments by assessing measurement invariance between males and females and across four weeks. Indeed, Mullen et al. (2011) determined the PACES-8 was invariant across six months. Because experiences and outcomes that occur within the first few weeks after one's change in his or her behavior are linked to satisfaction with physical activity (Baldwin et al., 2013), four weeks (i.e., about one month) was chosen in this study as a shorter timeframe to assess longitudinal invariance. This period was also deemed to be a practical amount of time between intensive repeated assessments for future longitudinal work.

6.5.1 Validation Hypotheses

Because enjoyment of and satisfaction with physical activity are overlapping yet conceptually distinct constructs (Baldwin & Sala, 2018; Chmielewski et al., 2016), they should be strongly positively correlated. Past studies have reported correlations of 0.38, 0.57, and 0.77 between these two constructs (Chmielewski et al., 2016; Tsafou et al., 2016; Williams et al., 2008). Given the use of the purposefully crafted satisfaction measurement approach, the correlation was expected to be on the stronger end of this range. It also was hypothesized that enjoyment and satisfaction would be strongly and positively correlated with physical activity behavior. Past research has found correlations ranging from 0.16 to 0.27 between enjoyment and physical activity (Chmielewski et al., 2016; Mullen et al., 2011) and 0.17 to 0.33 between satisfaction and physical activity (Chmielewski et al., 2016; Fleig et al., 2011; Tsafou et al., 2016, 2017; Williams et al., 2016). The correlations reported in this study were expected to be higher than what has been found in past research due to the removal of measurement error using structural equation modeling.

6.6 Methods

6.6.1 Participants and Procedures

Older adults living in the United States were recruited through ResearchMatch (www.researchmatch.org), a national online health research volunteer registry supported by the U.S. National Institutes of Health. To be eligible, participants were required to be at least 55 years of age, be able to read and understand English, and to have no indication of cognitive impairment. Potential participants were identified by filtering on these eligibility criteria in ResearchMatch's participant selection system, and an initial message detailing the study was sent in batches to randomly selected individuals meeting the criteria. As one purpose of this study is to test the measurement invariance between gender, the initial interest message was purposefully sent in gender batches to attempt to recruit equal numbers of males and females. In total, 5,750 males and females were randomly selected by ResearchMatch's participant selection system and were sent the interest message. Those indicating interest were then emailed a unique link to an online Qualtrics survey. After clicking "I agree" to an online consent form, they completed the first questionnaire (T_1). Four weeks later (T_2), the participants received an email inviting them to

take a second identical questionnaire. The physical activity question was asked first, and demographics and health-related questions were consistently asked last (see Measures below). The order of the presentation of the PACES-8 and the satisfaction measure were randomized. Moreover, the items within each scale were also randomized such that they did not appear in a consistent order across participants. Randomization was implemented using Qualtrics' randomization features. Data collection occurred from August to September 2019. A participant flowchart is presented in Figure 6.1. Participants were compensated with a $10 Amazon gift card. This study was approved by the Purdue University Institutional Review Board (IRB Protocol #: 1906022325). See Appendix A for further information regarding recruitment and sample size.

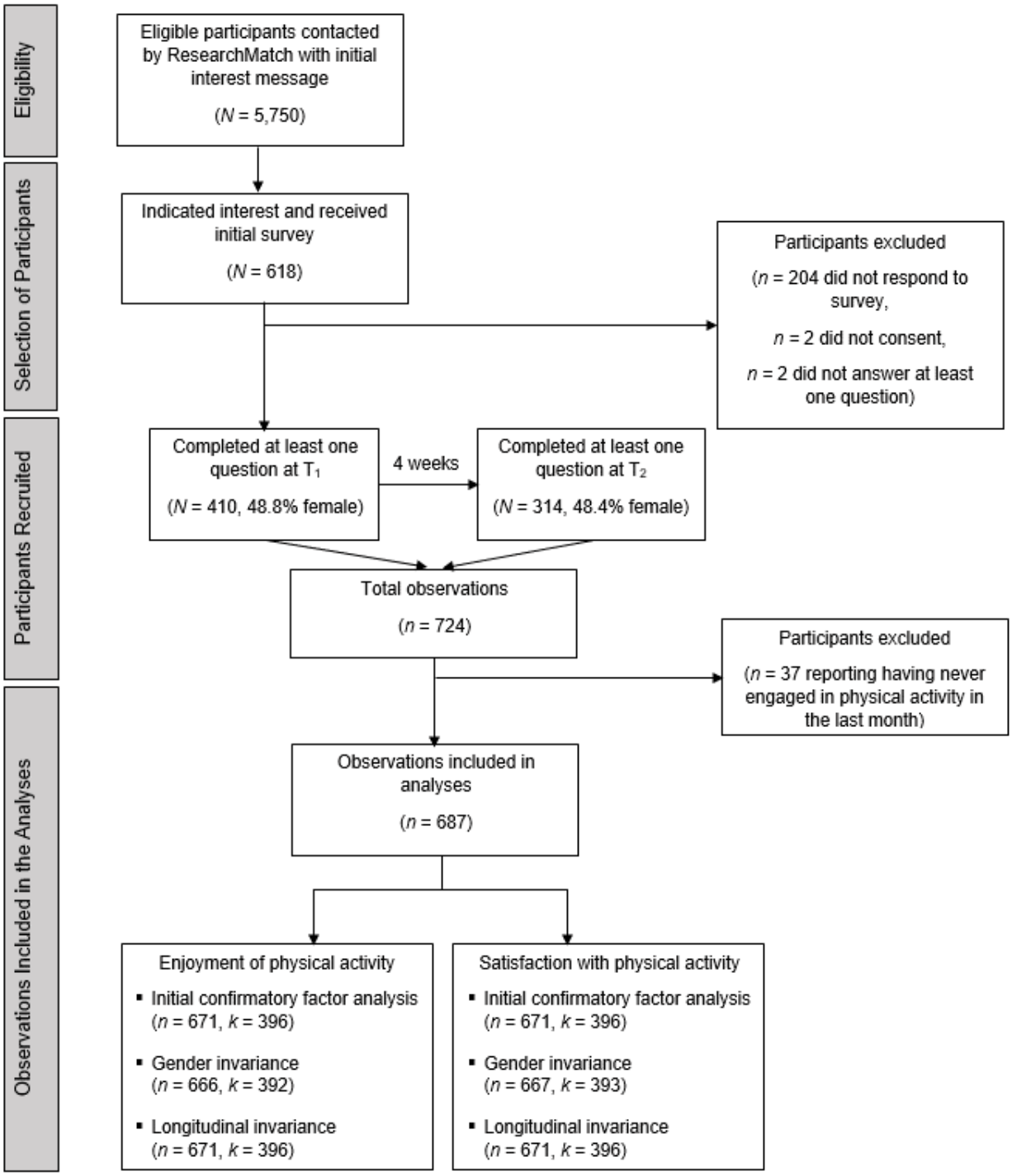

Figure 6.1. Participant flow chart.

Notes. N: number of respondents; n: number of observations; k: number of clusters. Percentage of female responses for T_1 and T_2 were calculated after missing gender information was imputed based on available responses from the prior or subsequent time point.

6.6.2 Measures

6.6.2.1 Enjoyment of Physical Activity

The PACES-8 (Mullen et al., 2011) consists of eight items and asks participants to "Please rate how you feel at the moment about the physical activity you have been doing." Responses were indicated on a 7-point scale and included choices such as "*I find it pleasurable/I find it unpleasurable*" and "*It is very invigorating/It is not at all invigorating*." Six items were reverse coded such that higher scores on the PACES-8 indicated more enjoyment. The full scale is presented in Appendix B.

6.6.2.2 Satisfaction with Physical Activity

The satisfaction measure was developed following a three-step process with a separate sample of older adults (N = 10, 6 males, 77 to 85 years; IRB Protocol #: 1902021741). Further details of the three-step development process are presented in Appendix C. Briefly, the single item that has commonly been used in past research was retained, as it closely reflects the theoretical definition of the satisfaction construct (Baldwin & Sala, 2018; Rothman, 2000). The developed measure includes three additional items that tap onto different facets of satisfaction, namely *expectancy violation*, *realizations given the expended effort*, and *emotional responses*. Responses are indicated on a 7-point scale (e.g., "*very dissatisfied*" to "*very satisfied*"). The four-item measure is fully presented in Appendix C.

6.6.2.3 Leisure-Time Physical Activity

A one-item measure of physical activity was used to assess how often in the past month the participants had been physically active for at least 30 minutes in the same day (Gionet & Godin, 1989). Responses ranged from 1 (*never*) to 7 (*4 days or more per week*). Prior to answering the question, the following definition of physical activity was provided to respondents: "Physical activity refers to activities that get your body moving. Doing such activities would result in noticeable increases in breathing, heart rate, or sweating." Examples of physical activities in which older adults typically participate (e.g., walking, dancing, gardening, yard work, swimming; Amireault et al., 2019) were provided. Participants were explicitly

instructed not to include activities that they engaged in as part of their job, volunteering, or caretaker duties.

Validity evidence supporting the use of this question and interpretation of its score in the adult population (age ≥ 18 years) has been previously reported by Gionet and Godin (1989) and Godin, Jobin, and Bouillon (1986). Because this one-item physical activity measure only asks about the frequency of physical activity, the measurement error typically associated with the reporting of the duration and intensity of physical activity is less likely to bias the measure (Nigg et al., 2020; Rikli, 2000). Furthermore, the same sample of older adults involved in the development process for the satisfaction measure were interviewed regarding this item to ensure its adequate interpretation. Additional details about these interviews and adaptations made to the original item are presented in Appendix D.

6.6.2.4 Sample Demographic and Health Characteristics

Participants self-reported their age, gender, race/ethnicity, education, employment, relationship status, self-rated health, and any chronic conditions (e.g., arthritis) experienced. Weight and height were also self-reported in order to calculate body mass index (BMI). BMI was calculated by dividing weight (kilograms) by height squared (m^2).

6.6.3 Data Analysis

6.6.3.1 Data Screening and Preparation

First, data were screened for duplicate respondents, out-of-range values, missing data, and distributional anomalies. As both the enjoyment and satisfaction measure utilize Likert-type responses, outliers were not considered an issue. A comparison was made between those who responded to the survey at both times and those who dropped out after completing the survey at T_1; these groups were similar on demographic characteristics, mean responses to the enjoyment and satisfaction items, and frequency of leisure-time physical activity. See Appendix E for more details regarding data preparation and the comparison between dropouts and completers. Additionally, because the PACES-8 asks about "the physical activity you have been doing," and this satisfaction approach asks individuals to assess their satisfaction with outcomes from past physical activity, those indicating that they have not participated in physical activity in the last

month were excluded. Data screening was conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and Stata version 16 (StataCorp LLC, College Station TX, USA).

6.6.3.2 Gender and Longitudinal Invariance Analyses

The invariance analyses were conducted using Stata version 16 (StataCorp LLC, College Station TX, USA). Measurement invariance was assessed within a structural equation modeling framework (Bollen, 1989). First, a one-factor model was specified for both enjoyment and satisfaction, and model fit was assessed using confirmatory factor analysis for the entire sample. Second, the models were tested to determine whether the form (e.g., number of underlying latent variables) was the same between males and females and also across T_1 and T_2 when allowing parameter estimates to be freely estimated (i.e., different between gender and time groups). Finally, factor loadings were constrained to be equal between males and females and across T_1 and T_2 to determine if the relationships between the latent variables and the indicators were the same. Lagrange multiplier tests were performed to determine whether the factor loadings were the same for both males and females and at both measurement occasions. Given the multiple tests run, an alpha value of 0.01 was used as the significance level for the Lagrange multiplier tests.

Observations with missing data were excluded from the invariance analyses. Additionally, to increase sample size, observations were pooled from both T_1 and T_2 for the analyses. To account for this clustering of repeated measures within respondents, cluster variance estimation was used. Moreover, because the distributions of the enjoyment and satisfaction item scores were negatively skewed (see Appendix E), clustered bootstrapping with 500 replications was used to obtain standard errors to correct for non-normal outcomes for the initial confirmatory factor analyses and to assess invariance of form. The robust cluster estimator was used to assess invariance of factor loadings due to the incompatibility of Stata invariance commands with bootstrap results. Figure 6.1 provides the number of observations (n) and clusters (k) for all analyses. The invariance analyses were also run with a data set that included those who responded "never" to the physical activity item. Overall results did not change.

Multiple model fit criteria were examined when considering how well the models fit the data. Global fit measures include the chi-square test (χ^2; $p > 0.05$ for acceptable fit), the Tucker-Lewis Index (TLI; ≥ 0.90 for acceptable fit), the comparative fit index (CFI; ≥ 0.90 for

acceptable fit), the root mean square error of approximation (RMSEA; < 0.10 for acceptable fit), the coefficient of determination (CD; ≥ 0.90 for acceptable fit), and the standardized root mean square residual (SRMR; < 0.08 for acceptable fit). Component fit measures [i.e., factor loadings, reliability values (R^2)] were also considered. The R^2 value represents a structural equation approach to item reliability that can be interpreted as the proportion of variance in a scale item that is explained by the underlying construct (Bollen, 1989). Although ranges and thresholds for satisfactory reliability scores are somewhat arbitrary, R^2 values ≥ 0.70 were considered strong, values > 0.40 and < 0.70 were considered moderate, and values ≤ 0.40 were considered weak (Bollen, 1989).

6.6.3.3 Validity Evidence Based on Relations to Other Variables

The models were used to assess the correlation between the latent variables of enjoyment and satisfaction. The correlations between the latent variables and the physical activity measure were also calculated and reported.

6.7 Results

The participants reporting being physically active at least once in the last month were on average 66.25 years of age (*SE* = 0.37), with an average BMI of 27.82 (*SE* = 0.29) at T_1. Additional participant demographics are presented in Table 6.1. Descriptive statistics for the PACES-8 and satisfaction items at both T_1 and T_2 are presented in Table 6.2. Respondents participated in physical activity between two and three days per week at both measurement occasions [T_1: *M* = 5.81, *SE* = 0.07; T_2: *M* = 5.69, *SE* = 0.09; scale items ranging from 2 (*about once in the last month*) to 7 (*4 days or more per week*)].

Table 6.1. Participant demographic characteristics reported at baseline (T_1; n = 392).

Demographic Characteristic	**Percentage (%)**
Female	48.0
White/Caucasian	88.0
Married/domestic partnership	63.8
Retired	54.3
Bachelor's degree or higher	72.7
"Excellent" or "very good" self-rated health	50.2
Arthritis	28.8
Heart disease	14.3

Table 6.2. Means and standard errors (SE) for the PACES-8 and satisfaction items at T_1 and T_2.

Item No.	**Items**	**First measurement occasion (T_1)**		**Second measurement occasion (T_2)**	
		Mean	SE	Mean	SE
	Enjoyment				
1	Pleasurable	5.55	0.07	5.59	0.08
2	Fun	5.12	0.07	5.11	0.08
3	Pleasant	5.31	0.07	5.39	0.08
4	Invigorating	5.33	0.07	5.29	0.08
5	Gratifying	5.65	0.07	5.66	0.08
6	Exhilarating	4.81	0.07	4.84	0.09
7	Stimulating	5.25	0.07	5.21	0.08
8	Refreshing	5.33	0.07	5.35	0.08
	Satisfaction				
1	Evaluation	5.34	0.08	5.23	0.09
2	Expectations	3.99	0.07	3.93	0.08
3	Realizations	5.28	0.08	5.21	0.09
4	Emotion	5.31	0.07	5.30	0.08

Notes. Responses to the PACES-8 items range from 1 to 7; higher values indicate higher levels of enjoyment of physical activity. Responses to the satisfaction items range from 1 to 7; higher values indicate higher levels of satisfaction with physical activity.

6.7.1 Enjoyment of Physical Activity

The enjoyment model was specified such that all eight items were indicators of enjoyment, error covariances were set to be 0, and enjoyment was scaled to the first item (i.e., "Pleasurable"). Model fit was then assessed for the entire data set. The model demonstrated an adequate fit, as all global model fit statistics were acceptable (TLI = 0.944, CFI = 0.960, CD = 0.941, SRMR = 0.032) except the chi-squared statistic (183.948, $df = 20$, $p < 0.05$) and the RMSEA value [0.111, 90% CI: (0.096, 0.126)]. All factor loadings were significant, and item reliability values were moderate to large, ranging from 0.54 to 0.73. The model was re-specified to improve fit before invariance testing. The first three items of the PACES-8 are phrased such that they elicit opinions of the activity itself (e.g., finding physical activity fun or pleasurable), whereas the remainder of the items are phrased such that respondents may reflect upon their positive affect after participation (e.g., feeling invigorated or stimulated). Thus, the model was re-specified such that the errors of the first three items were allowed to correlate. This model demonstrated a better global fit to the data [$\chi^2 = 48.768$, $df = 17$, $p < 0.05$; TLI = 0.987; CFI = 0.992; RMSEA = 0.053, 90% CI: (0.036, 0.070); CD = 0.929; SRMR = 0.017] and a similar component fit to the data; therefore, this model was retained for the invariance analyses.

6.7.1.1 Gender Invariance

The form of the re-specified model (i.e., the model with correlated error terms) was tested for males and females to determine if the form was the same for both genders. The model fit well for both groups. Regarding component fit, all factor loadings were significant and in the same direction, and item reliability values were moderate to large (see Table 6.3). Global fit measures also indicated a good fit [$\chi^2 = 66.717$, $df = 34$, $p < 0.05$; TLI = 0.987; CFI = 0.992; RMSEA = 0.054, 90% CI: (0.034, 0.073); CD = 0.930; SRMR = 0.021]. Factor loadings were then constrained to be equal across genders. Results from the Lagrange multiplier tests were all non-significant (see Table 6.4), indicating that all factor loadings were the same for males and females. Additionally, results from the Wald tests of equal covariances across gender were non-significant, indicating that the covariances among the three error terms were the same for males and females.

Table 6.3. Component fit indices for the enjoyment and satisfaction models with different estimates across groups.

Item No.	Parameter	Coefficient		Bootstrap 95% Confidence Interval		R^2 Values	
	Enjoyment	***Males***	***Females***	***Males***	***Females***	***Males***	***Females***
1	Pleasurable	1 (constrained)		-	-	0.62	0.68
2	Fun	1.05	0.98	(0.94, 1.16)	(0.84, 1.12)	0.60	0.60
3	Pleasant	1.00	0.96	(0.90, 1.09)	(0.84, 1.07)	0.55	0.62
4	Invigorating	1.15	0.91	(1.01, 1.28)	(0.73, 1.09)	0.76	0.63
5	Gratifying	1.02	0.88	(0.86, 1.19)	(0.76, 1.01)	0.64	0.58
6	Exhilarating	1.13	1.06	(0.98, 1.27)	(0.92, 1.20)	0.70	0.68
7	Stimulating	1.04	0.89	(0.86, 1.22)	(0.76, 1.01)	0.57	0.54
8	Refreshing	1.18	1.08	(1.06, 1.31)	(0.96, 1.20)	0.76	0.73
	cov(1, 2)	0.21	0.17	(0.10, 0.32)	(0.05, 0.29)		
	cov(1, 3)	0.36	0.21	(0.22, 0.49)	(0.10, 0.32)		
	cov(2, 3)	0.30	0.23	(0.16, 0.45)	(0.11, 0.36)		
	Satisfaction						
1	Evaluation	1 (constrained)		-	-	0.74	0.74
2	Expectations	0.72	0.72	(0.60, 0.84)	(0.59, 0.86)	0.50	0.46
3	Realizations	1.05	1.09	(0.91, 1.18)	(0.95, 1.23)	0.81	0.81
4	Emotion	0.87	0.87	(0.77, 0.98)	(0.75, 0.99)	0.74	0.77
	Enjoyment	***Time 1***	***Time 2***	***Time 1***	***Time 2***	***Time 1***	***Time 2***
1	Pleasurable	1 (constrained)		-	-	0.66	0.62
2	Fun	0.98	1.05	(0.88, 1.09)	(0.92, 1.19)	0.59	0.61
3	Pleasant	0.94	1.04	(0.84, 1.04)	(0.94, 1.15)	0.56	0.62
4	Invigorating	1.00	1.09	(0.88, 1.12)	(0.93, 1.25)	0.71	0.69
5	Gratifying	0.97	0.93	(0.85, 1.09)	(0.78, 1.09)	0.64	0.57
6	Exhilarating	1.04	1.19	(0.91, 1.16)	(1.03, 1.35)	0.67	0.73
7	Stimulating	0.97	0.99	(0.83, 1.11)	(0.85, 1.13)	0.58	0.54
8	Refreshing	1.08	1.20	(0.99, 1.17)	(1.07, 1.33)	0.72	0.78
	cov(1, 2)	0.19	0.22	(0.07, 0.30)	(0.11, 0.33)		
	cov(1, 3)	0.29	0.31	(0.16, 0.41)	(0.20, 0.43)		
	cov(2, 3)	0.30	0.24	(0.15, 0.44)	(0.13, 0.35)		
	Satisfaction						
1	Evaluation	1 (constrained)		-	-	0.74	0.74
2	Expectations	0.71	0.73	(0.60, 0.83)	(0.61, 0.85)	0.47	0.50
3	Realizations	1.08	1.05	(0.94, 1.22)	(0.93, 1.17)	0.79	0.83
4	Emotion	0.88	0.87	(0.77, 0.99)	(0.76, 0.97)	0.73	0.78

Notes. All coefficients are significant ($p < 0.05$). "cov(x, y)" indicates the covariance between item x and item y. R^2: reliability values.

Table 6.4. Invariance results for the enjoyment and satisfaction models with equal factor loadings across groups.

Item No.	Parameter	Gender Invariance		Longitudinal Invariance	
		χ^2	*p*-value	χ^2	*p*-value
	Enjoyment				
1	Pleasurable	2.05	0.15	2.52	0.13
2	Fun	0.01	0.91	0.01	0.91
3	Pleasant	0.20	0.65	1.05	0.31
4	Invigorating	4.20	0.04	0.07	0.79
5	Gratifying	0.16	0.69	2.02	0.16
6	Exhilarating	0.59	0.44	1.99	0.16
7	Stimulating	0.27	0.60	0.45	0.50
8	Refreshing	0.10	0.75	0.63	0.43
	cov(1, 2)	0.06	0.81	0.10	0.75
	cov(1, 3)	1.85	0.17	0.07	0.80
	cov(2, 3)	0.28	0.60	0.46	0.50
	Satisfaction				
1	Evaluation	0.06	0.81	0.05	0.83
2	Expectations	0.01	0.91	0.22	0.64
3	Realizations	0.30	0.59	0.11	0.74
4	Emotion	0.07	0.79	0.02	0.89

Notes. The null hypothesis of the Lagrange multiplier test is that the constraint (i.e., constraining the factor loading to be equal across groups) is valid. Lagrange multiplier test results are reported for parameters that were constrained (i.e., the factor loadings). The null hypothesis of the Wald test is that a constraint would have been valid. Wald test results are reported for parameters that were not constrained (i.e., the error covariances). "cov(x, y)" indicates the covariance between item x and item y.

6.7.1.2 Longitudinal Invariance

The form of the re-specified model was tested across T_1 and T_2. The model fit well at both measurement occasions [$\chi^2 = 61.715$, $df = 34$, $p < 0.05$; TLI = 0.989; CFI = 0.993; RMSEA = 0.049, 90% CI: (0.029, 0.069); CD = 0.930; SRMR = 0.018]. Factor loadings were all significant and in the same direction, and item reliability values were moderate to large (see Table 6.3). Factor loadings were constrained to be equal at both time points, and results from the Lagrange multiplier tests were non-significant (see Table 6.4), indicating that factor loadings were the same at both times. Results from the Wald tests of equal covariances across time were also non-significant, indicating stable covariances across time.

6.7.2 Satisfaction with Physical Activity

The satisfaction model was specified such that all four items were indicators of satisfaction, error covariances were set to be 0, and satisfaction was scaled to the first item (i.e., "Evaluation"). The fit of the model for the entire data set was assessed. The model demonstrated an excellent overall fit. All global model fit statistics were acceptable [$\chi^2 = 4.214$, $df = 2$, $p > 0.05$; TLI = 0.996; CFI = 0.999; RMSEA = 0.041, 90% CI: (0.000, 0.096); CD = 0.917; SRMR = 0.008], factor loadings were all significant, and item reliability values were moderate to large, ranging from 0.48 to 0.81.

6.7.2.1 Gender Invariance

The form of the model was then tested for males and females. The global model fit was excellent for both groups [$\chi^2 = 5.562$, $df = 4$, $p > 0.05$; TLI = 0.997; CFI = 0.999; RMSEA = 0.034, 90% CI: (0.000, 0.095); CD = 0.918; SRMR = 0.010]. Additionally, all factor loadings were significant and in the same direction, and item reliability values were moderate to large (see Table 6.3). Factor loadings were constrained to be equal for males and females, and the results of the Lagrange multiplier tests were all non-significant (see Table 6.4); thus, factor loadings were the same between genders.

6.7.2.2 Longitudinal Invariance

The form of the model was tested across time, and the model fit demonstrated an excellent fit at both times [$\chi^2 = 4.607$, $df = 4$, $p > 0.05$; TLI = 0.999; CFI = 1.000; RMSEA = 0.021, 90% CI: (0.000, 0.088); CD = 0.916; SRMR = 0.008]. Factor loadings were all significant and in the same direction, and item reliability values were moderate to large (see Table 6.3). Finally, factor loadings were constrained to be equal at T_1 and T_2. The Lagrange multiplier tests were all non-significant (see Table 6.4).

6.7.3 Validity Evidence Based on Relations to Other Variables

The latent variables of the invariant models were positively correlated with the physical activity measure and with each other (Figure 6.2). All correlations were positive and of expected magnitude. Correlations between the items and physical activity are presented in Appendix E.

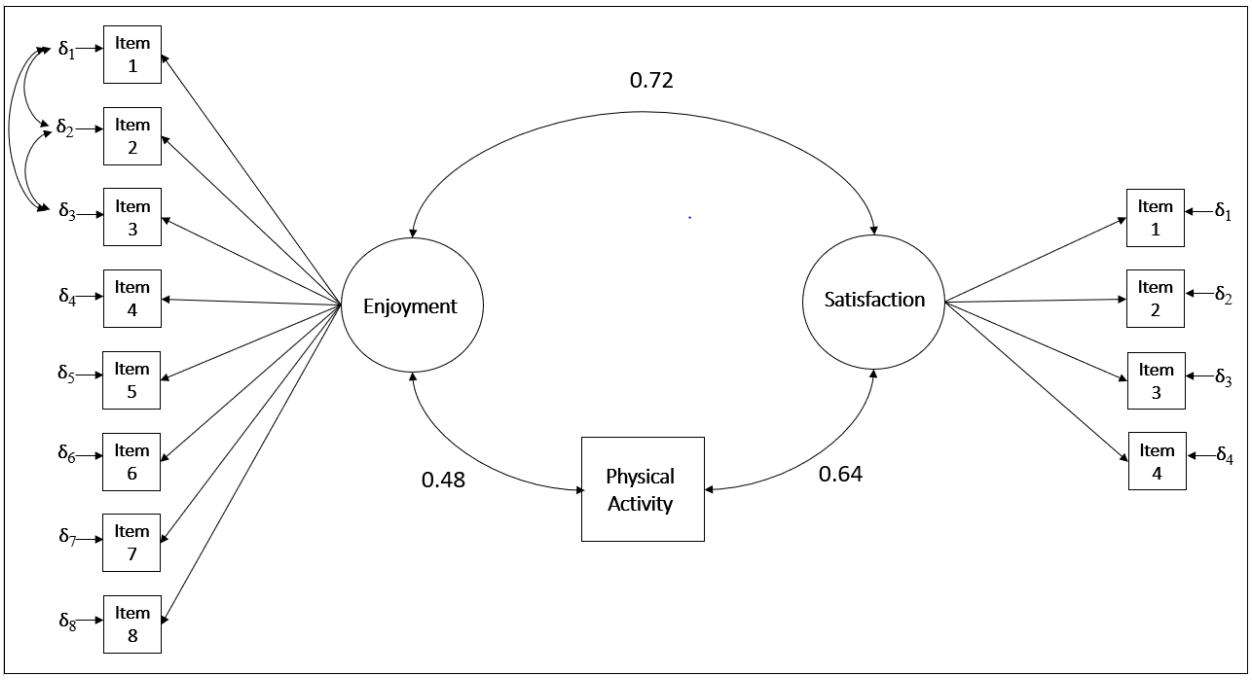

Figure 6.2. Correlations between latent variables and physical activity behavior.

Notes. n = 664, k = 395. δ denotes the item errors. All p-values ≤ 0.001. Analysis was conducted using clustered bootstrapping with 500 replications. n: number of observations; k: number of clusters.

6.8 Discussion

The purpose of this study was to examine the robustness of measures of two potential actionable mechanisms of behavior change and maintenance: enjoyment of and satisfaction with physical activity. Measurement invariance was evaluated for gender and across measurement occasions among a sample of English-speaking older adults living in the United States. A second purpose of this study was to investigate convergent validity based on relations to other variables.

Past research has explicitly highlighted the need for the development of new satisfaction measures within the physical activity literature (Chmielewski et al., 2016). The measure used in this study was purposefully developed with a sample of older adults to address this need and assess satisfaction with the outcomes and experiences of physical activity. This novel, four-item measure was then found to represent a well-fitting, one-factor model for a second sample of older adults and to be invariant between males and females and across two measurement occasions four weeks apart. Additionally, the latent variable satisfaction was positively

correlated with physical activity (r = 0.64) and with the latent variable enjoyment (r = 0.72). Thus, this study provides evidence for a psychometrically sound multi-item satisfaction measure for use with older adults in a physical activity context.

Previously, Mullen et al. (2011) found that the PACES-8 represented a well-fitting, one-factor model of enjoyment and was invariant between two exercise groups and across two measurement occasions, six months apart, for a sample of older adults (M_{age} = 66.43, SD = 5.67). Consistent with these results, this study provides additional support for a one-factor model among an older adult sample. The current study has also demonstrated that the PACES-8 is invariant between gender (males and females) and across a shorter timeframe (four weeks), further establishing its robustness within the older population. Moreover, compared to the correlations reported in Mullen et al.'s (2011) study (r = 0.16 and 0.17), a stronger positive correlation between the latent variable enjoyment and frequency of leisure-time physical activity was calculated in the current study (r = 0.48). It should be noted that the smaller correlations between enjoyment and physical activity found by Mullen et al. (2011) may be due to the fact that the Physical Activity Scale for the Elderly (PASE; Washburn et al., 1993) used in the prior study assesses domains in which the physical activity performed may not be perceived as enjoyable (e.g., occupational activity). These domains were specifically excluded from the physical activity measure used in the current study. Additionally, Mullen et al. (2011) calculated their correlation with the total scale score rather than the latent construct enjoyment.

Often in the physical activity and health psychology literature, items from Likert-type scales are summed or averaged to create a composite score to use as a predictor or outcome variable. Importantly, however, if the relation between the indicators and construct of interest differs between groups (or across time), summing or averaging the scores of scale items in the same way for different groups (or at several time points) would provide estimates of the construct that are not directly comparable. This study revealed that factor loadings could be considered equal in all invariance analyses, suggesting that the relationships between the PACES-8 and satisfaction items and the latent variables enjoyment and satisfaction, respectively, are the same between males and females and across time. Thus, creating a composite score in this way for these groups would be acceptable. This study also found that the better fitting model for enjoyment included correlated errors between the first three items of the PACES-8. A strength of structural equation modeling is that it can account for this measurement error; other

methods (e.g., multiple linear regression) assume that variables are measured error-free. While these correlated errors do not affect how the scale associates with other variables, researchers may wish to utilize a structural equation modeling framework when assessing enjoyment with the PACES-8 and account for these correlated errors in order to use a better fitting model.

6.8.1 Limitations

The generalizability of the study findings is limited by the underrepresentation of certain subgroups of the older adult population. The sample consisted predominately of educated, white individuals. Additionally, the participants included in the invariance and validity analyses were pre-registered members of an existing national online health research volunteer registry, and therefore results may not generalize to older adults who are less interested in health research. Moreover, respondents were limited to older adults living in the United States. It is thus likely that most participants of the study could be considered as having a Western cultural background. Enjoyment and satisfaction may have different meanings for individuals of other cultures. Lastly, the self-reported data may be subject to social desirability bias and shared method variance. This may have inflated the correlations between enjoyment, satisfaction, and physical activity.

6.8.2 Conclusions

Physical activity enjoyment and satisfaction represent two theoretical constructs that may facilitate older adults' sustained engagement in physical activity. These constructs were assessed using the PACES-8 and a new approach to the measurement of satisfaction with physical activity among adults ages ≥ 55 years. Notably, this satisfaction measurement approach consists of a relatively brief, four-item measure that better represents the multifaceted nature of the satisfaction construct. Results from this study support the robustness of the PACES-8 and this novel satisfaction measure; therefore, these instruments could be used in future mechanistic behavioral research to estimate direct and indirect (mediation) effects among older adults.

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6.11 Appendix A.

Recruitment and Sample Size

Prior to conducting this study, we did not know how many potential participants to expect to respond to the initial ResearchMatch message with interest. Moreover, as we sought to recruit equal numbers of both genders, we were cautious not to unintentionally recruit a disproportional number of males to females. Therefore, we proceeded to send the initial message in gender batches of 200-400 and noted in real time the respective numbers of males and females who responded with interest. We subsequently sent more batch messages when more participants were required for a gender. Within a structural equation modeling framework, it is recommended to have at least "several cases" per free parameter estimated (Bollen, 1989). Our enjoyment model (the largest of the two models) required the estimation of 16 and 19 parameters for the initial and re-specified model, respectively, for the first confirmatory factor analysis. We therefore attempted to recruit and retain 200 males and 200 females for a total of 400 participants at each measurement occasion. An *N* of 800 thus would have allowed for 50 and 42 cases per parameter for the initial and re-specified enjoyment model, respectively. Even with a conservative *N* of 600, the confirmatory factor analyses would still have had "several" cases per free parameter.

Reference

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6.12 Appendix B.

Physical Activity Enjoyment Scale-8

Please rate how you feel at the moment about the physical activity you have been doing.

O	O	O	O	O	O	O
I find it pleasurable						I find it unpleasurable
O	O	O	O	O	O	O
It's no fun at all						It's a lot of fun
O	O	O	O	O	O	O
It's very pleasant						It's very unpleasant
O	O	O	O	O	O	O
It's very invigorating						It's not at all invigorating
O	O	O	O	O	O	O
It's very gratifying						It's not at all gratifying
O	O	O	O	O	O	O
It's very exhilarating						It's not at all exhilarating
O	O	O	O	O	O	O
It's not at all stimulating						It's very stimulating
O	O	O	O	O	O	O
It's very refreshing						It's not at all refreshing

6.13 Appendix C.

Satisfaction Measure

When you think about engaging in physical activity, you probably have some expectations about the physical activity experience itself (i.e., feelings while doing it) and its consequences (i.e., benefits from it). The following questions will ask you to describe your feeling of satisfaction with your physical activity.

As of today, how dissatisfied or satisfied are you with what you have experienced as a result of regularly engaging in one or more physical activities?

Very dissatisfied	Dissatisfied	Slightly dissatisfied	Neutral	Slightly satisfied	Satisfied	Very satisfied

To what extent do you think your expectations for regularly engaging in one or more physical activities in the last month have been realized?

Very much worse than expected	Worse than expected	Slightly worse than expected	Matched expectations	Slightly better than expected	Better than expected	Very much better than expected

Given the effort you put into trying to meet your physical activity goals in the last month, how would you rate the outcomes (e.g., benefits and feelings) of physical activity you have experienced?

Very poor	Poor	Slightly poor	Fair	Slightly good	Good	Very good

How would you describe your feeling of satisfaction with what you have experienced as a result of regularly engaging in one or more physical activities in the last month?

Terrible	Unhappy	Slightly unhappy	Neutral	Slightly pleased	Pleased	Delighted

Three-Step Development Process for a New Measure of Satisfaction

Step 1: Review of the literature

Expectancy violation, realizations given the expended effort, and emotional responses were three facets of the satisfaction construct determined through a review of the health psychology, physical activity psychology, and consumer sciences literature.

Expectancy violation. Satisfaction includes an assessment of expectancy violation (e.g., Sears & Stanton, 2001; Williams et al., 2008) – that is, whether initial expectations were not achieved. Consistent with theory and this facet of satisfaction, older adults who initially expected to improve their physical fitness, weight, and body appearance – but perceived no or lower than expected improvements in these outcomes – demonstrated lower physical activity participation compared to those whose perceived outcomes better matched their expectations (Jones et al., 2005; Neff & King, 1995; Wilcox et al., 2006).

Realizations given the expended effort. A relative assessment of the costs and benefits from engaging in a behavior is theorized to inform people's overall satisfaction assessment (Rothman, 2000). This facet can be reflected in one's rating of the outcomes afforded by the exercise or physical activity experience, given the effort one put into trying to reach or meet relevant personal goals (e.g., Baldwin et al., 2009; Williams et al., 2016).

Emotional responses. Building upon consumer sciences and marketing literature, intense negative or positive emotional responses to an experience may consist of high levels of dissatisfaction or satisfaction stemming from elements of surprise. For instance, people might be disgusted (extreme dissatisfaction) or delighted (extreme satisfaction) when they perceive their performance to surprisingly fall well below or far exceed one's initial expectations, respectively (Barnes & Krallman, 2019; Ma et al., 2017). Consistent with this view, older women who did not initially expect to improve their physical fitness and reduce their stress but perceived improvements six months later ("surprised pessimists") reported higher physical activity levels compared to those whose initial expectations for change in fitness and stress were high but perceived no improvements ("disappointed optimists") (Neff & King, 1995; Wilcox et al., 2006).

Step 2: Draft of the satisfaction measure

The new measure of satisfaction was drafted. The single item that has commonly been used in past research was retained, as it closely reflects the theoretical definition of perceived satisfaction (Baldwin & Sala, 2018; Rothman, 2000). However, the wording of the question was

modified so that it was less likely to lead the respondents to focus only on the positive end (i.e., "As of today, how dissatisfied or satisfied are you…?" instead of "As of today, how satisfied are you…?"). One question for each of the other three relevant facets of perceived satisfaction identified in the review of the literature was created on a 5-point bipolar scale.

Step 3: Cognitive interviews

The purpose for conducting the cognitive interviews was to identify potential problems related to communicating the intent of the meaning of the questions to respondents, verify whether respondents were likely to not know or have trouble remembering information, and assess the adequacy of the range of responses to be recorded. A total of 10 face-to-face interviews were conducted with six older males and four older females (77 to 85 years of age) from the surrounding community area after providing their consent (IRB Protocol #: 1902021741). The interviewees were well educated (all completed a university degree) and primarily white/Caucasian. A verbal, retrospective probing approach was used (Willis, 2004). Accordingly, after each participant completed all satisfaction items, a trained interviewer asked questions to probe for information related to the clarity of the questions and adequacy of the response categories. All participants shared a similar understanding of "satisfaction" and "expectations" that was consistent with theory and the intent of the measure. Finally, interview data suggested that the participants could appropriately discriminate response categories (e.g., "slightly satisfied" vs. "very satisfied;" "matched expectations" vs. "below" or "above expectations") and formulate meaningful answers. Because there were no issues with category discrimination, response categories were expanded from five to seven to allow for more options at the negative and positive ends of the scale.

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6.14 Appendix D.

One-Item Measure of Physical Activity

Physical activity refers to activities that get your body moving. Doing such activities would result in noticeable increases in breathing, heart rate, or sweating.

For example, physical activity may include:

- *Walking or rolling* (e.g., brisk walking, hiking, walking the dog, wheelchair rolling)
- *Play, games, sports, or exercises* (e.g., biking, dancing, golf without using a power cart, jogging or running, swimming, seated volleyball, tennis, water aerobics, working out using machines or weights)
- *Around-the-house activities* (e.g., gardening, such as continuous digging or hoeing)

Please **do not include** activities that may be a part of **your job, volunteering, or caretaker duties**.

In the last month, how often have you participated in one or more physical activities for at least 30 minutes in a same day?

- ◯ Never
- ◯ About once in the last month
- ◯ About 2 or 3 times in the last month
- ◯ About once per week
- ◯ About 2 days per week
- ◯ About 3 days per week
- ◯ 4 days or more per week

Cognitive interviews were conducted with six older males and four older females (77 to 85 years of age) from the surrounding community area. The purpose of these interviews was to identify potential problems related to communicating the intent of the meaning of the physical activity item. All participants provided their informed consent (IRB Protocol #: 1902021741). See Appendix C for more participant characteristics. Participants first read the provided definition of leisure-time physical activity and then completed the frequency of physical activity measure. A trained interviewer asked the following questions:

- What does “regular physical activity during your leisure-time” mean to you?
- Tell me about the types of physical activity you participate in.
- How did you arrive at that answer?

Most respondents (60%) had difficulty with comprehending the original definition of “leisure-time.” For instance, it was not initially clear as to what was to be included as “leisure” physical activity or exercise. For these respondents, there was a difference between leisure-time physical activity (walking, gardening, and swimming) and scheduled or planned physical activity (e.g., group exercise classes or programs that are scheduled at a specified day/time and offered at a fitness center). For some respondents, activities performed during their leisure-time could include non-physical activities or sedentary activities, such as reading. Therefore, the decision was made to remove the definition of “leisure-time,” and an additional sentence was added before the question. Based on the types of activities the respondents were engaging in, no changes were made to the original examples listed for the item. Based on the respondents’ explanations of their determinations of frequency, no changes were made regarding the number of response categories or labels. Details regarding the ultimate changes made to the original wording and presentation of physical activity item are provided in Table 6.D.1.

Table 6.D.1. Main findings of the cognitive interviews regarding the 1-item frequency measure of physical activity (N = 10).

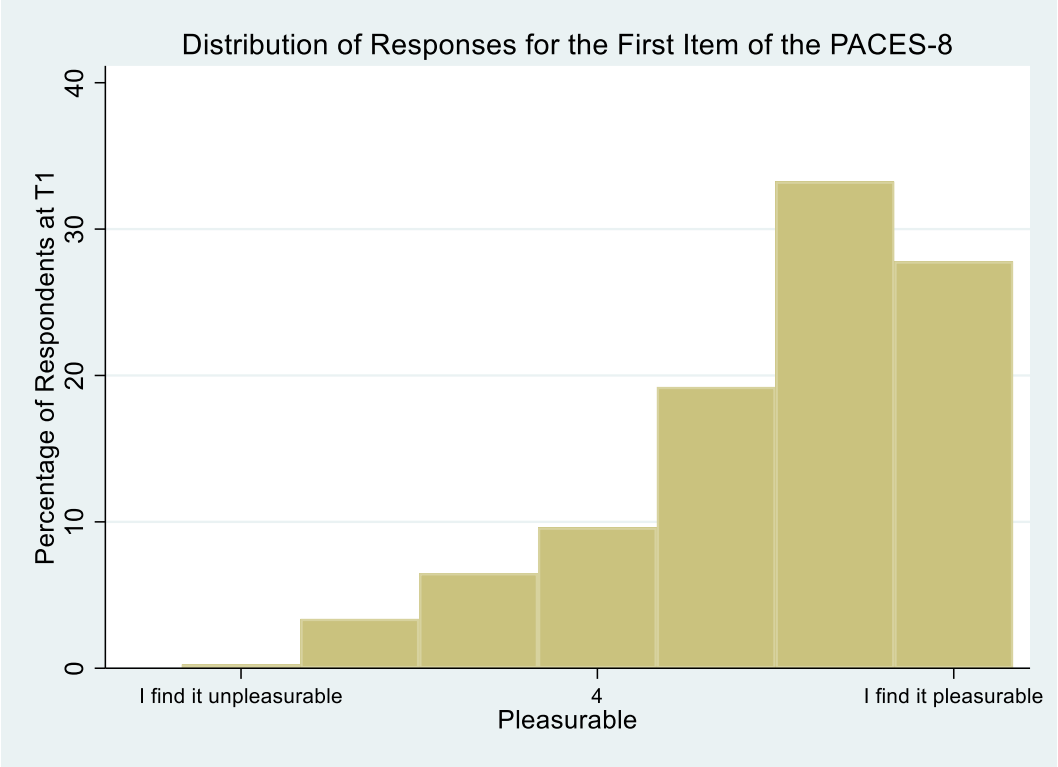
Domain	Original wording and presentation	Changes made
Comprehension of the physical activity context "leisure-time"	**Physical activity** refers to activities that get your boding moving. Doing such activities would result in noticeable increases in breathing, heart rate, and maybe sweating.	**Physical activity** refers to activities that get your body moving. Doing such activities would result in noticeable increases in breathing, heart rate, or sweating.
	Leisure time refers to time that can be spent on one's own discretionary time rather than principal work, volunteering, or caregiving duties	[The definition of "leisure time" was removed]
	For example, leisure-time physical activity may include:	For example, physical activity may include: [the term "leisure-time" was deleted]
	Walking or rolling (e.g., brisk walking, hiking, walking the dog, wheelchair rolling)	*Walking or rolling* (e.g., brisk walking, hiking, walking the dog, wheelchair rolling)
	Play, games, sports, or exercises (e.g., biking, dancing, golf without using a power cart, jogging or running, swimming, seated volleyball, tennis, water aerobics, working out using machines or weights)	*Play, games, sports, or exercises* (e.g., biking, dancing, golf without using a power cart, jogging or running, swimming, seated volleyball, tennis, water aerobics, working out using machines or weights)
	Around-the-house activities (e.g., gardening, such as continuous digging or hoeing)	*Around-the-house activities* (e.g., gardening, such as continuous digging or hoeing)
		Please **do not include** activities that may be a part of **your job, volunteering, or caretaker duties**.

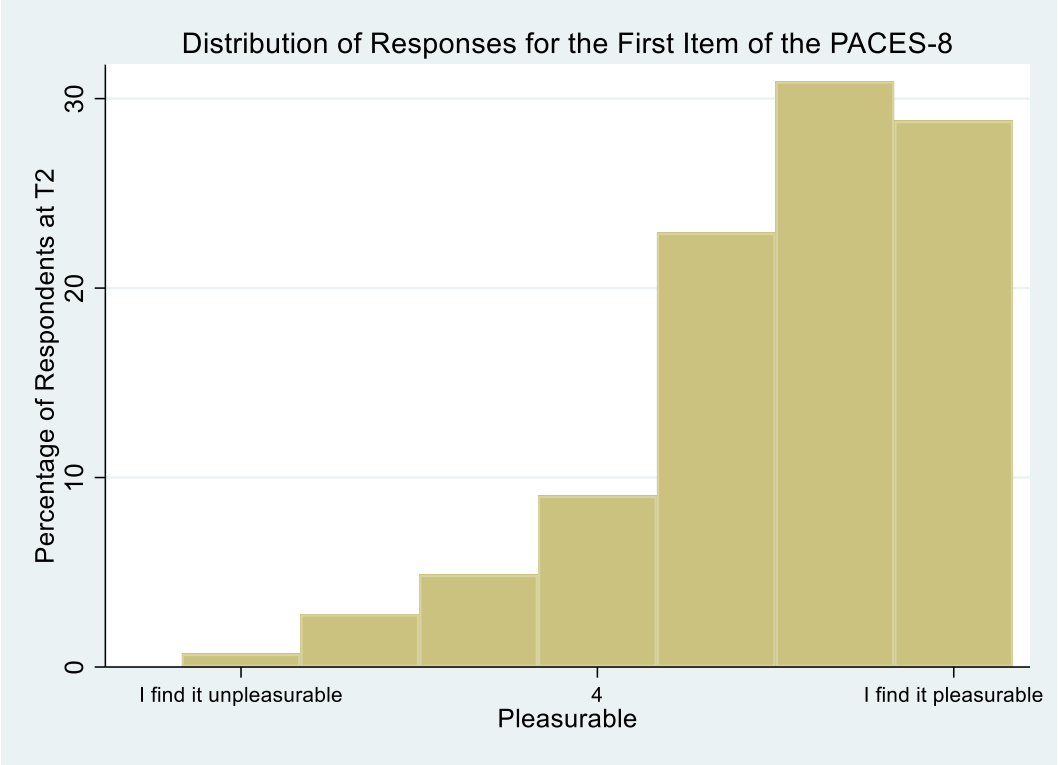
6.15 Appendix E.

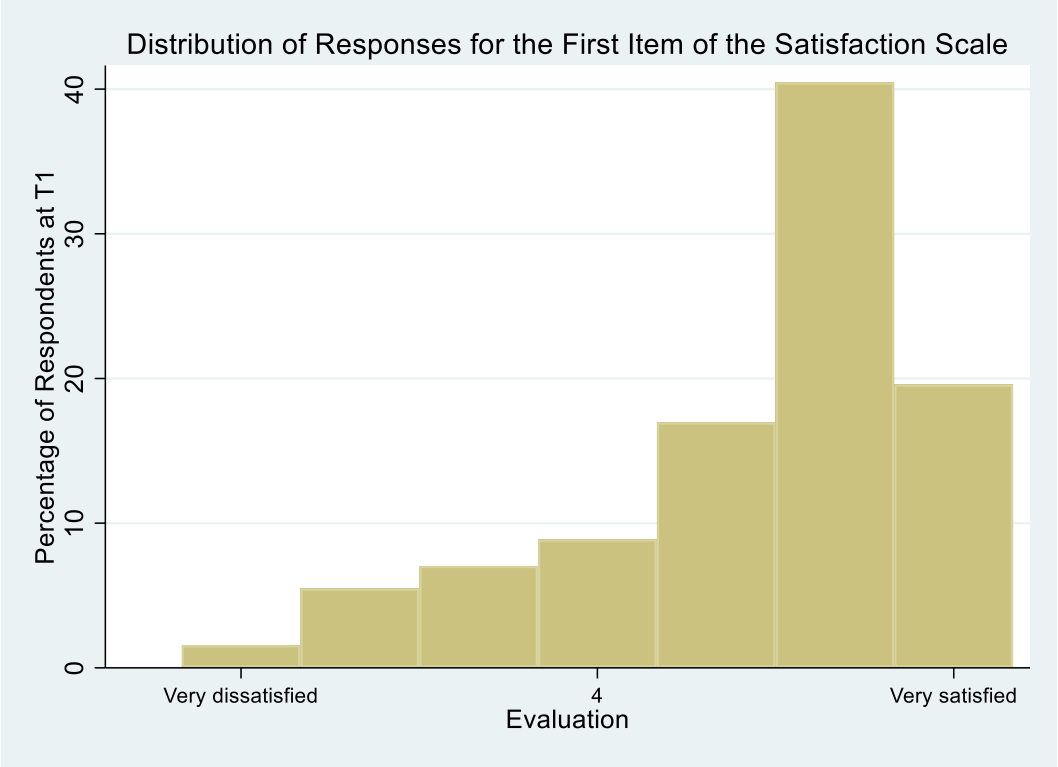
Data Screening and Preparation

No duplicate responses to the survey were detected for either the T_1 or T_2 survey. Missing gender information at a given time point was imputed based on available data (e.g., gender information provided at T_2 was imputed for missing gender information at T_1). Prior to conducting the invariance analyses, a visual inspection of the responses to the enjoyment and satisfaction items indicated that distributions were slightly negatively skewed (see below for example distributions). Additionally, a comparison was made between those who responded to the survey at both times and those who dropped out after completing the survey at T_1. Dropouts and completers were similar on demographic characteristics, mean responses to the enjoyment and satisfaction items, and frequency of leisure-time physical activity (see Table 6.E.1). Finally, means, standard errors, and correlations of the scale items and the physical activity measure were calculated and are reported in the results and Table 6.E.2 in this file.

Example Distributions of the First Items of the Physical Activity Enjoyment Scale-8 (PACES-8) and Satisfaction Measure at Two Time Points






Distribution of Responses for the First Item of the Satisfaction Scale
Percentage of Respondents at T1
0
10
20
30
40
Very dissatisfied
4
Very satisfied
Evaluation

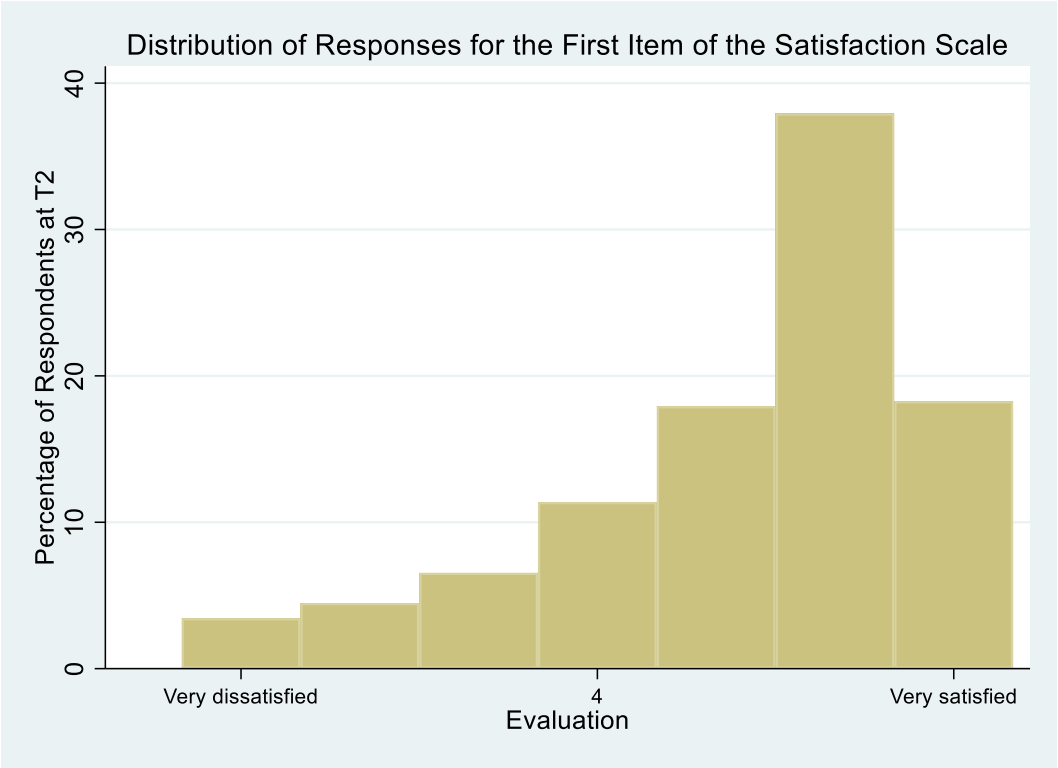

Distribution of Responses for the First Item of the Satisfaction Scale
Percentage of Respondents at T2
0
10
20
30
40
Very dissatisfied
4
Very satisfied
Evaluation

Table 6.E.1. Comparison of time 1 demographic information and scores on the first items of the satisfaction and enjoyment measures for completers and dropouts.

Variable	**Completers (*n* = 314)**	**Dropouts (*n* = 96)**	**Effect Size**
	Mean (SD)		**SMD (95% CI)**
Age (years)	66.40 (7.21)	65.97 (6.51)	0.06 (-0.17, 0.30)
BMI (kg/m^2)	28.04 (5.82)	27.45 (4.96)	0.11 (-0.12, 0.35)
Physical activity	5.54 (1.81)	5.81 (1.47)	-0.18 (-0.41, 0.05)
Education	5.20 (1.53)	5.11 (1.46)	0.06 (-0.18, 0.30)
Evaluation	5.26 (1.58)	5.11 (1.51)	0.10 (-0.13, 0.33)
Pleasurable	5.52 (1.45)	5.33 (1.32)	0.14 (-0.09, 0.37)
	Percentage		**OR (95% CI)**
White/Caucasian	92.8%	86.8%	0.51 (0.24, 1.08)
Married/partnership	65.7%	61.5%	0.84 (0.52, 1.36)
Retired	55.4%	60.0%	1.21 (0.75, 1.95)
"Excellent" or "very good" self-rated health	48.9%	57.1%	1.40 (0.87, 2.24)

Notes. BMI: body mass index. SD: standard deviation. SMD: standardized mean difference. OR: odds ratio. CI: confidence interval. Education (highest degree received) ranged from 1 (some high school, no diploma) to 8 (doctorate).

Table 6.E.2. Correlations between Physical Activity Enjoyment Scale-8 (PACES-8) and satisfaction items and physical activity at T_1 (below the diagonal) and T_2 (above the diagonal).

Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1. Pleasurable	-	0.73	0.79	0.64	0.61	0.66	0.59	0.70	0.49	0.36	0.49	0.51	0.40
2. Fun	0.72	-	0.74	0.63	0.60	0.65	0.60	0.69	0.50	0.34	0.50	0.51	0.38
3. Pleasant	0.76	0.73	-	0.65	0.60	0.66	0.54	0.68	0.56	0.35	0.53	0.61	0.41
4. Invigorating	0.66	0.62	0.60	-	0.62	0.74	0.60	0.71	0.60	0.38	0.58	0.63	0.46
5. Gratifying	0.66	0.62	0.62	0.69	-	0.60	0.58	0.66	0.54	0.35	0.54	0.52	0.45
6. Exhilarating	0.68	0.62	0.59	0.71	0.63	-	0.65	0.76	0.46	0.31	0.44	0.47	0.36
7. Stimulating	0.58	0.61	0.54	0.65	0.61	0.66	-	0.61	0.43	0.21	0.45	0.43	0.34
8. Refreshing	0.73	0.67	0.67	0.71	0.69	0.67	0.62	-	0.49	0.34	0.50	0.51	0.37
9. Evaluation	0.52	0.53	0.54	0.58	0.57	0.52	0.49	0.53	-	0.59	0.78	0.77	0.56
10. Expectations	0.36	0.36	0.34	0.39	0.31	0.42	0.30	0.34	0.58	-	0.66	0.61	0.48
11. Realizations	0.52	0.51	0.52	0.57	0.55	0.51	0.53	0.51	0.76	0.62	-	0.81	0.62
12. Emotion	0.50	0.51	0.52	0.57	0.51	0.49	0.51	0.50	0.75	0.58	0.76	-	0.59
13. Physical Activity	0.40	0.36	0.40	0.40	0.45	0.33	0.37	0.35	0.57	0.47	0.55	0.50	-

Notes. All correlations are significant ($p < 0.05$). Items 1, 3, 4, 5, 6, and 8 of the PACES-8 were reverse coded such that higher values on the Likert-scale indicated more enjoyment. Items 1-8 refer to the PACES-8 items, and items 9-12 refer to the four items of the satisfaction measure.

CHAPTER 7. DISCUSSION

Self-determination, satisfaction, enjoyment, and identity are theory-based motives that are considered the primary drivers of volitional health behavior, as these motives help people prioritize and execute behaviors over time (Kwasnicka et al., 2016). The purpose of this dissertation research project was to identify which of these motives are related to older adults' physical activity maintenance, to establish under what conditions these motives are related to maintenance, and to test the robustness of four scales developed to measure these motives.

7.1 Factors Related to Older Adults' Physical Activity Maintenance

Findings from this multiple-study dissertation project provide support for a positive relationship between each maintenance motive and older adults' physical activity maintenance. Stronger evidence was provided to support the relation between self-determination and maintenance. Nevertheless, collectively, this program of work is consistent with the guiding framework for behavioral maintenance (Kwasnicka et al., 2016).

7.1.1 Self-determination

The meta-analysis described in Chapter 4 revealed that older adults who report more self-determined motivation for engaging in physical activity are also those who maintain their physical activity over time ($r = 0.189$). While this effect may be classified as "small," the systematic review was developed such that the included primary studies controlled for past physical activity. Consequently, this estimate is less likely to be inflated by the effects of past behavior and may underestimate the true relationship (Weinstein, 2007). Furthermore, qualitative results highlight the importance of personal, internal motivation (e.g., self-determined motivation) for re-engagement in physical activity. Lastly, although physical activity maintenance was not operationalized in the studies described in Chapters 5 and 6 (which will be a recurring comment throughout this section), higher levels of more self-determined motivation were found to be strongly related to more frequent physical activity behavior throughout the prior month ($0.51 \leq r \leq 0.61$). The relationships between self-determined regulatory styles and physical activity in Chapter 5 were bivariate correlations estimated with the explicit removal of

measurement error using structural equation modeling; this may explain why these correlations are stronger than that reported in the meta-analysis.

7.1.2 Satisfaction

Three studies included in the systematic review suggest that there is a positive association between satisfaction and physical activity maintenance. Additionally, a novel four-item satisfaction measure was developed and assessed for robustness as part of this dissertation. Although physical activity maintenance was not operationalized in this measurement study, there was a positive correlation (r = 0.64) between satisfaction and frequency of physical activity among older adults who reported being active at least once during the prior month. This correlation is stronger than previous research has reported (e.g., 0.17 – 0.33; Chmielewski et al., 2016; Fleig et al., 2011; Tsafou et al., 2016, 2017; Williams et al., 2016), which may be due to the explicit modeling of measurement error, the bivariate nature of the correlation, and the thorough creation of the measurement approach with members of the target population.

7.1.3 Enjoyment

Four studies in the systematic review also suggest that there is a positive association between behavioral enjoyment and physical activity maintenance. Additionally, older adult participants of the qualitative studies indicated that enjoying social interactions and enjoying aspects of the location in which physical activity is being carried out are facilitating of maintenance. The Physical Activity Enjoyment Scale-8 (Mullen et al., 2011) was assessed for robustness in Chapter 6. While physical activity maintenance was not operationalized, this study concluded that there was a positive correlation between enjoyment of the behavior and frequency of physical activity during the prior month (r = 0.48), which again is stronger than what has been reported in other studies (e.g., 0.16 – 0.27; Chmielewski et al., 2016; Mullen et al., 2011). Past studies have included other physical activity domains (e.g., occupational activity; Mullen et al., 2011) in addition to leisure-time physical activity, which may explain these smaller correlations, and the bivariate correlation reported in the current work was estimated with the removal of measurement error.

7.1.4 Identity

One doctoral dissertation reviewed in Chapter 4 observed a positive association between identity and older adults' physical activity maintenance. A few older adults interviewed in Chapter 2 suggested that they maintained their physical activity because it has become a part of who they are. Finally, minding the lack of maintenance operationalization in Chapters 5 and 6, two dimensions of physical activity identity – namely, role identity and physical activity beliefs – were both related to monthly frequency of physical activity (0.62 and 0.55, respectively). Previously, Strachan et al. (2010) found a correlation of 0.33 between one dimension of physical activity identity and physical activity frequency for older adults.

7.1.5 Other Factors

It is also important to mention that the qualitative findings of this dissertation underscore other factors that may be associated with physical activity maintenance in addition to the four maintenance motives. These findings parallel other health behavior maintenance themes reported in Kwasnicka et al.'s (2016) review, as well as other findings from work that has investigated older adults' physical activity maintenance and exercise adherence (Rhodes et al., 1999; van Stralen et al., 2009). Social support functions (e.g., encouragement), social interactions, and environmental aspects (e.g., convenience, accessibility) help older adults maintain their physical activity; likewise, Kwasnicka et al.'s (2016) review notes that theories of health behavior maintenance suggest that supportive physical and social environments are helpful for maintaining health behaviors (e.g., by lowering opportunity costs of the behavior). Moreover, one's social network and perceived access have previously been reported as facilitators of both physical activity initiation and maintenance for older adults (van Stralen et al., 2009), and another knowledge synthesis found that social support helps older individuals continue their exercise (Rhodes et al., 1999). Self-regulation – including processes such as planning, which help people manage their behavior and engage in goal-directed activities – and habit are two other health behavior maintenance themes detailed in Kwasnicka et al.'s (2016) review. Scheduling physical activity and having a well-integrated (e.g., habitual) physical activity routine were found to facilitate physical activity maintenance among older adults in this research project. In other research, action planning and coping planning have been found to be related to initiation

and maintenance, respectively, for this population (van Stralen et al., 2009). Thus, this dissertation research project is consistent with other themes included in Kwasnicka et al.'s (2016) theoretical framework of health behavior maintenance and aligns with previous findings regarding older adults' physical activity behaviors.

7.2 Conditions Under Which Factors Influence Physical Activity Maintenance

This dissertation project provides insight regarding the conditions under which these factors influence physical activity maintenance – specifically for whom and in which context. It should be noted that this insight is not conclusive and could serve as new hypotheses to test in future studies with additional older samples and appropriate, quality measures (e.g., the measures investigated in this program of work).

The systematic review revealed that self-determination may be more strongly related to physical activity maintenance for older individuals with existing health conditions. This would imply that older adults who have ailments such as cancer or arthritis and who also either personally value the outcomes of physical activity, have integrated physically active behaviors as part of themselves, or are intrinsically motivated to engage in active behaviors are more likely to sustain physical activity over time.

Qualitative findings presented in Chapter 2 also provide enlightening information as to in which context and for whom certain factors may promote older adults' physical activity maintenance. Different types of social influences may promote either sustained engagement of or re-engagement in physical activity. It was suggested that instrumental support facilitates the former, while emotional support facilitates the latter. Additionally, having a routine and an accessible and convenient location in which to be active may be particularly helpful for re-engaging in physical activity after time away from the behavior. This suggests that having a set schedule which includes knowing where the activity will take place (i.e., a previously performed action plan) may be protective against setbacks instigated from high risk situations (e.g., one week away from activity; Armitage, 2005). However, self-regulatory strategies (e.g., developing a physical activity routine) may be more effective methods for facilitating physical activity maintenance for older adults who prefer structure or who identify as physically active.

7.3 Robustness of Four Maintenance Motive Measures

The Experimental Medicine approach "requires thorough and rigorous efforts to assay targets" (Sheeran et al., 2017, p. 584), which includes developing appropriate measures for the population and assessing the robustness of these measures. This dissertation investigates psychometric properties of the previously developed Physical Activity Enjoyment Scale-8 (physical activity enjoyment; Mullen et al., 2011), a modified Behavioral Regulation in Exercise Questionnaire (physical activity regulatory styles, including self-determined motivation; Markland & Tobin, 2004; Mullan et al., 1997; Wilson et al., 2006), and a modified Exercise Identity Scale (physical activity identity; Anderson & Cychosz, 1994). Furthermore, this work contributes to the physical activity literature by creating and validating a new, four-item approach to the measurement of satisfaction.

The latent constructs measured by these instruments were found to be strongly and positively associated with physical activity, as would be expected. Additionally, the constructs were strongly and positively associated with other select variables as posited by theory (e.g., satisfaction and enjoyment). Furthermore, the models of these constructs represented by each measure fit well for the analyzed sample of older adults, and all were found to be invariant over four weeks and between males and females. In other words, the structure of the models and the way the indicators related to the underlying latent constructs were stable over time and between both genders. As such, this work supports the robustness of these measures for use with an older population to measure constructs relevant to physical activity. These four measures can be used to assess the maintenance motives within the older adult population and can be used to make meaningful, direct comparisons between older males and females and across four weeks.

7.4 Implications and Future Directions

Although this dissertation research project provides support for enjoyment, satisfaction, identity, and self-determination as motives that are related to physical activity maintenance among older adults, this evidence is limited. Therefore, future studies that appropriately measure physical activity maintenance, attend to issues of potential attrition, and account for missing data (see Chapter 4) should be conducted to confirm the existence and strength of the relationships between the motives and physical activity maintenance. This dissertation provides support for

the use of four measures to assess the motives in these future studies. Additionally, Kwasnicka et al. (2016) suggest that *at least one* motive is necessary for health behavior maintenance. Establishing which motive(s) are most influential for older adults' physical activity maintenance – either separately or in combination – would help support the prioritization of certain motives for future testing in interventions.

This dissertation also raises the question as to what about physical activity is most enjoyable and thus most motivating for long-term engagement for older adults: the behavior itself, or aspects associated with the behavior (e.g., social interactions). Devereux-Fitzgerald et al. (2016) have suggested that enjoyment of social interactions is key to physical activity intervention acceptance among this population. Determining what is most enjoyable and for whom would help researchers identify appropriate intervention strategies to promote immediate, positive affective feelings that may encourage physical activity maintenance.

Provided these motives are positively related to physical activity maintenance for older adults, the next step of the Experimental Medicine approach involves identifying the most optimal way to modify each motive for the target population and subgroups of the population. For instance, strategies that support individuals' basic psychological needs of relatedness (e.g., feeling connected to others while being physically active), competence (e.g., feeling as if a certain physical activity task or behavior can effectively be accomplished), and autonomy (e.g., feeling in control of physical activity decisions) may help someone internalize more self-determined motivation for physical activity (Rhodes et al., 2019; Ryan & Deci, 2000). Additionally, mindfulness-based or acceptance-based techniques, such as bringing attention to someone's values and associating physical activity with those values, may also help increase both self-determined motivation for the behavior and self-identification with physical activity (Stevens et al., 2020; Stevens & Bryan, 2015). Importantly, the current program of work found that one dimension of physical activity identity – physical activity beliefs – was positively related to introjected regulation, which is a regulatory style that has been linked to poorer psychological outcomes and shorter-term physical activity (Pelletier et al., 2001; Ryan & Connell, 1989). Given this finding, researchers may wish to focus on the role identity dimension of physical activity identity to promote better long-term health outcomes. Therefore, a mindfulness-based strategy that targets both self-determined regulatory styles and identity may be particularly impactful. Moreover, Rhodes et al. (2016) concluded that commitment (i.e.,

personal importance of the behavior), perceived ability (i.e., personal capability to perform the behavior), and social activation (e.g., social comparison, feelings of belonging) may be critical antecedents for identity development. A recent review and meta-analysis investigating experimental manipulations of affective judgments, including enjoyment, on physical activity did not uncover any one behavior change technique as a moderator that positively influenced these judgments (Rhodes et al., 2019). However, strategies involving the monitoring of past positive emotional consequences from the behavior – which theoretically may be successful strategies – were not reviewed (Rhodes et al., 2019). Similarly, monitoring progress related to relevant behavioral outcomes may be a strategy to use to enhance satisfaction; this is indeed in line with Rothman's (2000) original theorizing of how the satisfaction construct helps to maintain a behavior.

7.5 Limitations

The generalizability of the findings reported in this dissertation research project is limited by characteristics of the participants. In the qualitative studies and the studies included in the systematic review, participants were primarily female. Additionally, those recruited for the original studies in this dissertation were highly educated and mostly white/Caucasian. This program of work also focused on leisure-time physical activity, and therefore results may not generalize to other physical activity domains, such as occupational or transportation.

There are also limitations regarding the internal validity of this dissertation project. Physical activity was predominantly measured via self-report across all studies, including those in the systematic review, which may have contributed to inaccurate estimates of association. However, the studies reported in Chapters 2, 5, and 6 utilized a previously validated measure of physical activity that attempted to limit reporting error (e.g., by not asking about intensity or duration). Many of the primary studies in the systematic review were at high risk of bias due to missing data, and missing observations were excluded from the analyses in Chapters 5 and 6. However, these missing observations (i.e., the participant responses) in Chapters 5 and 6 were considered outcome variables in the measurement model equations and thus an imputation technique to handle this missing data would not have improved the results.

7.6 Strengths

There are multiple strengths of this dissertation. First, this work was guided by both a translational and theoretical framework. The use of a theoretical framework connects this work to other research focused on similar constructs and contexts, while the use of a translational framework provides an understanding for how this work contributes to the process of moving science toward practice. This dissertation also incorporated multiple methods (e.g., thematic analysis, meta-analysis, structural equation modeling) to answer the overarching aims, which strengthens the evidence put forth in this dissertation by providing converging findings from various sources. This dissertation directly involved members of the target population (i.e., the interviewees in Chapter 2, informants in cognitive interviews), which leads to more relevant – and thus potentially more impactful – discoveries. Results in all studies were reported in sufficient detail, including within multiple appendices, to aid in replication and scientific transparency. Finally, interdisciplinary expert collaboration and guidance was sought throughout this project, which enhances the interpretation and application of the work.

7.7 Conclusion

Many older adults do not regularly participate in physical activity. This highlights the need for the development of physical activity interventions that are more conducive to promoting maintenance among this population. The program of work reported here generally supports enjoyment, satisfaction, identity, and self-determination as factors associated with older adults' physical activity maintenance (with the strongest amount of support for the motive of self-determination) and provides insight as to under what conditions these motives are related to this behavior. Furthermore, this dissertation helped develop and validate new and modified measurement instruments as appropriate assessments of these motives for the older population. This dissertation therefore attends to the first two steps of the Experimental Medicine approach and contributes to the physical activity and gerontology literature by offering pieces of a "roadmap" that serve as a starting point upon which future research can expand (Sheeran et al., 2017). This dissertation encourages precision and specificity in future intervention development by emphasizing the importance of the mechanisms of change – the *why* behind behavior change

– that may ultimately lead to more effective behavioral interventions and consequently long-term health.

7.8 References

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