Understanding the intention-behavior gap towards aerobic exercise in persons with multiple sclerosis

by

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Abstract

Background: Despite strong intentions to engage in regular aerobic exercise, persons with Multiple Sclerosis (PwMS) frequently encounter a significant intention-behavior gap, limiting potential health benefits from sustained aerobic exercise. While existing research has addressed general barriers to exercise in this population, further examination of psychological processes that contribute to this gap is necessary. This study applied the Multi-Process Action Control (M-PAC) framework to identify reflective, regulatory, and reflexive predictors related to the intention-behavior gap toward aerobic exercise in PwMS.

Methods: Using a cross-sectional e-survey, 395 PwMS were recruited through a regional healthcare system (Stormont Vail; n = 88), an online participant platform (Prolific; n = 274), and online discussion forms (n = 33). Participants completed a 48-item questionnaire assessing demographics, clinical variables, and M-PAC constructs (reflective, regulatory, reflexive processes). Individuals were classified into three action control profiles: Successful Intenders (SI), Unsuccessful Intenders (USI) and Non-intenders. Hierarchical multinomial logistic regression analyses identified predictors influencing intention formation and successful adherence (action control) to aerobic exercise guidelines.

Results: The intention formation model represented strong fit ($R^2 = 0.58$) and classified younger age (OR = 0.966; $p = .011$), positive affective judgements (OR = 1.203, $p < .001$), higher perceived capability (OR = 1.235, $p = .002$), and greater perceived opportunity (OR = 1.258 $p = .029$), as significant predictors of intention formation. The action control model represented moderate fit ($R^2 = 0.23$) and classified strong exercise identity (OR = 1.140, $p = .004$) and lower PDDS scores (OR = 0.849, $p = .032$) as significant predictors of PwMS successfully meeting MS aerobic exercise training guidelines. Additionally, proactive regulation (OR = 1.067, $p = .017$) and reactive regulation (OR = 1.076, $p = .024$) were significant predictors in earlier action control models, but lost significance once reflexive processes were accounted for.

Conclusions: Findings from this study highlight potential processes important for forming exercise intentions among PwMS, including positive affective judgements, perceived capability, and perceived opportunity. Additionally, directly enhancing exercise identity may be beneficial for bridging the intention-behavior gap, however, development of behavioral regulation is essential. These applications may be beneficial for guiding interventions to increase sustained aerobic exercise adherence in PwMS long-term.

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List of Abbreviations

Multiple Sclerosis	MS
Persons with Multiple Sclerosis	PwMS
Dissemination in space	DIS
Dissemination in time	DIT
Magnetic resonance imaging	MRI
Physical Activity	PA
Social Cognitive Theory	SCT
Theory of Planned Behavior	TPB
Transtheoretical Model	TTM
Self Determination Theory	SDT
Behavior Change Techniques	BCTs
Multi-Process Action Control	M-PAC
Successful Intender	SI
Unsuccessful Intender	USI
Successful Non-intender	SNI
Unsuccessful Non-intender	UNI
Multinomial Logistic Regression	MLR
Patient Determined Disease Steps	PDDS
Discriminant Function Analysis	DFA
Akaike Information Criterion	AIC
Theoretical Domains Framework	TDF
Pseudo R-squared (Nagelkerke's)	R^2

Chapter 1 – Introduction

1.1 Overview of Multiple Sclerosis

Multiple Sclerosis (MS) is an inflammatory autoimmune disease that degrades the myelinated axons of the central nervous system, leading to progressive deterioration of the myelin sheath (Goldenberg, 2012). As of 2020, approximately 2.8 million people worldwide have MS, with prevalence increasing since 2013 (Walton et al., 2020). In the U.S., estimates from 2008 to 2010 administrative health claims datasets indicated a prevalence of 309.2 per 100,000, (~700,000 cases) with subsequent projections suggesting a prevalence of 362.6 per 100,000 (913,925) as of 2017 and nearing one million cases today (Nelson et al., 2019; Wallin et al., 2019).

The disease course for PwMS is highly variable, with symptoms including motor control problems (e.g., gait impairment and muscle spasms), vision problems (e.g., double vision and optic neuritis), fatigue, cognitive impairment, and other debilitating symptoms (Ghasemi et al., 2016). The majority of PwMS (~85%) experience periods with symptom flare-ups followed by complete or partial recovery, known as relapse-remitting MS. The remaining ~ 15% have either progressive or less common forms, including (primary progressive MS, primary relapsing MS, and benign MS; (Goldenberg, 2012). A diagnosis of MS cannot be determined from a singular measure, thus guidelines referred to as the McDonald criteria have been implemented [Table 1] (Thompson et al., 2018). First, someone must present symptoms that correspond with lesions/inflammation within either the brain or spinal cord in multiple areas and time points, otherwise known as dissemination in space (DIS) and time (DIT). Magnetic resonance imaging (MRI) can then be used to confirm that lesions are occurring within multiple areas and time points. An additional tool for identifying the presence of MS is a spinal tap procedure, utilized to detect the presence of oligoclonal bands in the cerebrospinal fluid, which is a sign of inflammation within the central nervous system (Arrambide et al., 2018). Thus, a neurologist will need evidence of two or more relapses that are disseminated in time and space. This must be supported by either objective clinical evidence (spinal tap, lesions confirmed by MRI) or a combination of clinical and historical evidence, where at least one lesion is objectively identified and past reported symptoms suggest a previous relapse (Thompson et al., 2018). The complexity of an MS diagnosis can be attributed to the heterogeneous nature of the disease (Lucchinetti et al., 2000), making no one sign, symptom, or clinical test sufficient. This heterogeneity not only complicates diagnosis but also presents challenges in effective disease management and treatment (Weiner, 2009), necessitating stratified, tailored approaches.

Dissemination in Space (Lesions)	Dissemination in Time (Attacks)	Additional Criteria for MS Diagnosis
2 or more	**2 or more**	**None.** Clinical evidence alone will suffice
1 lesion	**2 or more**	**Dissemination in space on MRI** (Or await further clinical attack implicating a different CNS site)
2 lesions	**1 attack**	**Dissemination in space on MRI** (Or await further clinical attack implicating a different CNS site)
1 lesion	**1 attack**	**Dissemination in space and time** (Or await further clinical attack implicating a different CNS site)
0 lesions	**0 attacks** Progression from onset (Primary Progressive)	One year of disease progression **AND** at least 2 out of 3 criteria: • Dissemination in space in the brain • Dissemination in space in the spinal cord based on 2 or more T2 lesions • Positive CSF

Table 1 - Mc Donald Diagnostic Criteria for MS - Adapted from (Thompson et al., 2018)

1.2 Managing Multiple Sclerosis with Exercise

Over the past three decades, research on physical activity (PA) has grown substantially, with exercise in particular becoming recognized as one of the most effective non-pharmacological strategies for MS symptom management (Du et al., 2024; Yang et al., 2024). Typically, PA is broadly categorized into four domains: occupational, transport, domestic, and leisure (Caspersen et al., 1985). Within the leisure domain, exercise—defined as planned, repetitive activity intended to improve or maintain physical function (Caspersen et al., 1985)—has gained recognition as a powerful tool for its neuroprotective effects, ability to target physiological symptoms, and superior impact on MS symptom management compared to general PA (Du et al., 2024). Unlike incidental PA (e.g., unstructured movements integrated into daily life such as gardening, household chores, or walking to work), exercise training offers a strategic and targeted approach to managing MS symptoms (e.g., Gait, muscle spasticity, and muscle strengthening), as well as enhancing cognitive capacity, alleviating fatigue, and a wide range of MS symptoms (Motl & Sandroff, 2015).

This growing, empirical evidence of exercise benefits for PwMS has led to a paradigm shift in its perception among both patients and healthcare professionals. Historically, exercise was believed to aggravate MS disease symptoms, leading to clinicians and PwMS avoiding exercise for symptom management or treatment (Tallner et al., 2013). However, traction regarding PA and exercise benefits for PwMS has grown steadily over the past 3 decades, leading to the view of PA and specifically exercise serving as a tool for tertiary (symptom management), secondary (disease-modifying effects), and potentially primary (risk of MS development) prevention (Dalgas et al., 2019; Tallner et al., 2013).

A major outcome of MS exercise research includes the development of the MS Exercise Training Guidelines [Table 2] based upon a rapid review of 13 prior reviews on exercise and PA recommendations (Y. Kim et al., 2019). Aerobic exercise, in particular, has emerged as a key contributor to MS-specific benefits including physical (e.g., improved balance, walking capacity), mental (e.g., reduced fatigue, mood), and quality of life-related outcomes (e.g., enhanced daily functioning, reduced somato-affective symptoms of depression) (Motl & Sandroff, 2015; Swank et al., 2013).

Multiple Sclerosis Exercise Training Guidelines	
Aerobic	• 2-3x/week • 10-30 minutes • 40-60% target HR • Increase length/intensity slowly over time
Resistance Training	• 2-3x/week • 5-10 exercises: 1-3 sets, 8-15 repetitions • Incorporate free weights, resistance bands, or body weight

Table 2 Multiple Sclerosis Exercise Training Guidelines – adopted from (Y. Kim et al., 2019)

1.3 The Exercise Intention-Behavior Gap

A growing body of evidence on the benefits of exercise for MS has led to a shift from actively avoiding exercise to the recommendation of exercise for MS disease treatment and management. Therefore, the scientific literature shows that PwMS have increased their intentions to engage in regular exercise (Learmonth & Heritage, 2021; Schüler et al., 2019). However, PwMS often fail to follow through on their exercise intentions (Christensen et al., 2016). The disconnect between behavioral intentions (wanting to do something) and behavior participation (doing the behavior) is commonly known as the intention-behavior gap (Sheeran & Webb, 2016). Specific to PwMS, researchers have put forth numerous efforts into identifying key physical and mental barriers and facilitators of exercise (Kayes et al., 2011; Stroud et al., 2009), effective exercise promotional strategies (Motl, Pekmezi, et al., 2018; Richardson et al., 2022), as well as the exercise needs and wants of PwMS and their health care providers to inform targeted exercise interventions (Learmonth et al., 2018; Richardson et al., 2020). The majority of MS exercise-related studies utilize highly regarded behavioral frameworks and models for addressing exercise behavior change. The majority of these frameworks are based on Social Cognitive Theory (SCT) constructs (Fifolt et al., 2020), including the Transtheoretical Model (TTM) (Prochaska & Velicer, 1997; Schüler et al., 2019), Theory of Planned Behavior (TPB) (Ajzen, 1991; Kirk & Haegele, 2019), Self-Determination Theory (SDT) (Learmonth & Heritage, 2021; Ryan & Deci, 2000), and COM-B (i.e., Behavior Change Wheel (Michie et al., 2011; Riemann-Lorenz et al., 2021). Each of these models targets a different aspect of exercise behavior. TTM outlines the stages of change for exercise behavior formation, TPB focuses on exercise intention formation, SDT highlights intrinsic and extrinsic influences on exercise behavioral regulation, and the behavior change wheel provides a framework of behavior change techniques (BCTs) for designing interventions based on key barriers and facilitators. However, while these exercise behavioral models help explain how intentions develop and how behavior can be influenced, they do not fully account for why strong intentions often fail to translate into sustained action (Wieber et al., 2015).

The persistence of the intention behavior gap for exercise behavior suggests that additional mechanisms beyond intention formation determine whether exercise behavior is enacted and maintained over time. The persistence of the intention-behavior gap in not only clinical but general populations as well has led to the development of multiple action control theories. One prominent PA-related theory, the Multi-Process Action Control (M-PAC) framework (R. E. Rhodes, 2017), suggests three hierarchically organized processes that play a role in the translation of exercise intention formation into sustained exercise behavior. Reflective processes (affective judgments, perceived opportunity, perceived capability, instrumental attitudes) represent the first layer of the framework, representing the conscious beliefs and expectations of PA. Regulatory processes encompass the actions and cognitive strategies individuals use to translate their intentions into PA (e.g., goal setting). Reflexive processes (i.e., habit and identity), represent the autonomic drivers which guide our regular day-to-day behaviors. M-PAC emphasizes the role of habit and identity formation as key contributors to sustained behavior, which often takes between six to eight weeks to form under ideal circumstances (Kaushal & Rhodes, 2015). The delayed onset of reflexive processes emphasizes the necessity for the development of regulatory processes, notably behavioral regulation (R. E. Rhodes, 2021), for individuals to fully translate intentions toward sustained behavior.

1.4 Addressing the Intention Behavior Gap in PwMS

The use of the M-PAC framework primarily relies on the dichotomization of individual intention and behavior given a set of distinct exercise guidelines (R. E. Rhodes, 2017). A yes/no scale for assessing intention to achieve a pre-determined exercise behavior has been developed and is frequently utilized in M-PAC studies (Courneya, 1994). As for behavioral categorization, the MS exercise guidelines for aerobic exercise serve as an ideal source with clear protocols for meeting exercise behavior (2x weekly, 30 minutes per session; Kim et al., 2019). As a result, four distinct action profiles for PwMS may emerge: 1) successful intenders (SI), 2) unsuccessful intenders (USI), 3) successful non-intenders (SNI), and 4) Unsuccessful non-intenders (UNI). However, given exercise participations' natural reliance on pre-determined intentions to achieve realization, the UNI group typically does not emerge within prior literature leading to a sole non-intender group (R. E. Rhodes, Spence, et al., 2016). Definitions and application of these profiles to the MS exercise guidelines can be found in [Table 3].

Action Control Profile	Technical Definition	MS Exercise Guidelines Classification
Successful intender	High intention, high behavior	Intends to meet guidelines, meets guidelines

Unsuccessful intender	High intention, low behavior	Intends to meet guidelines, does not meet guidelines
Successful non-intender	Low intention, low behavior	Does not intend to meet guidelines, does not meet guidelines
Unsuccessful non-intender	Low intention, high behavior	Does not intend to meet guidelines, meets guidelines

Table 3 - Action Control Profile Categorization

Despite extensive research on exercise in PwMS, the intention-behavior gap remains largely under-researched in the MS population. While studies have examined barriers and facilitators to exercise, few have specifically investigated why PwMS who intend to exercise often fail to follow through. Research such as (Schüler et al., 2019) emphasizes MS-specific barriers like fatigue and mobility's role in behavior realization. Few studies in the MS literature have implemented action control models; however, those that have used frameworks such as the health action process approach (HAPA; (Chiu et al., 2011) or Kuhl's (1985) action control model (Penner et al., 2007). However, no study has yet to use the M-PAC framework within the MS population. The key difference between HAPA and the M-PAC framework is that HAPA prioritizes the role of SCT-based constructs such as self-efficacy throughout both motivational and volitional phases of behavior change, integrating action control through regulatory mechanisms such as planning and self-monitoring. M-PAC, however, uniquely expands upon these SCT constructs and regulatory strategies by incorporating the role of autonomic (reflexive) drivers of behavioral maintenance. M-PAC's reflexive properties include the role of habit and identity. While HAPA includes sufficient measures of intention and behavior, enabling action control assessment, its focus remains on conscious regulatory strategies as the most proximal factor towards exhibiting long-term behavior change. Given that M-PAC suggests the development of automatic drivers of behavior to decrease reliance on self-regulatory strategies for exercise behavior, the M-PAC framework offers unique insight into the key differences between individuals who are successful and unsuccessful in reaching their intended behaviors. Identifying these differences between groups may provide utility for informing future researchers and clinicians on which BCTs and promotional strategies to utilize with PwMS, based on their current perceptions, intentions, and exercise behavior. Unlike other action-control models, M-PAC provides the necessary structure to specifically test these factors. The relevance of the M-PAC framework or similar action control models to explicitly address these factors, however, it is also important to acknowledge the body of evidence suggesting that clinical factors/covariates such as disease type, duration, and mobility all play a role in the development of exercise intentions and behaviors. Thus, general and clinical components should be first assessed as baseline, non-modifiable characteristics that influence exercise behavior. By accounting for these variables, researchers can then isolate the unique contributions of M-PAC processes in explaining the intention-behavior gap among PwMS. Examination of these processes can in turn provide key insights into promotional techniques for PwMS to maximize effectiveness and behavioral translation.

1.5 Statement of the Problem

Exercise research for PwMS has made significant strides in methodology for developing intentions, as well as implementing key resources and tools for facilitating behavior change. However, there remains a critical intention-behavior gap in PwMS, limiting intention realization. Limited studies in MS research have thoroughly explored the intention-behavior gap in PwMS, and to the extent of my knowledge, no studies have suggested or incorporated the M-PAC framework. Thus, the exploration of M-PAC processes on the translation of aerobic exercise intentions toward exercise behavior in PwMS is a critical research area yet to be addressed.

1.6 Purpose of Study

The purpose of this study is to utilize the M-PAC framework to examine the intention-behavior gap among PwMS aiming to meet the aerobic component of the MS exercise training guidelines. Specifically, the study will classify participants into four action-control profiles (SI, USI, NSI, UNI) based on two dichotomized results, as recommended for M-PAC analysis. Once classified, M-PAC processes will be evaluated for each profile using hierarchical multinomial logistic regression (MLR), a standard approach for assessing M-PAC's predictive capacity in group categorization (Tabaczynski et al., 2023; Vallerand et al., 2017).

To analyze the intention-behavior gap, seven validated measures will assess distinct processes within M-PAC's three overarching domains: reflexive, regulatory, and reflective. Given the relevance of general and clinical demographics in exercise participation, additional covariates (age, disability level) and factors (gender, MS type, comorbidities) will be included. Using MLR, the study will determine how M-PAC processes influence the likelihood of classification into each profile, with the SI group serving as the reference. This approach will identify which M-PAC processes most strongly predict PwMS's intentions, as those that successfully realize their intentions.

Chapter 2 - Literature Review

2.1 Physical Activity and Exercise Participation Rates in People with Multiple Sclerosis

PA participation in PwMS is significantly lower than the general population. Klaren et al. (2013) examined moderate to vigorous PA (MVPA) levels in 800 PwMS and 137 healthy controls via accelerometry data from 2006-2013. PwMS engaged in an average of 18.7 minutes of MVPA per day, which is 13.1 minutes less than the 31.8 minutes observed among healthy controls. Only 19.5% of PwMS met the recommended 150 minutes per week, compared to 47.7% of healthy controls, which aligns with national averages (Elgaddal, 2022). Klaren et al. (2013) focused on examining the clinical barriers contributing to lower MVPA levels in PwMS. MS phenotypes and clinical covariates had a significant influence on MVPA participation. People with relapse-remitting MS participated in 9.3 more minutes of MVPA than those with progressive MS ($d = 0.50$. $p < .001$). This is expected as relapse-remitting is characterized by periods of symptom flare-up (relapse) and remission with reduced symptomatic stress. Progressive MS on the other hand involves a steady decline in function, with fewer periods of remission, typically leading to greater rates of mobility impairment and limited opportunities to exercise (Pilutti et al., 2016). MS disease duration also impacted MVPA, with those who had been diagnosed for a shorter period participating in 7.2 minutes more than those with a longer disease duration ($d = 0.39$, $p < .001$). Additionally, those who relied on ambulatory devices such as canes and bilateral support had notably reduced rates of MVPA at 13.1 and 18-minute differences, respectively, compared to non-assisted mobility ($d = 0.74$, $d = 1$, $p < .001$). Sociodemographic variables such as employment status and education marginally influenced MVPA levels at 8.2 and 6.1 minutes ($d = 0.45$, $d = 0.33$, $p < .001$) less among unemployed and non-college graduates compared to college graduates, while gender, race, and income had no significant effects. It should be noted here that PA participation rates in PwMS come primarily from clinical trials that report greater than 90% white. As a result, there are ongoing efforts to increase diversity and reporting of ethnicity in clinical trials (Motl et al., 2023).

A follow-up study by Klaren et al. (2016) expanded the sample from (Klaren et al., 2013) to 963 PwMS, including 107 older adults (>60 years), and examined both MVPA and sedentary behavior. Findings revealed that older and middle-aged PwMS spent significantly more time sedentary than younger adults ($d = 0.25$ and 0.47 respectively), consistent with general population trends (Harvey et al., 2013). Older adults averaged only 12.6 (16.7) minutes of MVPA daily, compared to 19.3 (20.2) and 24.5 (20.1) minutes in middle-aged and younger adults, respectively. Consequently, 14% of older adults met MVPA guidelines of (>30 min/day), compared to 20.8% and 28.4% of middle-aged and young adults, respectively.

Given the variability of symptoms in PwMS and their low rates of MVPA, future research should focus on developing and testing individualized exercise protocols that optimize engagement, address disease-specific barriers, and explore the underlying mechanisms contributing to poor exercise participation.

2.2 Barriers to Exercise Participation in PwMS

General barriers to exercise participation in PwMS are like those observed in the general population and include personal factors (e.g., family obligations) and environmental factors (e.g., work demands), with lack of time and work-related constraints being the most frequently cited obstacles (Manaf, 2013). However, PwMS also face unique challenges related to MS-specific factors, such as fatigue, psychological symptoms (depression, fear), and varying levels of disability, which interact with these general barriers to further exacerbate inactivity levels. A systematic review by Correale et al. (2022) investigated the list of barriers to PwMS to evaluate their influence on exercise participation. Forty-one PwMS were evaluated, with 75.3% of respondents reporting no exercise participation, consistent with previous literature. Individuals with secondary progressive MS were significantly less likely ($p < .001$) to engage in exercise training (91.7%), reflecting the impact of advancing disability on activity levels. The most common barriers to attending/beginning a new exercise program reported by PwMS included fatigue, mobility, and time. Additionally, self-confidence, finances, and MS-supportive facilities (e.g., rehab centers, health and wellness programs) were noted. Correale et al. (2022) also highlighted general practitioners as an ideal source of exercise promotion. However, only 25.5% of respondents received advice from their general practitioner or neurologist to engage in regular exercise. Of these respondents, only 47.1% of them heeded advice. Of the remaining individuals who received exercise advice from their general practitioner but did not initiate change, 69.7% reported heightened levels of motivation to start a new exercise program. While general practitioners and neurologists have the potential to promote exercise, the limited provision of advice and sub-par adherence rates highlight a need to reevaluate current health promotion strategies.

2.3 Healthcare Providers Role as Facilitators for Exercise Promotion in Persons with Multiple Sclerosis

Neurologists acknowledge the importance and potential of exercise promotion during clinical appointments for PwMS; however, they often feel inadequately equipped to address barriers to exercise adherence due to systematic and practical constraints (Learmonth et al., 2017, 2018). Key barriers include limited time during consultations, inconsistent messaging across providers, and a lack of standardized resources to support exercise counseling. A qualitative study by Learmonth et al. (2018) examined perspectives from 44 healthcare providers (neurologists, occupational therapists, physical therapists, and nurses) to identify critical gaps in exercise promotion. Three themes emerged: 1) a structural deficiency in opportunities to integrate exercise promotion within routine healthcare (e.g., time constraints), 2) the need for standardized protocols and provider education on exercise strategies, and 3) a demand for actionable tools to personalize exercise recommendations based on patient-specific barriers. These limitations create a disconnect between providers' recognition of exercise benefits and their ability to facilitate meaningful exercise behavior change in PwMS. This disconnect potentially contributes to the intention-behavior gap in PwMS. PwMS widely prefer the neurologist to be the primary source of their exercise information and prescription (Learmonth et al., 2017), and providers are supportive yet do not have the necessary materials to facilitate adequate exercise promotion (Learmonth et al., 2018). Without structured, evidence-based approaches embedded within healthcare interactions, providers will continue to struggle to bridge this gap, leaving PwMS without the necessary support to transition from aerobic exercise intentions to long-term behavior. Later literature built upon these findings, where healthcare providers were further assessed on the facilitators and barriers to exercise promotion through the lens of the Socio-Ecological Model (Learmonth et al., 2021). These findings reinforced the challenges identified by (Learmonth et al., 2018), with providers continuously expressing uncertainty about integrating exercise promotion into patient care. In response to these challenges, conceptual models have been proposed to facilitate exercise promotion within clinical care. One such model, developed by Motl, Barstow, et al. (2018) integrates theoretical frameworks (SCT, Socio-Ecological Model) to structure exercise promotion into three hierarchical layers: 1) provider training support, 2) provider-patient interaction, and 3) exercise engagement. This model emphasizes the importance of preparing healthcare professionals for initiating exercise discussions, making referrals (e.g., physical therapists), and supporting patients to meet exercise intentions. While this model has been positively received by healthcare providers in qualitative evaluations, critiques highlight the need for greater individualization within the provider-patient interaction. The current model primarily utilizes a “one size fits all” approach, as opposed to ensuring tailored approaches that address diverse patient’s needs. Additionally, these proposals hinge on the expectation that those who intend to exercise, if given the right resources, will act on those intentions. However, this perspective neglects the intention-behavior gap, where motivation, intention, and resources alone are insufficient to develop aerobic exercise behavior maintenance. This body of work supports the notion that healthcare providers play an instrumental role in developing exercise intentions and providing resources and an environment to facilitate behavior change. However, the frameworks and theories guiding many of these proposals rely on the assumptions that strong intentions will inherently translate into consistent exercise behavior. This assumption overlooks that many individuals may fully intend to exercise and have access to the necessary resources yet struggle to realize their goals.

2.4 Currently Applied Frameworks for Exercise Promotion in MS

Numerous behavioral change models and frameworks have been proposed to increase the prevalence of PA participation within the MS population. A review of two prevalent models within the realm of MS PA research: Social Cognitive Theory (SCT; Bandura, 1991) and the Theoretical Domains Framework (TDF; Michie et al. 2005) was conducted by Pekmezi & Motl (2022). SCT was recognized for its prominent status in MS PA research, especially within the realm of telehealth (Damush et al., 2011). SCT proposes that health behaviors are primarily influenced by personal beliefs/attitudes, as well as social/physical environments. However, like other social cognitive-based models (i.e., TPB), SCT emphasizes that behavioral outcomes are influenced by expectations and perceptions of one’s ability to exercise, which are critical in transforming intentions into actions. In this model, intentions are viewed as the crucial motivational phase that precedes exercise engagement. However, this view often fails to capture the complex reasons why people might not act on their intentions.

The TDF complements SCT by offering a broader lens on the range of internal and external factors that can influence adherence to PA. TDF conceptualizes behavior as a result of one's belief towards capability, opportunity, and motivation (COM-B; (Michie et al., 2011). These three constructs can be further broken down into 14 distinct domains, (e.g., skills, social influences) for more precise identification of what hinders or facilitates PA. TDF was initially designed to guide researchers seeking to design behavioral interventions (Atkins et al., 2017). However, a key point within Michie et al. (2011) identifies that TDF alone is undertheorized and that behavioral theories should be utilized to identify which BCTs should be targeted. A 93-item BCT taxonomy (Michie et al., 2013) catalogs an array of potentially effective strategies, yet identifying which subset of BCTs is most efficacious for intention–behavior translation remains a major challenge in MS-focused interventions (Spring et al., 2021).

2.5 The Exercise Intention-Behavior Gap in People with Multiple Sclerosis

Exercise behavior often relies on the formation of clear intentions. In the general population, however, intentions do not always equate to sustained behavior, often referred to as the intention-behavior gap (Faries, 2016; Sheeran & Webb, 2016). Intention plays a key role in behavior change, as evidenced by McEachan et al. (2011) who note a correlation of 0.48 between PA intention and behavior. Yet, this correlation accounts for only 23.9% of the variation in this behavior, leaving most of the variance unexplained. Despite consistency in correlational studies, a meta-analysis by (Webb & Sheeran, 2006) identified 47 intervention studies where intention was improved in the intervention groups compared to control groups. Findings from this meta-analysis identified that large changes in intention ($d = 0.66$) only resulted in small behavioral changes ($d = 0.36$), with the correlation between intention and behavior dropping to $r = 0.18$ in intervention-based studies. However, these correlations are not PA-specific, leading to a similar method approach conducted by Webb & Sheeran (2006) specific to studies that evaluate intention formation and subsequent behavior change regarding PA (R. E. Rhodes & Dickau, 2012). These findings identified an average effect size of ($d = 0.45$) for intention and ($d = 0.15$) for subsequent behavior, leading to a trivial correlational value of $r = .07$.

Despite the importance of understanding the intention-behavior gap, limited research has explored this phenomenon in PwMS. A single reported intervention targeting intention formation to the author's knowledge has been reported in the MS population regarding rehabilitation services. Kersten et al. (2015) conducted a mixed-methods feasibility study on if-then plans to bridge the intention-behavior gap in PwMS and stroke patients facing mobility issues. Twenty participants were randomized between goal setting only and goal setting with if-then plans. The study found if-then plans to be feasible, with qualitative data highlighting their usefulness in structuring rehab strategies. Despite encouraging results, no follow-up trial was conducted to assess long-term effects.

Preliminary evidence, such as the work by Schüler et al. (2019), suggests that the exercise intention behavior gap is exacerbated in PwMS by heightened self-regulatory demands (e.g., symptom and medication management) and the unpredictable nature of the disease. These factors often interfere with the ability of PwMS to act on exercise intentions, particularly when faced with physical or psychological barriers. Schüler et al. (2019) propose tailored strategies to address the intention behavior gap in PwMS, emphasizing PA interventions must go beyond encouraging PA intention formation, and focus on mechanisms that facilitate PA. Given these considerations, utilizing M-PAC to assess the reflective, regulatory, and reflexive processes determining the translation of the PA intention-behavior gap in PwMS provides researchers with a potential framework for identifying key BCTs [Figure 1] to target in behavior change interventions for PwMS to facilitate the translation of exercise intentions into sustainable, long-term PA participation.

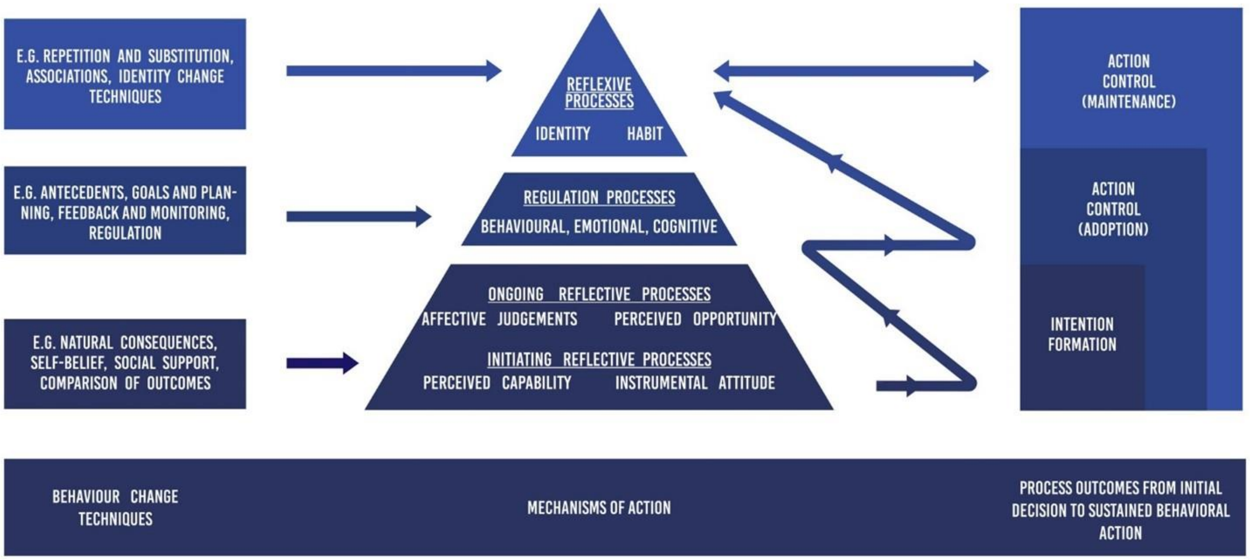

Figure 1 - Multi Process Action Control Framework - Rhodes et al., (2021)

2.6 Role of Multi-Process Action Control Processes in Multiple Sclerosis Research

2.6.1 Reflective Processes in Multiple Sclerosis Research

The role of reflective processes is deemed essential for the development of exercise intentions. Deriving from SCT-based constructs, the four processes (affective judgments, instrumental attitudes, perceived capability, perceived opportunity) encapsulate the intention-formation level of M-PAC. Affective judgments reflect anticipated emotional responses to aerobic exercise; PwMS are more likely to form intentions when they expect a positive experience (Goldoust et al., 2022). These judgments are predictors of intention in clinical populations

(Tabaczynski et al., 2023) and support the adoption of behaviors via reinforcement through enjoyment (Motl et al., 2006; Teixeira et al., 2022).

Instrumental attitudes concern expected health outcomes from aerobic exercise, such as fatigue reduction and various symptomatic relief (Flores et al., 2023; Motl & Pilutti, 2024). Although positively associated with intention and behavior (Goldoust et al., 2022; Kasser & Kosma, 2012), their influence is often weaker than affective judgments (Casey et al., 2017). These suggest that instrumental attitudes are insufficient for PwMS to develop intentions or initiate exercise behavior alone and must incorporate strategies that make benefits more salient or immediate (Casey et al., 2017; Schüler et al., 2019; Stroud et al., 2009).

Perceived capability refers to one's confidence in the ability to perform aerobic exercise, separate from individual motivations (R. E. Rhodes, 2017). BCTs targeting perceived capability are widely integrated into behavior change interventions in MS research, due to the population's experience with variable symptoms like fatigue, mobility impairments, and thermoregulatory dysfunction (R. E. Rhodes, 2017; Silveira et al., 2021). The general term of self-efficacy is frequently determined to be one of the most consistent correlates of exercise, with meta-analytic evidence showing moderate associations with behavior ($r = 0.30$-0.34; Casey et al., 2017). Evidence of perceived behavioral control remaining significant when accounting for disability suggests that perceived capability can buffer the impact of disease severity on activity (Kasser & Kosma, 2012).

Perceived opportunity refers to the extent to which one believes they have external means and opportunity to exercise (e.g., access to facilities, time availability, and accommodating environment;(R. E. Rhodes, 2017). Theoretically, it aligns with the controllability aspect of perceived behavioral control (i.e., whether external factors permit behavior). For PwMS, perceived opportunity is often constrained by both disease-related and logistical factors. Common barriers such as debilitating fatigue, mobility limitations, and MS symptom flare-ups can drastically limit one's opportunity to engage in exercise, even if motivation is high (Correale et al., 2022). Despite the practical relevance of these factors, perceived opportunity may play a more distal or moderating role relative to intention formation (R. E. Rhodes, 2017), suggesting that even when opportunities are objectively constrained, some individuals still form intentions based on internal drivers (i.e., affective judgments, perceived capability). Moreover, the M-PAC model theorizes that perceived opportunity serves as an ongoing reflective process, responsible more so for initial behavior enactment (R. E. Rhodes, 2017). In PwMS, whose decisions are shaped by fluctuating symptoms rather than environmental consistency, intentions often depend more on one's confidence in overcoming internal barriers (e.g., fatigue, physical limitations) than external logistics (Correale et al., 2022). Thus, while perceived opportunity may influence the translation of intentions into behavior, its role in the formation of those intentions could be hindered when perceived capability is a dominant factor.

2.6.2 Regulatory Processes in MS Exercise Research

While Reflective processes lay the groundwork for intention development, they alone are found to be insufficient for sustaining long-term behavior change (R. E. Rhodes & Dickau, 2012). The M-PAC framework posits the role of translating intentions into initial behavior via regulatory processes and BCTs such as goal setting and planning, feedback mechanisms, and strategies for tackling barriers to aerobic exercise participation (R. E. Rhodes, 2017). These self-regulating strategies serve as a metaphorical glue between one's conscious decision to exercise and the actual performance of their subsequent behavior. M-PAC distinguishes behavioral regulation into four distinct factors that contribute to successful behavioral regulation (proactive, reactive, social monitoring, and self-monitoring. Proactive regulation involves deliberate, forward-thinking strategies (i.e., action planning, goal setting, and time management) that help individuals enact their exercise intentions (R. E. Rhodes, 2017). In PwMS, where variable symptom flare-ups can disrupt behavior, proactive regulatory capacity is essential. Techniques like if-then implementation intentions (e.g., "If I feel too tired in the evening, I'll do a shorter session") have been utilized in MS research (Kersten et al., 2015). Additionally, relapse prevention planning is one of the strongest correlates of weekly exercise ($\beta = .51$) in PwMS (Cederberg et al., 2018).

Proactive regulation incorporates common strategies necessary for anticipated barriers such as goal setting, planning, and environmental preparation. Conversely, reactive regulatory strategies are incorporated during behavior enactment following an adverse event. These strategies are necessary when unanticipated barriers arise (i.e., relapse; (R. E. Rhodes, 2021). In addition, self-regulatory effort often involves tracking one's behavior (self-monitoring; i.e., exercise diary) and engaging social resources (social regulation i.e., workout partner) to support one's goals (R. E. Rhodes, 2021).

However, proactive strategies are primarily beneficial for anticipated encounters one might meet before enacting aerobic exercise. However, if an individual is currently participating in their desired behavior and immediately faces an unexpected barrier, temptation, or internal state (i.e., flare-up), in-the-moment self-regulation strategies such as reducing exercise intensity or taking longer rest periods need to be in place. For PwMS, these situations may include factors such as overheating, exacerbated fatigue, or muscle spasticity (Smith et al., 2006). This often leads to PwMS feeling overwhelmed by exercise, triggering an urge to stop the activity (Schüler et al., 2019). Emotional regulation is a common reactive strategy for PwMS, incorporating positive self-talk (e.g., I've handled worse fatigue before, five more minutes) or reminding themselves of the satisfactory feeling of completing a workout to encourage them (Hall-McMaster et al., 2016). These reactive regulatory processes serve to counteract the negative automatic tendencies that oppose exercise behavior (R. E. Rhodes, 2021). Humans have a basic impulse to avoid unpleasant experiences, and with PwMS having this impulse heightened via symptoms, reactive strategies are a critical buffer against these temptations to quit.

Self-monitoring involves tracking one's behavior, such as logging workouts or using an activity tracker (e.g., a smartwatch). It serves as a key regulatory strategy that reinforces intentions through feedback and accountability (R. E. Rhodes, 2017). For PwMS whose symptoms and capacity fluctuate, self-monitoring offers objective insight into activity levels and supports consistency despite variability. While robust evidence is limited, self-monitoring is positively associated with aerobic activity levels in PwMS ($r = 0.45$), indicating those who track their activity are more likely to be active (Cederberg et al., 2018). Self-monitoring is common in MS exercise interventions such as the LEAP-MS program, where participants set goals and log their physical activities, allowing both the patient and a physiotherapist to review progress (Lowe et al., 2021). Building on this internal strategy, social regulation complements self-monitoring by incorporating external sources of support and accountability. While self-monitoring helps enhance personal awareness and autonomy, social regulation leverages interpersonal relationships (family, friends, healthcare providers) to reinforce intentions and sustain engagement. This external reinforcement is particularly beneficial for PwMS, who often benefit from shared experiences, emotional support, and structured guidance. PwMS often cite social support as a key element that helps them initiate and maintain an exercise routine (Russell et al., 2023), and incorporating social activities into exercise (e.g., exercise class) may raise both affective judgments and provide a sense of camaraderie which sustains effort (Schüler et al., 2019).

2.6.3 Reflexive Processes in MS Exercise Research

While regulatory processes are critical for translating intention into initial action, they are effortful and resource dependent. Over time, the sustainability of exercise behavior increasingly relies on the reflexive processes that operate autonomously with less conscious effort (R. E. Rhodes, 2017). The M-PAC framework expands upon traditional action control models by expressing the role of reflexive processes and identifies two processes (habit, identity) that compose this autonomic behavior. Habit refers to the automatic enactment of aerobic exercise in response to established cues, theorized as a key mechanism for binding intentions into action by triggering the intended behavior spontaneously (R. E. Rhodes & Yao, 2015). As one repeatedly engages in exercise (e.g., a morning run), the behavior can become cued by factors such as time of day, leaving work, or other activities, reducing the need for ongoing decision-making. Habit is a significant predictor of physical activity and exercise behavior (de Bruijn, 2011; R.E. Rhodes et al., 2010; R.E. Rhodes et al., 2012). However, in the context of MS, the development of a strong exercise habit is challenging due to the unpredictable fluctuation in symptoms such as fatigue spikes, relapses, and variable physical capacity, disrupting consistent routines. Consequently, evidence of habit facilitating long-term maintenance of exercise and PA in PwMS is sparse and mixed, with qualitative studies indicating PwMS often must adjust their routines through self-regulatory measures rather than rely on automatic responses (Cederberg et al., 2018). This limitation suggests that while habit may play a role in exercise maintenance in the general population, its predictive strength in PwMS could be comparatively weak. PwMS often carefully plan and adjust their exercise behaviors around energy levels and symptoms, rather than relying on automatic routines (Stennett et al., 2020). Symptoms such as MS fatigue and muscle spasticity or pain are particularly salient barriers to performing exercise at regular times or in a uniform manner (Almarwani & Alosaimi, 2023). This inherent need for conscious adjustment suggests that true, unconscious habits toward aerobic exercise may be impractical for the MS community. In contrast, identity pertains to the integration of exercise into one's self-concept, such that being active becomes a core component of that individual's self-concept (R. E. Rhodes, 2017). Put simply, a strong exercise identity means that exercising regularly is part of "me", so failing to exercise not only undermines a health goal but also threatens one's sense of self. This makes identity a powerful driver for maintenance, kicking in when the initial novelty or externally driven self-regulatory behaviors fade. Emerging evidence suggests the benefit of targeting identity directly, as opposed to reliance on behavioral regulatory strategies to develop exercise identity (R. E. Rhodes et al., 2025). Identity's influence has been observed in clinical populations such as cancer survivors, where it was found that those who internalized an exerciser identity were able to maintain regular exercise through and beyond their treatment period by continuous adaptation (Roach et al., 2024). These findings indicate that during adverse conditions, unlike habit, an exercise identity can drive sustained behavior. Direct evidence in PwMS is limited, although suggests the pattern that exercise participation is closely tied with issues of identity and self-image. Qualitative research found that people with MS often view exercise as a way to cope with their condition and maintain their identity beyond diagnosis (Stennett et al., 2020). Some PwMS report having a sense of an "MS identity" which can act as an initial barrier to exercise (Russell et al., 2023). However, Russell et al. (2023) suggest that enabling a positive, exercise-enabling identity post-intervention increased PA behavior. This internalized identity can drive sustained aerobic exercise adherence by motivating individuals to adapt to their routines despite adverse symptoms. Collectively, the literature suggests that while both habit and identity are key reflexive processes in M-PAC, exercise identity may be a more robust predictor of long-term aerobic exercise maintenance in PwMS.

2.7 Mapping Multi-Process Action Control Framework to Behavior Change Techniques

BCTs have been systematically mapped to identify strategies that align with key psychological processes influencing exercise behavior (R. E. Rhodes, 2017). Furthermore, a systematic review by Silveira et al. (2021) identified 53 BCTs used across 54 physical activity interventions in PwMS. The most frequently utilized BCTs fell within reflexive processes of the M-PAC framework (i.e., perceived capability, instrumental attitudes), and some usage of regulatory BCTs (i.e., goal setting, self-monitoring). However, a noticeable drop-off occurred in reflexive processes (identity/habit), with the most frequently used reflexive BCT being adding objects to the environment (58%). More detailed findings can be found in [Table 4]. This mapping of BCTs to M-PAC processes can serve as a useful tool for future researchers to effectively implement into program design. However, there is currently no literature out there suggesting which M-PAC processes are significant predictors of aerobic exercise intention and realization in PwMS.

M-PAC Constructs	BCT Number	BCT Description	Usage in Multiple Sclerosis Studies N = 38, n (%)
Instrumental Attitudes	5.1	Information about health consequences	15 (39)
	5.2	**Salience of consequences**	**2 (5)**
	5.3	Information about social and environmental consequences	17 (45)
Affective Judgement*	3.3	Social support (emotional)	4 (11)
	5.6	Information about emotional consequences	4 (11)
	7.5	**Remove aversive stimulus**	**0 (0)**
	12.5	Adding objects to the environment	22 (58)
Perceived Capability*	4.1	Instruction on how to perform a behavior	34 (89)
	6.1	Demonstration of behavior	31 (82)
	6.2	Social comparison	11 (29)
	8.1	Behavioral practice	17 (45)
	8.7	Graded tasks	28 (74)
	15.1	Verbal persuasion about capability	12 (32)
Perceived Opportunity*	3.2	Social support (Practical)	12 (32)
	12.1	**Restructuring the physical environment**	**1 (3)**
	12.2	**Restructuring the social environment**	**1 (3)**

Behavioral Regulation*	1.1	Goal setting (Behavior)	28 (74)
	1.2	Problem solving	25 (66)
	1.4	Action planning	14 (37)
	1.8	**Behavioral contract**	**2 (5)**
	2.3	Self-monitoring of behavior	29 (76)
	2.6	Biofeedback	4 (11)
	7.1	Prompt/Cues	8 (21)
	10.7	**Self-incentive**	**1 (3)**
	11.2	**Reduce negative emotions**	**3 (8)**
	15.4	**Self-talk**	**0 (0)**
Identity*	6.2	Social comparison	11 (29)
	8.1	Behavioral practice	17 (45)
	8.2	**Behavioral substitution**	**1 (3)**
	12.5	Adding objects to the environment	22 (58)
	13.2	**Framing/reframing**	**1 (3)**
	13.3	**Incompatible beliefs**	**0 (0)**
	13.4	**Valued self-identity**	**0 (0)**
	13.5	**Identity associated with changed behavior**	**0 (0)**
Habit	7.1	Prompt/cues	8 (21)
	7.5	**Remove aversive stimulus**	**0 (0)**
	7.8	**Associative learning**	**0 (0)**
	8.1	Behavioral practice	17 (45)
	8.3	**Habit formation**	**1 (3)**
Bolded BCTs indicate < 10% usage in studies			

Table 4- Behavior Change Techniques Mapped against M-PAC framework (Rhodes et al., 2017, Addition of prevalence in MS studies (Silveira et al., 2021).

2.8 Purpose of the Current Study

Despite their influential insight into the role of intention formation on exercise promotion and participation in PwMS, Kersten et al. (2015) and Schüler et al. (2019) remain some of the very few published works examining intention formation and behavior change related to PA and exercise among PwMS. The wider body of literature emphasizes that PwMS frequently intend to engage in exercise, attributable to their heightened health awareness and desire for positive health outcomes. However, PwMS struggle to translate these intentions into behavior due to symptomatic influences (e.g., fatigue). Therefore, a critical gap exists in the exploration of bridging intentions and behaviors towards PA and aerobic exercise within the MS population. By identifying PwMS who intend/do not intend to engage in regular aerobic exercise, along with identifying those who do and do not adhere to regular aerobic exercise, we can utilize the M-PAC framework to identify which reflective, regulatory, and reflexive processes can be targeted by clinicians and researchers to effectively promote exercise to PwMS. To identify these outcomes, it is critical to first determine which sub-processes best predict membership to each action-control profile. This study aims to examine which sub-processes (affective judgments, instrumental attitudes, perceived capability, perceived opportunity, behavioral regulation, identity, and habit) best predict intention and subsequent exercise behavior utilizing MLR. Insights from these findings will aid in targeting established BCTs and health promotion strategies for PwMS based on their assigned action-control profile.

Therefore, the research questions and hypotheses are:

- Question 1: How prevalent are intentions and subsequent behavior towards aerobic exercise training in PwMS, and what is the prevalence of these action control profiles (SI,USI, SNI, UNI)?
    - Hypothesis: three action control profiles (SI, USI, UNI) will emerge from the data, consistent with prior M-PAC literature which suggests that intention is a prerequisite of behavior.
- Question 2: Which general demographics, clinical variables, and M-PAC processes predict PwMS to develop intentions to engage in aerobic exercise?
    - Hypothesis 2 perceived capability, affective attitudes, and PDDS will be significant predictors of intention formation (Casey et al., 2017; Correale et al., 2022; Kasser & Kosma, 2012; Motl et al., 2006; Schüler et al., 2019; Stroud et al., 2009; Teixeira et al., 2022).
- Question 3: Of those with MS who intend to meet aerobic exercise guidelines, which general demographics, clinical variables, and M-PAC processes will predict successful action control (i.e., SI)?

- Hypothesis 3: Identity will be a significant predictor of action control (Cederberg et al., 2018; Kersten et al., 2015; R. E. Rhodes, 2017; R. E. Rhodes et al., 2025; Roach et al., 2024; Russell et al., 2023; Stennett et al., 2020).

Chapter 3- Methods

3.1 Study Design and Data Collection

This study used a cross-sectional quantitative approach via e-survey data. Data collection occurred between the dates of January 24th, 2024, and February 21st, 2024. This e-survey was designed to last approximately 15 minutes and assessed 1) current aerobic exercise behavior, 2) aerobic exercise intentions, and 3) seven validated measures of the M-PAC) framework. Four measures targeted reflective processes (perceived capability, perceived opportunity, affective judgments, instrumental attitudes). One measure targeted regulatory processes (behavior). Finally, two measures targeted reflexive processes (habit, identity). The Kansas State University Institutional Review Board approved the study protocol (IRB-#12506-Various Exempt).

3.2 Participants and Recruitment

This study employed a non-probability, convenience sampling strategy to recruit participants with an MS diagnosis. Recruitment was conducted through three primary recruitment channels: 1) Stormont Vail Health System (a rural Midwest hospital system), 2) Prolific (an online, e-survey platform), and 3) online discussion forms (Reddit). The inclusion criteria required participants to have a healthcare provider-confirmed MS diagnosis, be 18 years or older, possess the ability to read and write in English, and currently reside within the United States. Participants with a Patient Determined Disease Step (PDDS; Learmonth et al. 2013) score of eight (bedridden) were excluded from the study. Participants were informed that their participation was voluntary and could withdraw at any time without penalty. Consent was obtained digitally at the start of the survey. Prolific automatically screened for country of residence to ensure only U.S.-based participants were enrolled. Social media respondents were manually screened for country of residence.

3.2.1 Stormont Vail

Recruitment procedures through the Stormont Vail Health System took place through the MyHealth app messaging system, where recruitment messages were sent to 578 eligible individuals identified with the ICD-10 code G35 (multiple sclerosis). Messages included study details, a link to the survey, and researcher contact information. Two follow-up reminder messages were sent one and three weeks from the initial recruitment date. Participants were offered voluntary entry into a 25$ gift card raffle upon survey completion by entering their email addresses into a separate survey. Eight gift cards were distributed across email addresses provided by Stormont Vail and social media respondents.

3.2.2 Prolific

The survey was advertised to the Prolific participant pool upon study publication. Participants received direct compensation of two dollars for completing the approximately 15-minute survey, following Prolific's minimum payment requirements. A budget of 800 dollars was allocated to the Prolific pool, limiting our max response total to 300 participants, due to a 33% surcharge ($2.67 per participant). No further follow-up was required due to Prolific's automated recruitment process.

3.2.3 Social Media

Recruitment messages were distributed via an advertisement post on the r/MultipleSclerosis subreddit, a public online forum with over 60,000 members. While not all members have MS, the subreddit is explicitly dedicated to persons affected by the condition. Participants recruited via social media could optionally provide their email through a separate Qualtrics form for entry to win one of eight $25 gift cards.

3.3 Measures

All participants completed a 48-item online survey hosted on Qualtrics XM (Provo, UT), covering demographics (6 items), and exercise intentions/behaviors aligned within the M-PAC framework (42 items). To maintain anonymity, survey responses were de-identified, and separate forms were used for raffle entries. Data was securely stored on a password protected server accessible only to authorized personnel.

3.3.1 Demographic and Clinical Variables

General demographics and clinical variables standard for MS research were collected via self-report. General demographics included age and gender (male, female). Clinical variables included type of MS diagnosis (relapse-remitting, primary progressive, secondary progressive, progressive relapsing), MS duration, disability (PDDS), and additional comorbidities (yes, no). An optional string input was provided for those who selected other on MS diagnosis or yes for comorbidities to elaborate. Additionally, respondents from social media were further screened for country of residence for exclusion criteria.

3.3.2 Aerobic Exercise Behavior and Intention

Before any reported non-demographic measures, two definitions were provided to the participants (See Appendix A). Aerobic activity was defined per ACSM guidelines as "any rhythmic activity involving large muscle groups that can be sustained continuously, such as walking, cycling, dancing, jogging, or running. Aerobic exercise is also commonly referred to as cardio or aerobics" (Patel et al., 2017). An additional definition of regular aerobic exercise was provided per the MS Exercise Training Guidelines. Regular aerobic exercise was defined as "engaging in 30-minute exercise sessions at least twice per week" (Y. Kim et al., 2019). A modified version of the Godin Leisure Time Exercise Questionnaire (GLTEQ; Godin, 2011) was used to assess aerobic exercise; frequency and duration (recorded in minutes). Aerobic exercise was classified as “exercise that improves the heart and lungs such as walking or running”. Responses to the GLTEQ categorized individuals as adherers and non-adherers to aerobic exercise guidelines. Adherers were classified as reporting at least two moderate or strenuous exercise sessions per week, with a reported length of at least 30 minutes per average session. This version of the GLTEQ was modified by adding a duration component (in minutes) to each frequency item, similar to the IPAQ format. These modifications allowed for the classification of individuals based on frequency, duration, and intensity of aerobic exercise and are consistent with previous applications for aerobic exercise measurement in M-PAC-based studies (Vallerand et al., 2017).

A modified Decisional Intentions to be Physically Active scale was used to assess intention (Courneya, 1994). Participants were asked “I intend to engage in at least 30 minutes of aerobic exercise 2 times per week over the next 4 weeks.” (yes/no). Responses to the decisional intentions assessment categorized intenders vs non-intenders. Those who select yes are categorized as the intender group, while those who select no are categorized as the non-intender group. Refer to [Table 3].

3.3.3 M-PAC Variables

Adherence to MS aerobic exercise training guidelines were assessed via self-report via reflective, regulatory, and reflexive processes. All M-PAC assessments specifically targeted aerobic exercise training, aligning with predefined definitions. To ensure clarity, participants were informed of the distinction between general physical activity and structured exercise and were instructed to consider intentional aerobic exercise sessions.

3.3.4 Reflective Processes

Perceived capability (4 items) and perceived opportunity (3 items) were assessed using the latest edition of the Perceived Behavioral Control scale (Lithopoulos et al., 2023). The tool was semantically modified to assess aerobic exercise, as opposed to aerobic PA (e.g., "I have the physical ability to do regular aerobic exercise over the next 3 months"). Responses were graded on a 5-point Likert scale, with 1 meaning "Strongly disagree" and 5 meaning "Strongly agree". All scales and measures were provided with a "prefer not to say option". Participants were requested to select a response before proceeding. Scores on each item were summed, indicating that individuals with higher scores held greater levels of perceived capability or opportunity.

Affective judgments (3 items) and instrumental attitudes (3 items) were assessed via a written questionnaire with three instrumental (beneficial/harmful, useful/useless, valuable/worthless) and three affective (enjoyable/unenjoyable, pleasant/unpleasant, invigorating/exhausting) items, in congruence with prior literature guidelines for scale design (Ajzen, 2006; Emerson et al., 2022). The scale was semantically modified to assess aerobic exercise. Responses were assessed on a 7-point Likert scale, with 1 meaning "extremely disagree, and 7 meaning extremely agree. Responses for each item were summed, indicating that individuals with higher scores held greater levels of affective judgments or instrumental attitudes.

3.3.5 Regulatory Processes

Behavioral regulation was assessed using the Physical Activity Regulation Scale (PARS), a 14-item instrument developed within the M-PAC framework (R. E. Rhodes & Lithopoulos, 2023). The PARS consists of 4 factors measuring a distinct component of behavioral regulation. Proactive regulation (4 items) assesses strategies for addressing anticipated barriers to aerobic exercise (e.g., "To be exercising, I have made a detailed plan regarding when to do aerobic exercise”), while reactive regulation (4 items) assesses strategies for addressing barriers that arise during aerobic exercise (e.g., “When I am upset, I have ways of coping so I can focus on my aerobic exercise plans”). Social monitoring refers to the strategies we rely on through our friends and family (e.g., “There is someone who could provide feedback on my aerobic exercise participation when needed”), while Self-monitoring refers to the strategies individuals use to keep track of their aerobic exercise activity (e.g., “I keep track of my aerobic exercise activities”). Responses were recorded on a 7-point Likert scale ranging from 1 meaning “strongly disagree” to 7 meaning “strongly agree”. The term “physical activity” was semantically modified to align with the study’s defined focus on aerobic exercise. Item scores within each factor were summed, with higher total scores reflecting greater behavioral regulation toward aerobic exercise training.

3.3.6 Reflexive processes

Habit was assessed via the Self-Report Behavioral Automaticity Index (Gardner et al., 2012). The 4-item scale (e.g., (Aerobic exercise is something I do without having to consciously remember”) is scored on a 7-point Likert scale with 1 meaning “strongly disagree” and 7 meaning “strongly agree”. The scale allows for language adjustment to align with the specific behavior being assessed; in this study, aerobic exercise was specified as the target behavior. Scores on each item were summed, with higher scores indicating a higher prevalence of automatic habits toward aerobic exercise.

Identity was assessed via the 3-item Exercise Role Identity Scale (Wilson & Muon, 2008). The scale was assessed on a 7-point Likert scale with 1 meaning “strongly disagree” and 7 meaning “strongly agree”. The term exercise was further specified within the language of the tool to emphasize aerobic exercise (e.g., “I consider myself someone who does regular aerobic exercise”). Responses for each item were summed, with higher scores indicating a higher association of aerobic exercise with one's identity. This subscale was selected for its alignment with theoretical definitions of identity as a self-perception of being an exerciser, independent from motivational salience or evaluative beliefs (Wilson & Muon, 2008), as opposed to the broader 9-item exercise identity scale (Anderson & Cychosz, 1994) including exercise beliefs, which could infer crossover with reflective processes (e.g., affective judgments, instrumental attitudes). This more direct measure of role identity towards aerobic exercise makes the subscale well-suited for examining identity as a reflexive process.

3.4 Sample size justification

An initial analytic plan involving discriminant function analysis (DFA) was developed to classify participants into one of four action-control profiles. DFA was deemed appropriate due to its capacity to derive linear combinations of predictors that best distinguish among multiple groups, along with it being the preferred technique for assessing the M-PAC framework (R. E. Rhodes & de Bruijn, 2013). A priori power analysis was conducted to determine the appropriate sample size for this study. Given the study's design, with four action control profiles as the groups and seven predictors (reflexive, regulatory, and reflective processes), the MANOVA: Special Effects and Interactions model was used as a proxy for the DFA. MANOVA and DFA share a reliance on multivariate F-tests, where predictors contribute to group separation through linear combinations of variables. This similarity justifies the use of MANOVA-based power analysis as a proxy for DFA (Faul et al., 2007).

A small-medium effect size ($f2 = 0.17$) was selected based on both Cohen’s guidelines and prior research within M-PAC studies. The alpha level was set at 0.01 with the power set at 0.8. With four action control profiles and seven predictors, the analysis estimated a required minimum sample size of 126 participants to evaluate the predictors' ability to distinguish among the four action control profiles, assuming equal group sizes. However, the literature suggests that the action control profile SNI represents a significant minority of the population, with previous analyses reporting as low as 2.2%, creating unequal group sizes (R. E. Rhodes & Lithopoulos, 2022). Heuristic guidelines for DFA suggest that each group has n+2 participants based on the number of predictor variables. This indicates a minimum group size of nine PwMS, increasing the minimum sample size to 409 participants. This value was calculated by the minimum group size (n=9) / smallest group proportion (2.2%). However, given this large discrepancy in action control profile distribution, the sample size still may not emerge.

Prior to finalizing the data analysis plan, preliminary assumption testing including Box's M test was conducted to evaluate assumptions required for DFA (homogeneity of variance-covariance matrices. Results indicated a significant violation of this assumption ($p < .001$), rendering DFA inappropriate. Consequently, hierarchical MLR was employed as an alternative analytic strategy. MLR is commonly used within the M-PAC literature and demonstrates greater tolerance for violations of variance-covariance assumptions (Tabaczynski et al., 2023; Vallerand et al., 2016b, 2017). Although MLR does not facilitate the same factor-based separation of groups as DFA, it enables the interpretation of odds ratios for each predictor relative to a selected reference group (e.g., SI vs. NI), thereby providing robust classification of participants into their respective action-control profiles under the given data conditions.

3.5 Statistical Analysis

SPSS Version 29.0.0.0 (241) was utilized for all statistical analyses. To facilitate dataset merging, variable names, and response categories were standardized across recruitment pools before survey distribution. Given that participants were provided options to not provide data (e.g., Prefer not to say), an additional category of Other/Unknown was created for MS type and comorbidities. Any subcategories with less than 10 responses were removed from the analysis.

3.5.1 Reference Categories

Three categorical variables will be included in the MLR analysis: gender, MS type, and comorbidities. The most prevalent category within the sample will be designated as the reference category. Accordingly, the reference category for gender will be female, for MS type will be relapsing-remitting MS, and for comorbidities will be none. Comparisons involving individuals who report "unknown/other" for MS type will be excluded from the analysis.

3.5.2 Multinomial Logistic Regression

Two hierarchical MLR analyses determined the multivariate correlations of aerobic exercise training participation in PwMS. As part of a purposeful selection of variables strategy (Bursac et al., 2008), univariate analyses (Chi-square and ANOVA) determined the inclusion of general demographics, clinical variables, and M-PAC variables within the MLR models. A threshold of $p < 0.10$ was required for inclusion within each model, similar to previous M-PAC-based regression studies (Tabaczynski et al., 2023; Vallerand et al., 2016b). The first MLR model assessed intenders vs non-intenders, and the second MLR model assessed successful vs unsuccessful intenders.

As part of the variable selection process, MS duration was initially considered but ultimately excluded from the final regression models. While multicollinearity was not an immediate concern between MS duration and age ($r = -0.647$, VIF = 1.721), the decision to exclude MS duration was grounded in its well-documented conceptual and empirical redundancy with age and PDDS. Prior research suggests that MS duration does not have unique predictive value for exercise behavior when age and disability are accounted for, as its effects are largely mediated through disease progression and functional decline (Beckerman et al., 2010; Monaghan et al., 2025).

The intender vs non-intender model included three blocks. Block 1 included general demographics, block 2 included general demographics, and clinical variables, and block 3 included general demographics, clinical variables, and reflective M-PAC processes. Given that regulatory and reflexive processes predominantly predict action control, rather than intention formation, these processes were not included in the intention formation model (Tabaczynski et al., 2023). The action control model included five blocks. Block 1 included general demographics. Subsequent blocks included the addition of clinical variables (2), reflective processes (3), regulatory processes (4), and reflexive processes (5). To evaluate the variance explained by the model, Nagelkerke's pseudo-R2 was selected based on usage in previous M-PAC research (Tabaczynski et al., 2023; Vallerand et al., 2017). Model fit was further assessed via likelihood ratio tests, Pearson chi-square, deviance chi-square, and the Akaike information criterion (AIC). AIC was consulted due to the Pearson and deviance tests providing differing results. AIC generally penalizes complex models with a high reliance on additional parameters. A reduction in AIC implies that the model explains the data well while using minimal parameters, thereby achieving an optimal balance between explanatory accuracy and model complexity (Vrieze, 2012).

3.5.3 Data Cleaning

All survey responses were assessed for inclusion based on predefined eligibility and data quality criteria. Listwise deletion was applied based on the following criteria: 1) ineligibility (failure to provide informed consent, failure on screening questions, or non-U.S. residence; social media only). 2) Careless responding was operationalized as a failure on two or more attention checks. 3) Incomplete data, defined as less than 90% survey completion, missing responses on key

M-PAC constructs, or absence of reported exercise intention and behavior. This approach aligned with the study's pre-specified data-cleaning criteria and analytic plan. While this method supports model interpretability and consistency, it may significantly reduce sample size.

3.6 Sensitivity Analysis

A sensitivity analysis was performed to verify that the main findings reflected genuine intention-behavior discordance—as advised by R. E. Rhodes (2017)—rather than a minor shortfall in meeting MS aerobic exercise training guidelines. In this analysis, action control categorizations were redefined using a 20-minute per session threshold instead of 30 minutes. MLR analyses were then re-run for the action control model with these revised categorizations.

Chapter 4 - Results

4.1 Sample Characteristics

A total of 509 surveys were collected. Eighty-seven participants were removed from the final analysis, with specific details listed in [Figure 2]. A total of 400 participants provided complete demographics, clinical variables, aerobic exercise, intentions, and M-PAC information necessary to run the analysis. The non-binary gender category was excluded from the analysis due

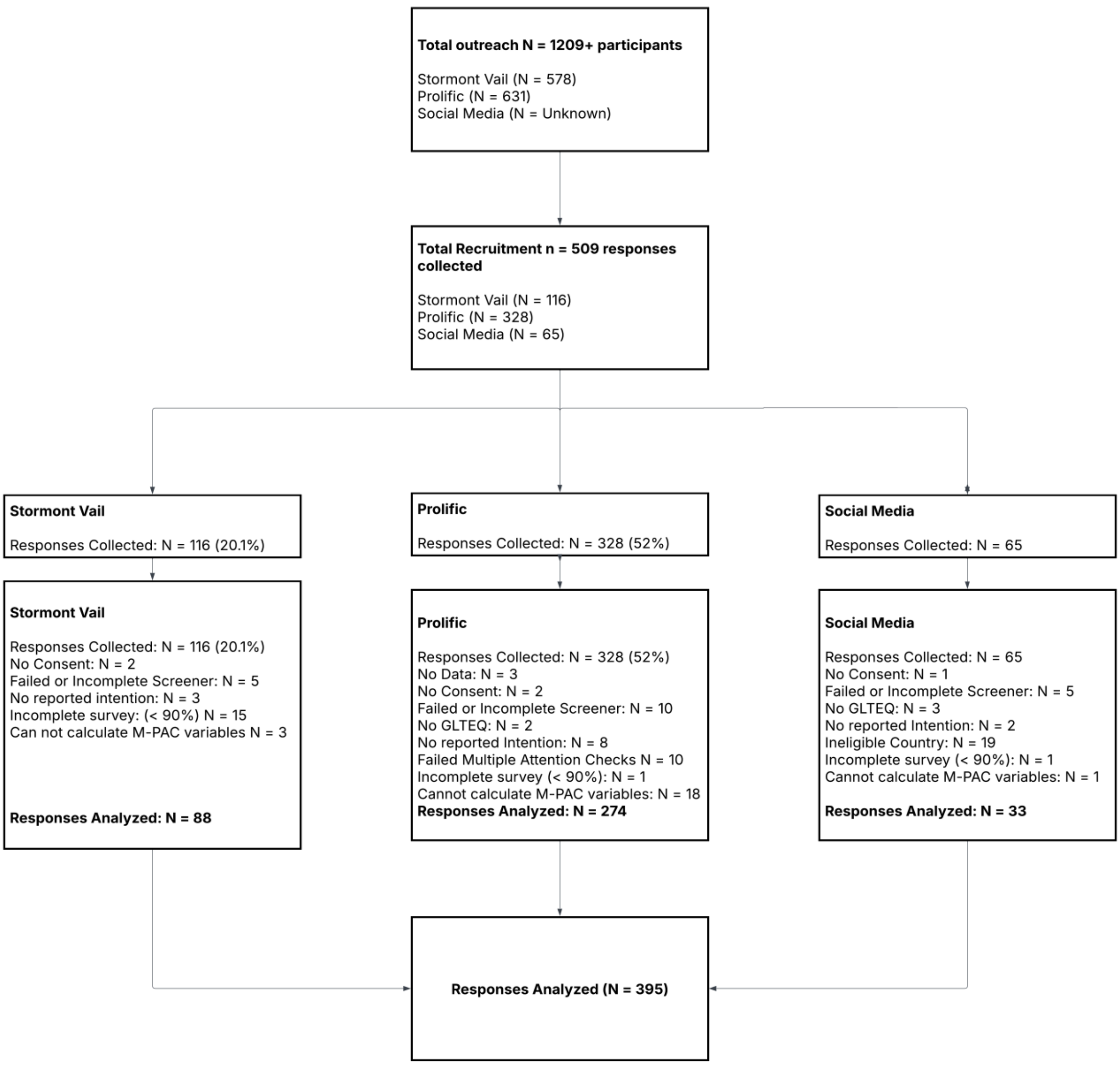

Figure 2 – Recruitment Flow Chart

to not meeting the heuristic threshold of 10 individuals per category (n = 5). The final sample included 395 participants: Prolific (n = 274), Stormont Vail (n = 88), and social media (n = 33).

Demographics and clinical variables are summarized in [Table 5]. Of the 395 respondents, 189 (47.3%) were classified as SI, 137 (34.3%) as USI, and 74 (18.5%) nearly half of the total sample reported meeting aerobic exercise guidelines. Disease duration appeared to influence adherence patterns. Among those diagnosed within the past five years (50.6% of the sample), 91.4% intended to meet aerobic exercise guidelines, and 57.9% successfully adhered to them. In contrast, participants diagnosed for over 20 years demonstrated a marked decline, with only 61.8% intending to meet the guidelines, and 25.5% successfully doing so.

4.2 Site Specific Demographics

4.2.1 Prolific

Prolific respondents were the youngest subgroup, with an average age of 36.9 years (±14.1), and had the highest proportion of individuals diagnosed within the past five years (61.3%). This group reported relatively low mobility impairment compared to the sample average with a PDDS score of 1.77 (±1.83). A total of 62.5% of respondents were male. Distribution of MS type also saw a high prevalence of progressive primary MS at 29.6%. Prolific was also the only subgroup to report cases of Progressive relapsing MS (3.8%). Prolific respondents also reported the highest prevalence of aerobic exercise intention (87.2%) and behavior (52.6%) compared to other recruitment channels (Stormont Vail, social media).

Table 3 – Demographic and MS characteristics: p = correlate of profile; (chi-square, ANOVA)

		Recruitment Sources			Intention Formation			Action Control		
	Total (n = 395)	**Prolific (n=274)**	**Stormont Vail (n = 88)**	**Social Media (n = 33)**	**Intenders (n = 322)**	**Non-Intenders (n = 73)**	**p**	**Successful Intenders (n = 189)**	**Unsuccessful Intenders (N = 133)**	**p**
General Demographics										
Gender (n, %)										
Female										
Male	247 (62.5%)	143 (52.2%)	76 (86.4%F)	28 (84.8%)	188 (58.4%)	59 (80.8%)	.001*	87 (46.0%)	47 (35.3%)	.055*
	148 (37.5%)	131 (47.8%)	12 (13.6%)	5 (15.2%)	134 (41.6%)	17 (19.2%)		102 (54.0%)	86 (64.7%)	
Age (Mean (SD))	41.41 (15.53)	36.87 (14.11)	55.14 (13.10)	42.57 (10.58)	39.11 (15.1)	51.55 (13.31)	.001*	37.73 (14.76)	41.09 (15.39)	.049*
Clinical Demographics										
MS Type (n, %)										
RRMS	211 (53.4%)	112 (40.9%)	71 (80.7%)	28 (84.8%)	166 (51.6%)	45 (61.6%)	.048*	89 (47.1%)	77 (57.9%)	.319
PPMS	88 (22.3%)	81 (29.6%)	4 (4.5%)	3 (9.1%)	80 (24.8%)	8 (11.0%)		49 (25.9%)	31 (23.3%)	
SPMS	37 (9.4%)	31 (11.3%)	5 (5.7%)	1 (3.0%)	27 (8.4%)	10 (13.7%)		17 (9.0%)	10 (7.5%)	
PRMS	15 (3.8%)	15 (5.5%)	0 (0%)	0 (0%)	14 (4.3%)	1 (1.4%)		9 (4.8%)	5 (3.8%)	
Other / Unknown	44 (11.1%)	35 (12.8%)	8 (9.1%)	1 (3.0%)	35 (10.9%)	9 (12.3%)		25 (13.2%)	10 (7.5%)	
MS Duration (n,%)										
< 5 years	197 (49.9%)	168 (61.3%)	11 (12.5%)	18 (54.5%)	180 (55.9%)	17 (23.3%)	.001*	114 (61.6%)	66 (49.6%)	.168
5-10 years	64 (16.2%)	46 (16.8%)	12 (13.6%)	6 (18.2%)	50 (15.5%)	14 (19.2%)		27 (14.6%)	23 (17.3%)	
10-15 years	45 (11.4%)	19 (6.9%)	21 (23.9%)	5 (15.2%)	34 (10.6%)	11 (15.1%)		19 (10.3%)	15 (11.3%)	
15-20 years	28 (7.1%)	14 (5.1%)	13 (14.8%)	1 (3.0%)	19 (5.9%)	9 (12.3%)		11 (5.9%)	8 (6.0%)	
20+ years	55 (13.9%)	21 (7.7%)	31 (35.2%)	3 (9.1%)	34 (10.6%)	21 (28.8%)		14 (7.6%)	20 (15.0%)	
Comorbidities (Mean (SD))										.094*
Yes	168 (42.5%)	114 (41.6%)	43 (48.9%)	11 (33.3%)	126 (39.1%)	28 (38.4%)	.015*	107 (56.6%)	56 (42.1%)	
No	210 (53.2%)	145 (52.9%)	43 (48.9%)	22 (66.7%)	182 (56.5%)	42 (57.5%)		70 (37.0%)	75 (56.4%)	
Unknown	17 (4.3%)	15 (5.5%)	2 (2.3%)	0 (0%)	14 (4.3%)	3 (4.1%)		12 (6.3%)	2 (1.5%)	
PDDS (Mean (SD))	1.79 (1.86)	1.77 (1.83)	2.03 (2.08)	1.39 (1.41)	1.61 (1.74)	2.63 (2.16)	.001*	1.43 (1.71)	1.85 (1.75)	.034*

Table 5- General Demographics and Clinical Variables

4.2.2 Stormont Vail

Contrary to Prolific, Stormont Vail participants were the eldest subpopulation with an average age of 55.1 years (±13.1) and 35.2% of respondents having lived with MS for over 20 years. Subsequently, Stormont Vail participants also reported the highest PDDS scores across recruitment channels, with an average score of 2.03 (2.08). Disease distribution for Stormont Vail included 80.7% of respondents reporting relapse remitting MS and was predominantly composed of women (84.6%). Stormont Vail respondents reported the lowest levels of aerobic exercise intention (60.2%) and aerobic exercise behavior (25%) among the three recruitment channels.

4.2.3 Social Media

The social media subgroup had the smallest sample size (n = 33) and reported an average age of 42.6 (±10.6) with 54.5% of respondents having been only diagnosed for five or fewer years. This group reported the lowest level of mobility impairment, with a mean PDDS score of 1.39 (±1.41). The distribution of MS type showed 84.8% of respondents had relapse remitting MS, 5.7% had secondary progressive MS, and 4.5% had primary progressive MS. Reported intentions for meeting the aerobic exercise guidelines was high at 90.9%, and exercise behavior was reported with 69.7% of respondents meeting aerobic guidelines.

4.3 Preliminary Data Diagnostics

M-PAC variables were screened for quality, normality, and completeness. Normality was evaluated using skewness and kurtosis benchmarks of ±2 and ±7, respectively(George, 2011; H.-Y. Kim, 2013). With the exception of instrumental attitudes, all variables demonstrated acceptable univariate distributions, with skewness ranging from -1.438 to -0.385 and kurtosis from -0.268 to 2.631. Instrumental attitudes exceeded these thresholds (skewness = -2.343, kurtosis = 7.187), suggesting a pronounced negative skew and leptokurtic distribution, where participants consistently endorsed high instrumental beliefs regarding the benefits of aerobic exercise. Multicollinearity diagnostics indicated that none of the selected predictor variables exceeded the commonly accepted thresholds (Pearson's $r \geq 0.70$ or VIF > 5; West et al. 1995), suggesting that multicollinearity was not a concern in the final models. Linearity in the logits was assessed via the box-tidwell test, with all predictor variables demonstrating non-significant interactions for intentions ($p = 0.085 – 0.972$) and behavior ($p = 0.056 – 0.820$), indicating that the assumption of linearity in the logit was met.

Internal consistency of the M-PAC variables was assessed using Cronbach's alpha. Individual subscale alpha values ranged from 0.897-0.920, indicating strong to excellent reliability across all constructs.

Data quality was further assessed via multiple embedded attention checks throughout the survey. Participants who failed multiple attention checks were excluded from the analytic sample ($n = 34$). However, participants were not excluded based on survey completion time or uniformity of responses across items. This decision was made in recognition of the characteristics of PwMS who may require variable amounts of time to complete the survey due to variable symptoms. Applying rigid time thresholds risked excluding valid responses from participants with lower disease burden. Likewise, consistent responding across items was not used as an exclusion criterion, as the M-PAC questionnaires utilized did not include reverse-scored items. Thus, uniform response patterns could reflect genuine, strongly held beliefs rather than satisficing or disengaged responses (Fong et al., 2010), especially in a context where high internal consistency is theoretically expected.

4.4 Demographics and Correlates of Intention Formation

To characterize the sample, action control profiles were grouped as intenders (SI, USI) and non-intenders (UNI, SNI). Intenders were primarily composed of younger PwMS (39.11 years (15.1)) who had been diagnosed for <5 years (55.9%) and had low PDDS scores (1.61 (1.74)). In contrast, non-intenders were older (51.55 years (13.3)) and exhibited worse disability (2.63 (2.16)).

For a more in-depth analysis of the models for intention formation and action control, please refer to [Table 6]. The univariate analyses revealed that all general demographics, clinical variables, and reflective processes were significant correlates of intention to meet MS aerobic exercise guidelines. In Model 1, which included only demographic variables (R2 = 0.16), age was a significant predictor of aerobic exercise intention (p< .001, OR = .954), indicating that for every one-year increase in age, the odds of an individual intending to meet MS aerobic exercise guidelines decreased by 4.6%. Model 2 (R2 = .23) introduced clinical variables, indicating that older participants (p = .001, OR = .964) and those with decreased reported mobility (p = .004, OR = 0.796) (i.e., PDDS) were less likely to meet MS aerobic exercise guidelines. Model 3 (R2 = .58) included all demographic and clinical variables and reflective processes. In this model, age was the only demographic predictor of intention formation (p = .011, OR = .966), suggesting for every one-year increase in age, the likelihood of an individual intending to meet guidelines decreases by 3.4%. Three of the four reflective processes emerged as significant predictors: affective judgments (p < .001, OR = 1.203; 20.3% decreased likelihood of intention to meet guidelines per 1-point increase), perceived capability (p = .002, OR = 1.235; 23.5% decreased likelihood of intention to meet guidelines per 1-point increase), and perceived opportunity (p = .029, OR = 1.258; 25.8% decreased likelihood of intention to meet guidelines per 1-point increase). Greater specifics including confidence intervals can be found in [Table 6].

4.5 Correlates of Action Control

The univariate analyses identified age, gender, PDDS, and comorbidities as significant factors associated with aerobic exercise behavior among individuals who intended to meet the guidelines ($p < 0.1$). Model 1 (R2 = .02) only included the general demographic variables age and gender, neither of which were significant predictors of action control. Model 2 (R2 = .06) included general demographic variables, and clinical variables PDDS and comorbidities. Model 2 saw PDDS emerge as the only significant predictor of meeting aerobic exercise guidelines ($p = .022$, OR = 0.854), where for every point higher on the PDDS scale, individuals were 14.6% less likely to meet MS aerobic exercise guidelines met the significance threshold of $p < 0.1$). Model 3 (R2 = .12) saw the addition of reflective processes to the model. Perceived opportunity was the only significant predictor of action control in the model ($p = .034$, OR = 1.147; 14.7% increased likelihood to realize intentions for every one-point increase), with higher perceived opportunity predicting the greater likelihood of meeting MS aerobic exercise guidelines. Model 4 (R2 = .14) added regulatory processes. Behavioral regulation was the only significant M-PAC process, ($p = .008$, OR = 1.027, 2.7% increased likelihood to realize intentions for every one-point increase). Additionally, PDDS reemerged as a significant predictor in this model ($p = .035$, OR = .856; 14.4% decreased likelihood to realize intentions for every one-point increase). Model 5 represents the final model, and includes demographic variables (age, gender), clinical variables (PDDS, comorbidities), reflective, regulatory, and reflexive processes. Model 5 saw PDDS remain a significant predictor of action control ($p = .035$, OR = 0.853; 14.7% decreased likelihood to realize intentions for every one-point increase). Identity emerged as the sole M-PAC process predictive of action control ($p = .005$, OR = 1.138)

4.6 Sensitivity Analysis

To conduct a sensitivity analysis, a recoding of successful behavior was assigned to a 20-minute threshold per session instead of 30 minutes to ensure the analysis captures true intention-behavior discordance rather than imposing overly strict adherence criteria. This recode created an additional 48 successful intenders, bringing the total count to 237 successful intenders (73.6%) and 85 unsuccessful intenders (26.4%). Age consistently emerged as a significant predictor of action control across models 1-3 (Model 1: $p = .012$, OR = .979; Model 2: $p = .012$, OR = .977; Model 3: $p = .014$, OR = .976). This is distinct from the primary analysis, where age did not emerge as a predictor in any of the models. Perceived capability was a stronger predictor in the sensitivity group, demonstrating increased significance in Model 3 ($p < .001$, OR = 1.286; 28.6% increased likelihood to realize intentions for every one-point increase) and emerging as a significant predictor in Model 4 ($p = .003$, OR = 1.256; 25.6% increased likelihood to realize intentions for every one-point increase).

Model 5 in the sensitivity analysis confirmed identity and PDDS as the two predictors of action control, with no additional predictors identified. However, the sensitivity analysis did reveal a substantial increase in explanatory power across all five models, with Model 5 demonstrating improved fit ($R^2 = .33$) compared to the primary analysis ($R^2 = .21$).

Variable	Model 1 OR (95% CI)	p	Model 2 OR (95% CI)	p	Model 3 OR (95% CI)	p	Model 4 OR (95% CI)	p	Model 5 OR (95% CI)	p
Intention Formation (non-intenders[a] vs intenders)										
General Demographics										
Age	0.954 (0.937 – 0.972)	.001	0.964 (0.945 – 0.982)	.001	0.966 (0.941 – 0.992)	.011	-		-	
Gender (Female[a] vs Male)	1.875 (0.966 – 3.639)	.063	1.881 (0.925 – 3.822)	.081	1.110 (0.442 – 2.788)	.824	-		-	
Clinical Demographics										
MS Type (RR[a])										
Secondary Progressive	-		0.807 (0.299 – 2.178)	.672	0.728 (0.189 – 2.799)	.644	-		-	
Primary Progressive	-		1.942 (0.794 – 4.751)	.146	0.470 (0.140 – 1.579)	.222	-		-	
Progressive Relapsing	-		4.286 (0.452 – 40.62)	.205	1.100 (0.055 – 28.44)	.886	-		-	
Comorbidities (Yes, No[a])	-		0.575 (0.319 – 1.034)	.065	1.052 (0.486 – 2.278)	.897	-		-	
PDDS	-		0.796 (0.683 – 0.929)	.004	1.050 (0.829 – 1.332)	.685	-		-	
Reflective Processes										
Instrumental Attitudes	-		-		1.042 (0.902 – 1.202)	.578	-		-	
Affective Judgements	-		-		1.203 (1.099 – 1.317)	.001	-		-	
Perceived Capability	-		-		1.235 (1.083 – 1.408)	.002	-		-	
Perceived Opportunity	-		-		1.258 (1.024 – 1.544)	.029	-		-	
Model Fit	$R^2 = 0.16$; $\chi^2 = 41.2$, AIC = 190.614, $p < .001$		$R^2 = 0.23$; $\chi^2 = 60.0$, AIC = 326.242, $p < .001$		$R^2 = 0.58$; $\chi^2 = 173.317$, AIC = 232.785, $p < .001$					
Action Control (Unsuccessful[a] vs. Successful)										
General Demographics										
Age	0.989 (0.973 – 1.004)	.151	0.991 (0.975 – 1.007)	.257	0.990 (0.974 – 1.007)	.258	0.992 (0.974 – 1.010)	.373	0.995 (0.977 – 1.014)	.633
Gender (Female[a] vs Male)	1.400 (0.866 – 2.264)	.170	1.439 (0.875 – 2.366)	.151	1.307 (0.775 – 2.203)	.315	1.208 (0.707 – 2.062)	.490	1.186 (0.684 – 2.054)	.544
Clinical Demographics										
Comorbidities (Yes, No[a])	-		0.968 (0.594 – 1.578)	.897	0.901 (0.624 – 1.709)	.901	1.045 (0.620 – 1.759)	.620	1.054 (0.616 – 1.802)	.848
PDDS	-		0.854 (0.746 – 0.978)	.022	0.886 (0.770 – 1.019)	.089	0.855 (0.740 – 0.989)	.035	0.849 (0.730 – 0.986)	.032
Reflective Processes										
Instrumental Attitudes	-		-		1.022 (0.903 – 1.156)	.733	1.022 (0.899 – 1.162)	.738	1.067 (0.932 – 1.220)	.349
Affective Judgements	-		-		1.019 (0.944 – 1.101)	.626	0.971 (0.890 – 1.059)	.502	0.932 (0.848 – 1.024)	.145
Perceived Capability	-		-		1.147 (1.011 – 1.301)	.034	1.125 (0.986 – 1.284)	.079	1.061 (0.925 – 1.218)	.396
Perceived Opportunity	-		-		1.033 (0.869 – 1.227)	.716	0.993 (0.831 – 1.186)	.993	0.997 (0.830 – 1.197)	.974
Regulatory Processes										
Proactive Regulation	-		-		-		1.067 (1.011 – 1.125)	.017	1.053 (0.996 – 1.113)	.068
Reactive Regulation	-		-		-		1.076 (1.010 – 1.147)	.024	1.022 (0.949 – 1.101)	.562
Social-Monitoring	-		-		-		0.995 (0.932 – 1.062)	.877	0.990 (0.925 – 1.059)	.767
Self-Monitoring	-		-		-		0.965 (0.902 – 1.032)	.297	0.957 (0.891 – 1.028)	.229
Reflexive Processes										
Identity	-		-		-		-		1.140 (1.042 – 1.248)	.004
Habit	-		-		-		-		1.024 (0.963 – 1.088)	.454
Model Fit	$R^2 = 0.02$; $\chi^2 = 5.8$, AIC = 221.317, $p = .056$		$R^2 = 0.06$; $\chi^2 = 15.7$, AIC = 382.79, $p = .008$		$R^2 = 0.12$; $\chi^2 = 26.8$, AIC = 423.834, $p < .001$		$R^2 = 0.17$; $\chi^2 = 42.2$, AIC = 422.435, $p < .001$		$R^2 = 0.23$; $\chi^2 = 56.0$, AIC = 409.617, $p < .001$	

[a] Denotes reference category; '-' indicates variable is not included within model; Italics indicate variable subgroupings

Table 6 - Multinomial Logistic Regression

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Chapter 5 – Discussion

Given the established presence of the intention-behavior gap in PwMS regarding exercise participation, the purpose of this study was to examine and identify which M-PAC processes, along with general and clinical covariates, were most predictive of group classification for intenders vs non-intenders and successful vs unsuccessful intenders. It was hypothesized that of the four action control profiles, SI, USI, and SNI would be the three profiles to emerge. Study findings aligned with this hypothesis. The second hypothesis was that PDDS, perceived capability, and affective judgments would be significant predictors of intention formation. Study findings partially supported this hypothesis, as it was not predicted that perceived opportunity would be a significant predictor. The third hypothesis was that exercise identity would be a significant predictor of action control. Study findings partially support this hypothesis, because it was unexpected that PDDS would also emerge as a significant predictor of action control.

5.1 Summary of Primary and Sensitivity Analysis Findings

The primary analyses revealed distinct factors influencing both the formation of exercise intentions and the translation of those intentions into behavior (action control). In terms of intention formation, older age, and greater disability were key impediments. Each additional year of age reduced the odds of intending to meet aerobic exercise guidelines by 3.4% in the final model. Notably in model 2, PDDS was a significant predictor in intention formation, with each additional level of disability reducing odds of intention formation by 20.4%. However, following the addition of reflective processes, age became the only significant covariate along with three reflective processes—affective judgments (i.e., feelings towards aerobic exercise), perceived capability (i.e., self-efficacy separate from motivation towards aerobic exercise), and perceived opportunity (the sense of having time, resources, and a conducive environment to facilitate exercise) emerged as significant positive predictors of intention. These findings partially align with hypothesis 2a. PDDS was initially hypothesized to be a significant predictor of intention formation, due to the overwhelming body of literature suggestive of higher PDDS scores indicating a sharp decline in exercise participation and a gradual decline in aerobic capacity (Klaren et al., 2013; Klaren, Sandroff, et al., 2016). However, PDDS was not significant in the final model of intention formation. On the other hand, the action control model saw PDDS and exercise identity emerge as significant predictors of meeting aerobic exercise guidelines. These findings align with hypothesis 2b, however, PDDS was not initially expected to be a predictor of action control, as exercise identity was anticipated to overtake general demographics and clinical variables.

5.2 Research Question 1: Action Control Profiles

This study confirmed the prevalence of an intention-behavior gap in PwMS, with action control profiles mirroring those in other populations (R. E. Rhodes & Lim, 2016; Tabaczynski et al., 2023; Vallerand et al., 2017). Although most participants intended to engage in aerobic exercise, 42% failed to act on those intentions, comparable to the 40-50% intention-behavior gap reported among other clinical populations such as cancer survivors (Tabaczynski et al., 2023; Vallerand et al., 2016b, 2016a). However, other studies have reported lower intention-behavior gaps in populations such as those with fibromyalgia and the youth population (Haider et al., 2024; Pastor-Mira et al., 2020). The hypothesis that three profiles would emerge, with the SNI group being too minimal to evaluate was supported. The scarcity of the SNI group likely reflects the necessity of intentions to initiate structured aerobic exercise training. Unlike incidental PA, which arises as a byproduct of daily routines (e.g., walking for transportation, household chores), structured aerobic exercise requires deliberate planning, effort, and commitment. For PwMS, barriers such as fatigue, mobility impairments, and additional symptoms (Moffat & Paul, 2019;

Ploughman, 2017), further reduce the likelihood of meeting MS aerobic guidelines without the explicit intention of doing so. This is consistent with qualitative data from other populations such as those with type 2 diabetes, where intention formation often required a triggering health event, where subsequent environmental cues and regulatory strategies were essential for intention translation (Blicher-Hansen et al., 2024).

5.3 Research Question 2: Predictors of Exercise Intentions

In examining the factors that contribute to aerobic exercise intention, three M-PAC constructs stood out as significant positive predictors of intention: affective judgment, perceived capability, and perceived opportunity. Participants with heightened levels of these three processes were far more likely to intend to engage in regular aerobic exercise. This result is consistent with social-cognitive theories applied to general PA and exercise behavior, in which attitudes and perceived behavioral control drive intentions to act (Rebar & Rhodes, 2020; R. E. Rhodes et al., 2019). A recent application of M-PAC in cancer survivors found a similar pattern, where affective attitudes and perceived capability were the strongest predictors of exercise intentions (Tabaczynski et al., 2023). These patterns also appear across other chronic disease groups, where reflective constructs consistently guide intention formation (Blicher-Hansen et al., 2024). This study extends the literature to PwMS, strengthening the evidence that intention formation is consistently guided by reflective processes across various clinical profiles.

Affective judgment was the strongest predictor of whether PwMS formed intentions to be active. This aligns with growing evidence that how people feel about exercise is often more influential than their cognitive assessment of its benefit (R. E. Rhodes, Gray, et al., 2019). While many PwMS may understand that aerobic exercise is beneficial, those with negative emotional associations (e.g., fear of pain, discomfort, fatigue) are significantly less likely to intend to exercise. In the M-PAC literature, affective judgments have been one of the most consistent predictors of intention across various populations (R. E. Rhodes et al., 2020; Tabaczynski et al., 2023). These findings further support the body of evidence that programs should foster positive emotional experiences for PwMS to promote adherence (Akbar et al., 2022; Straudi et al., 2014). This is an area where much of the existing MS exercise research is already focused, as existing interventions frequently incorporate social exercise settings (Adamson et al., 2023), music-enhanced workouts (Fasching et al., 2024), or gamified exercise (i.e., exergaming; Elhusein et al., 2024) to enhance enjoyment and motivation. However, while these approaches have demonstrated effectiveness, affective judgments alone are not enough to support the long-term maintenance of aerobic exercise.

Notably, Instrumental attitudes were a non-significant predictor of intention formation. This aligns with the current MS literature emphasizing that information provision is insufficient for enacting behavior change or increasing intentions in PwMS (Schüler et al., 2019). This finding is supported by parallel results in other clinical and general populations, where informational knowledge of benefits was nearly universal but failed to distinguish between intenders and non-intenders (R. E. Rhodes et al., 2020; Tabaczynski et al., 2023). PwMS are already highly aware of the health benefits of exercise. However, given the emotional and physical burden aerobic exercise can have on PwMS in the short term (e.g., thermoregulation), targeting affective judgments may be more effective.

Perceived capability emerged as a key predictor of intention formation in this study. While self-efficacy is critical for initiating health behaviors (Bandura, 1993), traditional measures often conflate capability with motivation, making it unclear whether individuals intend to exercise due to belief in their ability or motivation to act (Williams & Rhodes, 2016). Perceived capability distinguishes self-efficacy from motivation. Notably, this study's findings suggest that perceived capability may be more influential than actual physical ability in determining intention. While higher PDDS scores were initially associated with lower intentions, this effect became non-significant when perceived capability was accounted for, indicating that one's belief in their abilities is more influential on intention formation than objective physical limitations. These findings are corroborated by articles such as (Learmonth & Motl, 2016), who found concepts such as lost control, anxiety, or feelings of inadequacy were major perceived consequences of exercise engagement. Similarly, across several studies, perceived capability and perceived behavioral control were consistently among the strongest reflective predictors of intention formation (R. E. Rhodes et al., 2020; Tabaczynski et al., 2023; Vallerand et al., 2016b).

Perceived opportunity emerged as a predictor variable for intention formation, which was not hypothesized. Perceived opportunity lies within the category of "ongoing reflective processes" (R. E. Rhodes, 2021). The concept of ongoing reflective processes recognizes perceived opportunity as a variable that can shift from day to day for an individual. In other words, environmental, psychological, or physical factors may impact one's perceived opportunity to engage in exercise (i.e., bad weather). In the context of MS, PwMS often struggle with varying levels of disability throughout their disease progression. Clinical events such as relapses, falls, and nocioplastic pain are all relevant symptoms that may affect one's perceived opportunity to engage in regular aerobic exercise (Abou et al., 2024; Coote et al., 2020). For example, an individual who experiences significant tingling in their lower extremities or has recently experienced a fall, may not partake in their evening treadmill walk out of fear of injury.

PwMS who perceive adequate opportunities for exercise are more likely to intend to exercise (Kayes et al., 2011). This makes intuitive sense given the nature of MS, where environmental and resource barriers are frequent for this population (Kayes et al., 2011; Learmonth et al., 2015; Learmonth & Motl, 2016). For example, a qualitative study by Learmonth & Motl (2016) identified that the most reported barriers to exercise for PwMS were environmental limitations, such as a lack of accessible facilities, inadequate guidance or supervision, and difficulty finding appropriate exercise programs. Additional qualitative studies also revealed the need to promote opportunities for exercise for PwMS with higher disability levels (Learmonth et al., 2015). Considering the current MS sample included younger, less disabled PwMS early in the disease course who were more likely to intend to exercise further supports the notion that perceived capability is a vital component of exercise intention. Older PwMS who have progressed further into the disease course may feel that current exercise opportunities within the community are not readily available for them and their condition and that MS healthcare providers should play a role in promoting these opportunities (Learmonth et al., 2015). Environmental limitations may include a lack of accessible facilities, inadequate guidance or supervision by trainers, and difficulty finding appropriate exercise programs that can be adapted to their needs and capabilities. These additional hurdles can compound in PwMS due to symptomatic barriers, dampening the resolve to be active. If PwMS believe there is no convenient or safe place to exercise (or no available time or energy due to fatigue), it is unlikely they will form an intention to work out.

A particularly notable finding in this study was that age emerged as a significant predictor of intention formation, while PDDS did not in the final model. Given that PDDS is a widely used indicator of disease severity and impairment in PwMS, it would be expected to play a role in intention formation. This finding partially aligns with prior research indicating that aging is often associated with reduced participation in PA and exercise for PwMS (Klaren et al., 2013), however, limited evidence is available on actual reported intentions. While younger PwMS may view exercise as a modifiable and more proactive health behavior, older PwMS may potentially be more likely to associate it with past experiences of physical decline or fear of exacerbating already progressed symptoms.

Older PwMS may experience reduced exercise intentions due to psychological and environmental factors rather than physical disability alone. Factors such as lower perceived capability, limited opportunities, and psychological barriers like fear of falling or feeling "too old" to exercise can contribute to decreased intentions (Matsuda et al., 2011). Additionally, older PwMS may have had fewer exercise opportunities earlier in their disease course, as structured exercise recommendations for MS have only gained widespread traction in recent decades (. This could indicate a lack of regular exercise history among older PwMS and reduced confidence in initiating and maintaining exercise routines.

5.4 Research question 3: Predictors of action control

5.4.1 Exercise Identity

Findings from this study align with evidence suggesting exercise identity significantly predicts exercise participation, with this study applying that evidence to PwMS. A meta-analysis of 32 studies reports a robust association (r = 0.44) between PA identity and behavior (R. E. Rhodes, Kaushal, et al., 2016). Theoretically, identity serves as an internalized self-regulatory standard, where individuals experience psychological discomfort when actions deviate from their sense of self (Strachan et al., 2011). Within the M-PAC framework, identity is conceptualized as a reflexive process emerging through sustained behavioral regulation. Our results are consistent with this perspective, showing that a stronger endorsement of exercise identity among PwMS was associated with greater self-reported engagement in aerobic exercise. This association supports the theoretical proposition that identity may contribute to intention-behavior translation (R. E. Rhodes, 2021). This aligns closely with findings from (Tabaczynski et al., 2023), who observed that among cancer survivors, exercise identity emerged as the sole significant psychological predictor of behavior in their full M-PAC model, surpassing self-regulation and reflective processes. Similarly, in (Blicher-Hansen et al., 2024), identity formation was a defining characteristic of long-term PA maintainers in type 2 diabetics, where having an exercise-enabling identity enabled behavioral maintenance during illness flare-ups and low motivation days. These findings suggest that identity may operate as a reflexive anchor that can support behavior even when external circumstances can impact other processes (e.g., habit).

Given that interventions explicitly targeting identity development typically yield superior outcomes compared to traditional behavior-change techniques alone (R. E. Rhodes et al., 2025), integrating identity-focused BCTs into interventions appears to be potentially promising for promoting long-term adherence in the MS population. This approach is particularly relevant for PwMS who may initially prioritize their illness identity (i.e., "a person with MS"), potentially hindering the development of an exercise identity and reducing motivation (Russell et al., 2023). Identity-focused interventions could facilitate sustained behavior change by fostering an exerciser self-concept that can coexist with, rather than conflict against an individual's MS identity.

5.4.2 PDDS, Age, and Exercise Behavior: The Impact of Disability

Another emerging pattern included the consistent role of disease severity assessed via PDDS in both the early stages of intention formation models and the final models for action control. PDDS measures disability primarily through mobility impairment, and findings suggest that mobility impairment not only suppresses initial motivation to engage in exercise but also disrupts the execution of exercise plans, even among motivated individuals. Each one-point increase in PDDS corresponded with an approximate 20% decrease in the likelihood of forming exercise intentions. This finding aligns with known MS-specific barriers, indicating that greater impairment diminishes an individual's confidence and motivation to plan exercise, reflecting a pervasive impact across both intentional and behavioral stages. Consistent with previous research, increased disability has been associated with significantly lower moderate-to-vigorous physical activity (MVPA) participation. For instance, (Klaren et al., 2013) found substantial reductions in MVPA among PwMS relying on assistive devices, with effect sizes of d = 0.74 for unilateral support and d = 1.0 for bilateral support.

Observations by Klaren et al. (2013) were reinforced in our later action control models, where PDDS was a consistently influential factor in models 2, 4, and 5. Among PwMS who did form an exercise intention, higher disability made it markedly less likely that they followed through and met the exercise target. In model 2, PDDS was a significant independent predictor, where each PDDS point was associated with approximately 15% lower odds of an individual achieving the desired exercise frequency throughout all prevalent models. To put this into perspective, an individual with gait instability (PDDS = 3) was ~45% less likely to realize their intentions, compared to an individual with a reported PDDS of 0, even if they both stated an intention to engage in exercise.

This is consistent among broader M-PAC literature, where physical constraints such as post-treatment fatigue or cardiovascular limitations emerged as persistent behavioral barriers (Blicher-Hansen et al., 2024; Vallerand et al., 2017), even after accounting for motivation and planning. PDDS remained a significant predictor across multiple hierarchical models—persisting even after the addition of reflective, regulatory, or reflexive processes—suggesting that disability exerts a constant effect not fully mitigated by M-PAC constructs. Consequently, it is unlikely that BCTs by themselves can overcome the physical barriers preventing exercise participation in this population. Exercise interventions and health promotion strategies for PwMS should account for everyone's functional capacity, ensuring that aerobic exercise is adapted to their physical limitations.

It is important to acknowledge the moderate correlation between age and PDDS. ($r = 0.28$; Learmonth et al. 2013). In this study, each additional year of age reduced the likelihood of developing an exercise intention by 3.4%. To put this in perspective, if you take a 35-year-old PwMS, and a 65-year-old PwMS, the odds ratios present predict that the 35-year-old is approximately 2.86 times more likely to engage in exercise than the 65-year-old (1/0.966 = 1.0352, 1.035230 ≈ 2.82). However, age was not a significant predictor in the primary analysis for action control (2x weekly, 30 minutes per session), but was in the more lenient sensitivity analysis (2x weekly, 20 minutes per session). Age emerged as a significant predictor in models 1-3, indicating older PwMS faced initial barriers in establishing exercise routines. This suggests age-related differences primarily affect the early stages of adopting exercise behaviors but become less influential once regular, longer-duration exercise is established. In other chronic disease samples, similar age effects were observed: older adults reported weaker intentions and more difficulties initiating PA (Vallerand et al., 2016b), potentially due to psychological barriers and reduced prior exposure to structured exercise. Interventions such as a feasibility trial by (Cox & Rhodes, 2020) have begun implementing M-PAC-based content for later-life transitions, teaching behavioral strategies aligned with M-PAC to those who have more unstructured time post-retirement. While similar age patterns exist in other populations (Romero et al., 2018), differences in symptom profiles (pain, fatigue, psychological distress) may limit direct applicability to PwMS, warranting further investigation into targeted strategies for older MS patients.

5.4.3 Behavioral Regulation and the Transition to Identity-Driven Action

An important observation from the hierarchical models was the shifting influence of behavioral regulation relative to exercise identity in Models 4 and 5. Behavioral regulation in this context refers to the regulatory processes stage of the M-PAC framework and incorporates self-regulatory efforts and strategies (e.g., goal setting, action planning, etc.) that individuals utilize in the initial stages of exercise adoption. In model 4, it was found that higher behavioral regulation was associated with greater odds of executing one's exercise intentions, which is consistent with the vast literature showing that planning and self-monitoring are essential components of behavior change for PwMS (Silveira et al., 2021) and people in general in regards to PA and exercise (R. E. Rhodes, 2021). Behavioral regulation was a significant predictor of successful behavior specifically in its introductory model. This suggests that participants who engaged in more deliberate behavioral strategies – for example, making a when, where, what, and how plan for their aerobic exercise, tracking their workouts, having accountability partners, etc. – were more likely to meet their exercise goals. These findings align well with action control theories such as the health action process approach, which emphasizes that these techniques serve as a means to help bridge the gap between intent and behavior (Schwarzer, 2016). Implementing strategies such as creating concrete plans and monitoring progress may help PwMS mitigate forgetfulness, low motivation, or other common lapses that can prevent intentions from being realized.

However, our final model, which added reflexive components, mitigated the relevance of behavioral regulation of action control, and exercise identity emerged as the sole psychological predictor of aerobic exercise behavior. Essentially, once we accounted for how strongly someone identified with exercise, their self-regulatory efforts no longer uniquely explained who succeeded in being active. This transition is best understood within the M-PAC framework's developmental structure. M-PAC posits that regulatory processes are especially influential during the action initiation phase when exercise identities are not yet developed and individuals are still learning how to integrate behavior into their daily lives (R. E. Rhodes, 2017). This suggests that when exercise aligns with one's self-identity (or MS identity), sustaining aerobic exercise in PwMS may shift from relying on strategies and regulatory efforts to becoming an automatic behavior. In this context, the findings suggest a temporal shift consistent with M-PAC's progression from action to maintenance. Behavioral regulation may serve as an essential scaffold early in behavior initiation, but over time, as exercise becomes identity-congruent, aerobic exercise requires less effortful regulation. Thus, our data may capture a cross-sectional snapshot of this developmental arc.

5.5 Practical significance

Findings from this study highlight the importance of integrating behavioral regulation in exercise research for PwMS while offering the insight that fostering exercise identity for long-term adherence would be beneficial. The results reinforce the value of the M-PAC framework as an extension of traditional social cognitive models, which assume intention translates directly into behavior. The progression between reflective, regulatory, and reflexive processes might be particularly critical for PwMS, given the challenges and symptoms imposed by the disease. Higher disability levels may necessitate a stronger exercise identity to sustain engagement, whereas those with minimal disability might rely more on planning. By recognizing where PwMS are at in their developmental stage and identifying their current and/or developing associations with exercise, researchers and practitioners can ensure that they provide not only the right type of support but at the right time in the patient's development as well.

5.6 Clinical and Practical Implications

This study lays the initial groundwork for providing actionable insights for clinicians, rehabilitation specialists, and researchers seeking to improve exercise adherence in PwMS. Simply educating patients or urging effort is insufficient. Given the frequent usage of BCTs in behavioral PA and exercise, identifying which BCTs are associated with M-PAC processes and are effective in the MS population could potentially lead to the development of future interventions. MS interventions typically underutilize BCTs associated with regulatory and reflexive processes (R. E. Rhodes, 2017; Silveira et al., 2021), which are essential for translating intention into action. Findings suggest future interventions should emphasize these constructs, particularly for PwMS with strong intentions. Regarding intention formation, BCTs should target reflective constructs, and findings from this study suggest that perceived capability, perceived opportunity, and affective judgments may be the most effective for PwMS. Constructs targeting perceived capability are most commonly utilized in MS literature, including Instructions on how to perform a behavior [5.1], Demonstration of a behavior [6.1], and Graded tasks [8.7] (R. E. Rhodes, 2017; Silveira et al., 2021). While affective judgments and perceived opportunity are frequently targeted in MS behavior studies such as social support (practical) [3.2] and adding objects to the environment [12.5] other BCTs associated with these constructs are less utilized including social support (emotional) [3.3], information about emotional consequences [5.6], or restructuring the physical or social environment [12.1, 12.2].

Regarding those who have already expressed intentions to exercise but have failed to translate these intentions, our findings suggest that targeting both regulatory and reflexive processes through BCTs may provide utility. Goal setting [1.1] and self-monitoring of behavior [2.3] are the most commonly applied BCTs associated with regulatory processes in MS literature

(R. E. Rhodes, 2017; Silveira et al., 2021). However, a wide array of regulatory processes are underutilized, including behavioral contracts [1.8] biofeedback [2.6], self-incentive [10.7], reducing negative emotions [11.2], and self-talk [15.4]. Regarding reflective processes, these processes are rarely targeted in MS literature, with Behavioral practice [8.1], Adding objects to the environment [12.5], and social comparison [6.2] being semi-frequently incorporated in MS literature (Silveira et al., 2021). However, when assessing strictly identity-based BCTs characterized by Michie et al. (2013), BCTs such as Framing/reframing [13.2], Incompatible beliefs [13.3], Valued self-identity [13.4], and identity associated with changed behavior [13.5] were rarely or not at all utilized in MS exercise behavior studies (Silveira et al., 2021). These strategies may be particularly effective in behavior change interventions focused on the long-term adoption/maintenance of aerobic exercise.

Finally, future studies could benefit from seeking to understand when and for whom behavioral regulation or identity-focused BCTs are most effective. An approach could involve stratifying participants at baseline by assessing intentions and behaviors and evaluating progression through the M-PAC stages over time (reflective, regulatory, reflexive). Longitudinal designs could track changes in M-PAC constructs across multiple time points. Combining this will adaptive methods such as SMART would allow researchers to reassign BCTs based on individual response patterns, enabling investigation into whether reflexive processes could be effective if targeted earlier in the adoption phase. This approach would allow for precision in tailoring interventions to each PwMS.

Ultimately, our findings highlight those tailoring interventions based on an individual's stage within the action control continuum is ideal. For individuals with low intention, reflective BCTs should be prioritized, focusing on enhancing affective attitudes and perceived

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opportunity/capability. For individuals with high intention but low follow-through, regulatory strategies can provide structured support for behavior enactment, while simultaneously targeting reflexive processes such as identity to potentially aid in sustaining long-term adherence.

5.7 Future Research

For future research, several key areas warrant exploration to further understand and bridge the exercise intention-behavior gap in PwMS. First, while the current study identified exercise identity as a crucial predictor of meeting MS aerobic exercise guidelines, BCTs that target reflexive processes (e.g., identity development) are not commonly employed in MS studies (R. E. Rhodes, 2017; Silveira et al., 2021). Existing interventions primarily emphasize reflective constructs and, to a lesser extent, regulatory strategies (Silveira et al., 2021). Future studies should investigate integrating identity-based BCTs to enhance long-term adherence to exercise programs in PwMS. Furthermore, while exercise identity is a key predictor of adherence, simply applying all identity-focused BCTs may not be an effective approach. Instead, studies should evaluate which specific BCTs best work together in fostering long-term adherence. Studies can utilize experimental designs such as the multiphase optimization strategy (MOST) or sequential multiple assignment randomized trials (SMART) as promising methodological approaches to testing BCTs (Collins et al., 2007). The MOST framework allows researchers to systematically screen and optimize BCT components through factorial experiments, identifying which specific techniques or combinations contribute most to behavior change. Similarly, SMART designs enable the development of adaptive interventions by reassigning participants based on their behavioral responses over time, providing a flexible way to test whether reflexive-based BCTs are more or less effective following failure or regulatory strategies. These strategies could provide benefits to a more appropriate selection of BCTs when developing future interventions. By identifying the most impactful combinations, interventions can be more efficient, ensuring PwMS receive the necessary support for fostering exercise identity development.

Second, the role of PDDS and age on exercise intentions and action control suggested that age was a predictor of intention formation, but not action control in the primary analysis. Disability, however, remained a predictor throughout both models. Given the paradigm shift in exercise promotion for PwMS over the last 20 years, a potential avenue for future research could investigate the role of age, as well as disease duration, to identify whether diagnosis before widespread adoption of exercise promotion in PwMS has made a significant impact on the perception of aerobic exercise in the older MS population. Additionally, the interplay of PDDS and M-PAC processes could play a part in intention formation and subsequent behavior. Future research should examine how disability levels interact with M-PAC processes. For example, does perceived capability play a stronger role in intention formation for those with higher PDDS scores?

5.8 Strengths and Considerations

This study has several strengths and limitations for consideration. This study was the first to attempt to quantify the intention-behavior gap toward aerobic exercise adherence within the MS population, as well as the intention-behavior gap toward PA. By systematically evaluating the M-PAC processes, the study provided a nuanced understanding of the psychological and behavioral mechanisms underlying aerobic exercise intention and behavior in this population. Secondly, the study’s comprehensive approach to classifying PwMS into distinct action control profiles offers valuable insights for informing future intervention design and identifying strategies and techniques for promoting aerobic exercise to PwMS based upon their current perceptions and behavior towards aerobic exercise. The inclusion of the sensitivity analysis strengthens the integrity of the MLR analysis of action control by demonstrating consistency across different adherence thresholds (20 vs. 30-minute exercise sessions). Despite these positive strengths of the intervention, a few limitations are still prevalent. First, given the cross-sectional design of this study, the findings are based upon correlational inferences, as opposed to causal. Future longitudinal studies would open up the opportunity to assess whether key changes in processes (i.e., perceived capability, exercise identity) lead to the development or loss of long-term exercise habits. Additionally, recruitment occurred during the winter season, which may have influenced exercise behavior due to seasonal variation. Notably, a significant snowstorm affected Kansas during this period, potentially reducing exercise participation among Stormont Vail respondents. Geographical location also was not accounted for in responses collected via Prolific or social media, limiting the ability to contextualize seasonal effects across regions. We also did not account for site variance by including the recruitment site as a covariate, limiting the ability to detect contextual influences between recruitment sources. There is also the possibility of potential self-reporting and sampling bias. Non-probability convenience sampling was employed, potentially explaining the high frequency of exercisers in the sample compared to the expected average of 20 percent. Action control profiles were generated based on self-reported intentions and behaviors. While a validated measure (GLTEQ) was utilized for data collection, self-reporting is subject to recall bias and social desirability. Objective tracking of aerobic exercise (e.g., accelerometer + exercise diary) to validate self-reported adherence would enhance the validity of action control profiles. In regards to congruence between measures, the measure for intention only assessed exercise frequency and duration, without explicitly addressing intensity, potentially causing incongruence between behavior and intention measures. However, participants were informed of the complete MS aerobic exercise training guidelines—including intensity—before answering the intention item in a separate prompt. This procedural detail likely helped mitigate some of the incongruence, but the lack of direct intensity measurement within the intention item remains a limitation. Additionally, instrumental attitudes should be interpreted with caution, due to the high skewness and kurtosis reported. However, this was partially expected, as the literature suggests PwMS have high levels of instrumental attitudes towards exercise due to heightened health awareness (Casey et al., 2017). Furthermore, while the perceived behavioral control (PBC) measure aimed to capture both perceived capability and opportunity, its implementation without the accompanying contextual vignettes may have limited its sensitivity to situational constraints, possibly attenuating construct validity. Additionally, while the study did recruit participants from multiple sources to enhance diversity and increase sample size, each recruitment method did introduce potential biases. Participants from Prolific tended to be younger and intended to / did engage in aerobic exercise more regularly. Conversely, those recruited from Stormont Vail were generally older with greater disability levels, which may have contributed to lower reported intentions and adherence rates. This may limit the generalizability of these findings, primarily to PwMS with higher disability levels. Another limitation includes the exclusion of MS-specific symptoms such as fatigue, muscle spasticity, and other commonly reported symptoms that play a role in exercise participation. These symptom-level variables were not included due to the study's predefined analytic scope and the need to limit model complexity. Additionally, PDDS was identified as a suitable indicator of functional disability for PwMS, however, it does not fully capture the multidimensional nature of symptomatic burden. Future research should incorporate detailed symptom profiles to more comprehensively assess aerobic exercise intention and subsequent action control via MS-validated symptom measures including the Modified Fatigue Impact Scale, MOS Pain Effects Scale, or the MS Spasticity Scale. Additionally, age was modeled linearly, which may have limited detection of non-linear relationships with exercise behavior.

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Future studies should explore non-linear modeling approaches (e.g., quadratic) to test for curvilinear effects. Finally, while the study's operationalization of exercise adherence was based on aerobic exercise, the omission of alternative modalities (e.g., resistance training) is a limitation. While aerobic exercise is currently the most emphasized modality in MS research given its well-documented benefits, other modalities also play a key role in managing symptoms and mobility. Further exploration of whether the same demographic factors or M-PAC processes influence adherence across different exercise training modalities should be considered.

5.9 Conclusions

Despite the well-documented benefits of aerobic exercise for PwMS, nearly half of those who intend to exercise fail to follow through. This study identifies key demographics and psychological processes that impact the intention-behavior gap via the M-PAC framework. While affective judgments, perceived capability, and perceived opportunity drive intention formation, sustained aerobic exercise hinges primarily on exercise identity. To bridge this gap, future interventions should consider integrating identity-based BCTs to support long-term adherence. Additionally, given that PDDS remained a significant barrier among even those with strong intentions, exercise programs must be adaptable and accessible. By strategically incorporating identity-based strategies alongside existing SCT-based approaches, researchers and clinicians can potentially enhance exercise participation in PwMS, ultimately improving health outcomes and quality of life.

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Appendix A – Survey

Multiple Sclerosis - Intention & Behavior to participate in regular exercise - Stormont Vail Final

Survey Flow

Standard: Informed Consent (1 Question)
Standard: Demographics - 6 items (6 Questions)
Standard: Aerobic Exercise Primer (1 Question)
Standard: M-GLTEQ - 7 items (8 Questions)
Standard: Aerobic Exercise Identity - Reflex - 3 items (Wilson & Muon 2011) (5 Questions)
Standard: Aerobic ExHabit-Reflex - 4 items (Gardner et al., 2012) (5 Questions)
Standard: Aerobic Exercise - Intention - Intended - dichotomous - 1 item (Courneya, 1994) (1 Question)
Standard: Aerobic Exercise Behavioral Regulation - 14 items (Rhodes et al., 2023) (15 Questions)
Standard: Aerobic AJ/IA (Ajzen, 2006) About Exercise (Emerson et al., 2021) - 6 item (7 Questions)
Standard: Aerobic Perceived Capability & Opportunity 7 item Exercise - (Lithopoulos 2023) (8 Questions)
Standard: Debrief (2 Questions)

Page Break

Start of Block: Informed Consent

InformedConsent You are invited to participate in a research study titled "Possible Determinants of the Intention-Behavior Gap Towards Aerobic Exercise Participation in Persons with Multiple Sclerosis". This study is being conducted by **master's student Andrew Argie and Dr. Gina Besenyi** from the Department of Kinesiology at Kansas State University. The purpose of this research study is to assess current aerobic exercise behaviors in individuals living with Multiple Sclerosis (MS), and to explore regulatory, reflexive, and reflective behaviors related to exercise. This project aims to inform clinicians and researchers on the most prevalent differences in exercise perceptions between individuals who do and do not regularly participate. Outcomes of this study will potentially guide clinicians on effective methods for integrating exercise into MS healthcare, adapted to the unique needs and capabilities of individuals with distinct experiences or perceptions towards exercise. If you agree to take part in this study, you will be asked to complete an online survey/questionnaire. This survey will assess your behaviors, intentions, and perceptions of aerobic exercise as an individual with MS in order to categorize respondents into specified groups. The survey will focus on reflective, regulatory, and reflexive processes to identify distinguishable differences between groups. **The survey will take approximately 15 minutes to complete.** By consenting to participate, you confirm that you meet the inclusion criteria for this study, which include: 1) being at least 18 years of age, 2) having an MS diagnosis, 3) Being able to read and write English, 4) You are not bedridden, defined as being unable to sit in a wheelchair comfortably for more than one hour, and being confined to the bed due to your physical abilities. Following the survey, you will be provided with the opportunity to provide your email for entry into a $25 gift card raffle as thanks for your completion of the survey. However, we also hope that your participation will provide valuable preliminary data necessary to improve healthcare providers' and researchers' awareness of the most critical components of exercise promotion within the MS population. These efforts may indirectly benefit the quality of care between you and your healthcare providers. We believe there are no known risks associated with this research study. However, as with any online survey, there is always a potential risk of a breach of confidentiality. To the best of our ability, **your answers will remain confidential.** You will not have to provide your name. All data will be stored on a password-protected university server, and only trained research staff will have access. Data will only be presented or published in aggregate form. **Your participation in this study is completely voluntary, and you may withdraw at any time without any penalty.** If you have any questions about this project or encounter a research-related problem, **you may contact Andrew Argie at aargie@ksu.edu or 913-916-5279.** If you have any questions regarding your rights as a research subject, you may contact Lisa Rubin, Associate Vice President for Research Compliance (785) 532-3224 or Brad Woods, Associate Vice President for Research Compliance at (785) 532-3224. Additionally, identifiers might be removed from the identifiable private information or identifiable biospecimens and that, after such removal, the information or biospecimens could be used for future research studies or distributed to another investigator for future research studies without additional informed consent. **Do you consent to these terms?**

o yes (1)

o no (0)

Skip To: End of Survey If InformedConsent != 1

End of Block: Informed Consent

Start of Block: Demographics - 6 item

`

DemoScreen2 What is your age?

____

Skip To: End of Survey If Condition: What is your age? Is Less Than 18. Skip To: End of Survey.

DemoScreen3 Could you please specify which type of MS you were diagnosed with?

o Relapsing-Remitting MS (RRMS) (1)

o Primary Progressive MS (PPMS) (2)

o Secondary Progressive MS (SPMS) (3)

o Progressive-Relapsing MS (PRMS) (4)

o I am not sure (5)

o Prefer not to say (6)

o Other please describe (7) ____

DemoScreen4 Please read the choices listed in the graph below and choose the one that best describes your own situation. This scale focuses mainly on how well you **walk.** You might not find a description that reflects your condition exactly, but please mark the category that **describes your situation the closest.**

▼ 0 - normal (0) ... 8 - bedridden (8)

Skip To: End of Survey If DemoScreen4 = 8

DemoScreen5 For how long have you been diagnosed with MS?

▼ Less than 1 year (1) ... Prefer Not to Say (10)

DemoScreen6 What is your gender?

▼ Male (1) ... Prefer Not to Say (4)

DemoScreen7 Do you have any other medical conditions or diagnoses that significantly impact your health or physical functioning? If so, please list no more than three of the most impactful conditions (e.g., diabetes, cardiovascular disease, severe arthritis, respiratory disorders, related neurological conditions).

o yes (please specify) (1) ____

o no (0)

o Prefer not to say (8)

End of Block: Demographics - 6 item

Start of Block: Aerobic Exercise Primer

Aerobic Exercise Def The purpose of this study is to assess your behavior, intentions, and perceptions related to regular aerobic exercise training. **Aerobic exercise** is defined as any rhythmic activity involving large muscle groups that can be sustained continuously, such as walking, cycling, dancing, jogging, or running. Aerobic exercise is also commonly referred to as cardio or aerobics. **Regular aerobic exercise** for individuals with multiple sclerosis is defined as engaging in 30-minute exercise sessions at least twice per week, as outlined by the Multiple Sclerosis Exercise Training Guidelines. Please use these definitions for the remainder of the study

End of Block: Aerobic Exercise Primer

Start of Block: M-GLTEQ - 7 items

GLTEQ-Prep We would now like to learn more about your usual aerobic exercise behaviors. Considering a 7-Day period (a week), how many times on average do you do the following kinds of aerobic exercise for more than 15 minutes during your free time? (i.e., exercise that improves the heart and lungs such as walking or running),

GLTEQ-A STRENUOUS AEROBIC EXERCISE (HEART BEATS RAPIDLY) (e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling) (0-7)

▼ 0 (0) ... prefer not to say (8)

GLTEQ-A2 On average, how many minutes per session did you spend on strenuous aerobic exercise?

____

GLTEQ-B MODERATE AEROBIC EXERCISE (NOT EXHAUSTING) (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing) (0-7)

▼ 0 (0) ... prefer not to say (8)

GLTEQ-B2 On average, how many minutes per session did you spend on moderate intensity aerobic exercise?

____

GLTEQ-C MILD/LIGHT AEROBIC EXERCISE (MINIMAL EFFORT) (e.g., yoga, easy walking) (0-7)

▼ 0 (0) ... prefer not to say (8)

GLTEQ-C2 On average, how many minutes per session did you spend on mild/light intensity aerobic exercise?

____

GLTEQ-2 (2) Considering a 7-day period (a week) during your leisure time how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

- o Often (1)
- o Sometimes (2)
- o Rarely (3)
- o Prefer Not To Say (8)

End of Block: M-GLTEQ - 7 items

Start of Block: Aerobic Exercise Identity - Reflex - 3 items (Wilson & Muon 2011)

ExDefRef1 The following questions concern your personal beliefs about aerobic exercise. Please indicate the degree to which you agree or disagree with each statement when thinking about your exercise participation

Exercise Identity Q1 I consider myself someone who does regular aerobic exercise.

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)

o Prefer not to say (8)

Exercise Identity Q2 When I describe myself to others, I usually include my involvement in aerobic exercise

o Strongly disagree (1)

o Disagree (2)

o Somewhat disagree (3)

o Neither agree nor disagree (4)

o Somewhat agree (5)

o Agree (6)

o Strongly agree (7)

o Prefer not to say (8)

Exercise Identity Q3 Others see me as someone who engages in aerobic exercise regularly

o Strongly disagree (1)

o Disagree (2)

o Somewhat disagree (3)

o Neither agree nor disagree (4)

o Somewhat agree (5)

o Agree (6)

o Strongly agree (7)

o Prefer not to say (8)

`

Exercise Identity AC Aerobic exercise is an integral part of who I am as a person. In order to ensure you are paying attention, please select "Prefer not to say"

o Strongly disagree (1)

o Disagree (2)

o Somewhat disagree (3)

o Neither agree nor disagree (4)

o Somewhat agree (5)

o Agree (6)

o Strongly agree (7)

o Prefer not to say (8)

End of Block: Aerobic Exercise Identity - Reflex - 3 items (Wilson & Muon 2011)

Start of Block: Aerobic ExHabit-Reflex - 4 items (Gardner et al., 2012)

ExDefRef2 The following questions ask about your habits regarding aerobic exercise. Habits are behaviors that are so practiced they are often done without much thought or motivation. For example, for many people driving a car becomes a habit when one can think about all sorts of things, concentrate on the road, and give little thought to operating the controls of the car. Sometimes travelling to and from work becomes such a habit that we do not even think about our route anymore. Please select the answer that best represents you.

ExerciseHabit1 Aerobic exercise is something I do automatically

o Strongly disagree (1)

o Disagree (2)

o Somewhat disagree (3)

`

- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

ExerciseHabit2 Aerobic exercise is something I do without having to consciously remember

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

ExerciseHabit3 Aerobic exercise is something I do without thinking

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)

`

- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

ExerciseHabit4 Aerobic exercise is something I start doing before I realize I'm doing it

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

End of Block: Aerobic ExHabit-Reflex - 4 items (Gardner et al., 2012)

Start of Block: Aerobic Exercise - Intention - Intended - dichotomous - 1 item (Courneya, 1994)

Intention-Dichot-Ex I intend to engage in at least 30 minutes of aerobic exercise 2 times per week over the next 4 weeks.

- o Yes (1)
- o No (0)
- o Prefer not to say (8)

`

End of Block: Aerobic Exercise - Intention - Intended - dichotomous - 1 item (Courneya, 1994)

Start of Block: Aerobic Exercise Behavioral Regulation - 14 items (Rhodes et al., 2023)

ExBRegPrimer Sometimes we use strategies to help us do aerobic exercise regularly. Please use the following scale to answer the questions below.

ExBReg1 To be exercising regularly, I have made a detailed plan regarding **when** to do aerobic exercise

o Strongly Disagree (1)

o Disagree (2)

o Somewhat Disagree (3)

o Neutral (4)

o Somewhat Agree (5)

o Agree (6)

o Strongly Agree (7)

o Prefer not to say (8)

ExBReg2 To be exercising regularly, I have made a detailed plan regarding **where** to do aerobic exercise

o Strongly Disagree (1)

o Disagree (2)

o Somewhat Disagree (3)

o Neutral (4)

o Somewhat Agree (5)

o Agree (6)

o Strongly Agree (7)

o Prefer not to say (8)

ExBReg3 To be exercising regularly, I have made a detailed plan regarding **how** to do aerobic exercise

o Strongly Disagree (1)

o Disagree (2)

o Somewhat Disagree (3)

o Neutral (4)

o Somewhat Agree (5)

o Agree (6)

o Strongly Agree (7)

o Prefer not to say (8)

ExBReg4 To be exercising regularly, I have made a detailed plan regarding **how often** to do aerobic exercise

o Strongly Disagree (1)

o Disagree (2)

o Somewhat Disagree (3)

o Neutral (4)

- o Somewhat Agree (5)
- o Agree (6)
- o Strongly Agree (7)
- o Prefer not to say (8)

Page Break

ExBReg5 When I am upset, I use strategies to feel better so I can do aerobic exercise regularly

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

ExBReg6 When I am upset, I have ways of coping so I can focus on my aerobic exercise plans

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)

- Somewhat agree (5)
- Agree (6)
- Strongly agree (7)
- Prefer not to say (8)

ExBReg7 I recognize and accept when I am in a bad mood so I can focus on aerobic exercise

- Strongly disagree (1)
- Disagree (2)
- Somewhat disagree (3)
- Neither agree nor disagree (4)
- Somewhat agree (5)
- Agree (6)
- Strongly agree (7)
- Prefer not to say (8)

ExBReg8 I avoid spending long periods of time in environments that promote inactivity

- Strongly disagree (1)
- Disagree (2)
- Somewhat disagree (3)
- Neither agree nor disagree (4)
- Somewhat agree (5)
- Agree (6)

`

- Strongly agree (7)
- Prefer not to say (8)

ExBReg9 There is someone who could provide feedback on my aerobic exercise participation when needed

- Strongly disagree (1)
- Disagree (2)
- Somewhat disagree (3)
- Neither agree nor disagree (4)
- Somewhat agree (5)
- Agree (6)
- Strongly agree (7)
- Prefer not to say (8)

Page Break

ExBReg10 There is someone who will comment on whether I am meeting my aerobic exercise goals

- Strongly disagree (1)
- Disagree (2)
- Somewhat disagree (3)
- Neither agree nor disagree (4)
- Somewhat agree (5)

- Agree (6)
- Strongly agree (7)
- Prefer not to say (8)

ExBReg11 I ask someone to remind me to do aerobic exercise

- Strongly disagree (1)
- Disagree (2)
- Somewhat disagree (3)
- Neither agree nor disagree (4)
- Somewhat agree (5)
- Agree (6)
- Strongly agree (7)
- Prefer not to say (8)

ExBReg12 I keep track of my aerobic exercise activities

- Strongly disagree (1)
- Disagree (2)
- Somewhat disagree (3)
- Neither agree nor disagree (4)
- Somewhat agree (5)
- Agree (6)

`

- o Strongly agree (7)
- o Prefer not to say (8)

ExBReg13 I record my aerobic exercise activities

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

ExBReg14 I keep track of my aerobic exercise level

- o Strongly disagree (1)
- o Disagree (2)
- o Somewhat disagree (3)
- o Neither agree nor disagree (4)
- o Somewhat agree (5)
- o Agree (6)
- o Strongly agree (7)
- o Prefer not to say (8)

End of Block: Aerobic Exercise Behavioral Regulation - 14 items (Rhodes et al., 2023)

Start of Block: Aerobic AJ/IA (Ajzen, 2006) About Exercise (Emerson et al., 2021) - 6 item

AJ/IAInstruct We are going to ask you about your beliefs regarding regular aerobic exercise behavior for the next 3 months.

IA - Distal1 Over the next 3 months, engaging in aerobic exercise on a regular basis would be wise.

o ⊗Extremely Disagree (1)

o ⊗Quite Disagree (2)

o ⊗Slightly Disagree (3)

o Neutral (4)

o Slightly Agree (5)

o Quite Agree (6)

o Extremely Agree (7)

o Prefer not to say (8)

IA - Distal2 Over the next 3 months, engaging in aerobic exercise on a regular basis would be beneficial.

o ⊗Extremely Disagree (1)

o ⊗Quite Disagree (2)

`

- ⊗Slightly Disagree (3)
- Neutral (4)
- Slightly Agree (5)
- Quite Agree (6)
- Extremely Agree (7)
- Prefer not to say (8)

IA - Distal3 Over the next 3 months, engaging in aerobic exercise on a regular basis would be useful.

- ⊗Extremely Disagree (1)
- ⊗Quite Disagree (2)
- ⊗Slightly Disagree (3)
- Neutral (4)
- Slightly Agree (5)
- Quite Agree (6)
- Extremely Agree (7)
- Prefer not to say (8)

Page Break

`

AJ - Distal1 Over the next 3 months, engaging in aerobic exercise on a regular basis would be enjoyable.

o ⊗Extremely Disagree (1)

o ⊗Quite Disagree (2)

o ⊗Slightly Disagree (3)

o Neutral (4)

o Slightly Agree (5)

o Quite Agree (6)

o Extremely Agree (7)

o Prefer not to say (8)

AJ - Distal2 Over the next 3 months, engaging in aerobic exercise on a regular basis would be exciting.

o ⊗Extremely Disagree (1)

o ⊗Quite Disagree (2)

o ⊗Slightly Disagree (3)

o Neutral (4)

o Slightly Agree (5)

o Quite Agree (6)

o Extremely Agree (7)

o Prefer not to say (8)

`

AJ - Distal3 Over the next 3 months, engaging in aerobic exercise on a regular basis would be pleasant.

- o ⊗Extremely Disagree (1)
- o ⊗Quite Disagree (2)
- o ⊗Slightly Disagree (3)
- o Neutral (4)
- o Slightly Agree (5)
- o Quite Agree (6)
- o Extremely Agree (7)
- o Prefer not to say (8)

End of Block: Aerobic AJ/IA (Ajzen, 2006) About Exercise (Emerson et al., 2021) - 6 item

---

Start of Block: Aerobic Perceived Capability & Opportunity 7 item Exercise - (Lithopoulos 2023)

PCapOppInstruct These questions ask you about your confidence and/or control over engaging in regular aerobic exercise. Please select an option for each question using the scale provided. Consider what you would do for each question assuming you wanted to do the task.

PCap1-Exercise I have the physical and mental ability to engage in regular aerobic exercise over the next 3 months

- o Strongly disagree (1)
- o Disagree (2)

- Neither agree nor disagree (3)
- Agree (4)
- Strongly agree (5)
- Prefer not to say (8)

PCap2-Exercise I have enough skill to do the activities needed for me to aerobically exercise regularly over the next 3 months

- Strongly disagree (1)
- Disagree (2)
- Neither agree nor disagree (3)
- Agree (4)
- Strongly agree (5)
- Prefer not to say (8)

PCap3-Exercise I can handle the physical and mental demands of regular aerobic exercise over the next 3 months

- Strongly disagree (1)
- Disagree (2)
- Neither agree nor disagree (3)
- Agree (4)
- Strongly agree (5)

- o Prefer not to say (8)

PCap4-Exercise I am confident in my physical and mental ability to regularly aerobically exercise over the next 3 months

- o Strongly disagree (1)
- o Disagree (2)
- o Neither agree nor disagree (3)
- o Agree (4)
- o Strongly agree (5)
- o Prefer not to say (8)

Page Break

POpp1-Exercise I have the opportunity to regularly aerobically exercise over the next 3 months

- o Strongly disagree (1)
- o Disagree (2)
- o Neither agree nor disagree (3)
- o Agree (4)
- o Strongly agree (5)
- o Prefer not to say (8)

`

POpp2 - Exercise I could find a way to fit in my schedule to that I regularly aerobically exercise over the next 3 months

- o Strongly disagree (1)
- o Disagree (2)
- o Neither agree nor disagree (3)
- o Agree (4)
- o Strongly agree (5)
- o Prefer not to say (8)

POpp3 - Exercise I would have the chance to regularly aerobically exercise over the next 3 months

- o Strongly disagree (1)
- o Disagree (2)
- o Neither agree nor disagree (3)
- o Agree (4)
- o Strongly agree (5)
- o Prefer not to say (8)

End of Block: Aerobic Perceived Capability & Opportunity 7 item Exercise - (Lithopoulos 2023)

Start of Block: Debrief

Debrief-Stormont Thank you for taking the time to fill out this survey! The purpose of this study is to contribute to our knowledge of aerobic exercise behaviors and intentions in individuals who are diagnosed with multiple sclerosis. Your answers are valuable in helping future researchers and clinicians on the most effective methods and tools that can be utilized for promoting exercise participation in both research and clinical settings. Your time and efforts are greatly appreciated! If you have any questions, concerns, or would like a final report of the study's findings, please contact the study investigator, Andrew Argie at aargie@ksu.edu. You may also contact the Principal Investigator of the study Dr. Gina Besenyi at gbesenyi@ksu.edu. If you have any questions or wish to discuss on any aspect of the research with an official of the university or the IRB, you may contact Dr. Lisa Rubin, Chair, Committee on Research Involving Human Subjects, (785) 532-3224. If you would like to learn more about the Multiple Sclerosis exercise training guidelines, please see below for more resources. Cleveland Clinic - The Role of Physical Exercise in Managing Multiple Sclerosis Symptoms https://my.clevelandclinic.org/departments/neurological/depts/multiple-sclerosis/ms-approaches/exercise-in-ms PubMed - Exercise Training Guidelines for Multiple Sclerosis, Stroke, and Parkinson Disease https://pmc.ncbi.nlm.nih.gov/articles/PMC6586489/ National MS Society - Exercise and Physical Activity Recommendations for ALL People with MS: Guidelines and Videos Available https://www.nationalmssociety.org/news-and-magazine/news/exercise-and-physical-activity-recommend Participants have the opportunity to participate in a gift card raffle for 1 of 8 gift cards. Please click the next button in order to be taken to the end of the survey, where you will be provided a link. Thank you very much for taking the time to complete this survey!

Page Break

Raffle Entry
Thank you for completing this survey. If you would like to enter our gift card raffle, please click the link provided below. If you choose not to participate in the raffle, we sincerely appreciate your time and valuable input. Raffle Survey --> https://kstate.qualtrics.com/jfe/form/SV_0U3JBxgoe1lM8Wq

Appendix B – Survey Recruitment Materials

MyChart message to Stormont Vail Participants

Dear [Patient],

Stormont Vail Health's Clinical Research Center wants to share information about a research study sponsored by the Stormont Vail Health & Kansas State University Research Collaboration. This partnership, established in June 2023, connects university researchers with our health system to support research that benefits both health care and academics.

We are contacting you because you might qualify to participate in an online research study led by Dr. Gina Besenyi, an Associate Professor in the Department of Kinesiology at Kansas State University. This study focuses on understanding what psychological, behavioral, and environmental factors affect exercise participation in people with multiple sclerosis (MS). The goal is to use this information to help create programs that support consistent exercise among individuals with MS.

You may qualify for this study if you meet the following criteria:

• You are at least 18 years old.

• You have been diagnosed with multiple sclerosis.

• You can read and write in English.

If you choose to participate, you'll complete an online survey that asks about your exercise habits, your thoughts about exercise, and your related experiences. The survey takes about 15 minutes. Participation is completely voluntary, and your answers will remain anonymous. At the end of the survey, you'll have the chance to enter a raffle to win one of eight $25 gift cards by providing your email address in a separate, secure link.

If you're interested, click the link below to participate. If you have questions or need more information, you can contact the study's principal investigator, Dr. Gina Besenyi, at gbesenyi@ksu.edu. This study has been approved by the Kansas State Institutional Review Board (IRB-12506-Various).

https://kstate.qualtrics.com/jfe/form/SV_8CzNZ8jqgfvVCDA

If you have concerns about receiving this letter, please contact the Stormont Vail Health Research Ethics Line: (785) 368-0428

Thank you for considering this opportunity.

Clinical Research Center, Stormont Vail Health

Recruitment Post for Social Media Respondents

Dear all,

My name is Andrew Argie, and I am currently a graduate student in the Department of Kinesiology at Kansas State University. Our team invites you to participate in a research study aimed at understanding exercise intentions and behaviors in individuals diagnosed with Multiple Sclerosis (MS). This study is being conducted within the Department of Kinesiology at Kansas State University by myself and Dr. Gina Besenyi. This study is being conducted as a component of my current Master's thesis. Your insights would be invaluable in helping us better understand the underlying factors that influence positive and negative associations with exercise specific to the MS population. The findings from this study aim to inform healthcare providers and researchers on which strategies will be most effective for promoting exercise for individuals with MS by taking into account diverse experiences and perceptions around exercise.

Participation involves completing an online survey that will take approximately 15 minutes. The survey includes questions on exercise behavior, attitudes toward exercise, and related experiences. Your responses will be kept confidential, and any data collected will be anonymized to ensure your privacy. You will receive the opportunity to provide your email at the end of the survey in order to enter into a gift card raffle for one of multiple $25 gift cards.

If you are interested in participating, you may click the link below. If you would like more information regarding the study, you may contact Andrew Argie at aargie@ksu.edu, or the principal investigator Dr. Gina Besenyi at gbesenyi@ksu.edu.

Thank you very much for considering this opportunity to contribute towards research aimed at improving the quality of exercise support and promotion within healthcare settings.

This post has been approved by the moderation team.

Survey Link --> https://kstate.qualtrics.com/jfe/form/SV_3sCLFmWAHCYdQGy