HHS Public Access
Author manuscript
Mult Scler Relat Disord. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:
Mult Scler Relat Disord. 2022 January ; 57: 103312. doi:10.1016/j.msard.2021.103312.

Social Cognitive Theory variables as correlates of physical activity in fatigued persons with multiple sclerosis

Brenda Jeng, MS[1,†], **Katie L. J. Cederberg, PhD**[2], **Trinh L. Huynh, MPH**[1], **Petra Silic, BS**[1], **Catherine D. Jones, MSPH**[1], **Corey D. Feasel, MEd**[1], **E. Morghen Sikes, PhD**[3], **Jessica F. Baird, PhD**[1], **Stephanie L. Silveira, PhD**[4], **Jeffer E. Sasaki, PhD**[5], **Robert W. Motl, PhD**[1]

[1]Department of Physical Therapy, University of Alabama at Birmingham, School of Health Professions 360, 1720 2nd Ave S, Birmingham, AL 35294 USA

[2]Department of Psychiatry and Behavioral Sciences, Stanford University, 401 Quarry Road, Stanford, CA 94305 USA

[3]Division of Occupational Therapy, Shenandoah University, 44160 Scholar Plaza Suite 100, Leesburg, VA 20176 USA

[4]Department of Kinesiology, Health Promotion, and Recreation, University of North Texas, 1155 Union Circle #310769, Denton, TX 76203 USA

[5]Graduate Program in Physical Education, Federal University of Triângulo Mineiro, Av. Tutunas, 490. Sala 211, Bairro Tutunas, 38061-500 Uberaba, MG, Brazil

Abstract

Background: There is interest in the application of behavioral interventions based on theory for increasing physical activity among adults with multiple sclerosis (MS). To date, researchers have applied theory such as Social Cognitive Theory (SCT) for identifying correlates of physical

Corresponding Author Details: Brenda Jeng, Department of Physical Therapy, University of Alabama at Birmingham, School of Health Professions Building 360x, 1720 Second Avenue South, Birmingham, AL, 35294 USA, Tel: (205)975-1306, bjeng@uab.edu.
†Institution where study was performed

Credit Author Statement
Brenda Jeng: Conceptualization, Investigation, Formal Analysis, Data curation; Writing – Original Draft
Katie L. J. Cederberg: Conceptualization, Methodology, Investigation, Formal Analysis, Project administration, Writing – Review & Editing
Trinh L. Huynh: Conceptualization, Investigation, Project administration, Writing – Review & Editing
Petra Silic: Conceptualization, Investigation, Writing – Review & Editing
Catherine D. Jones: Investigation, Writing – Review & Editing
Corey D. Feasel: Investigation, Writing – Review & Editing
E. Morghen Sikes: Conceptualization, Methodology, Investigation, Writing – Review & Editing
Jessica F. Baird: Software, Investigation, Writing – Review & Editing
Stephanie L. Silveira: Software, Formal Analysis, Investigation, Writing – Review & Editing
Jeffer E. Sasaki: Conceptualization, Methodology, Investigation, Writing – Review & Editing
Robert W. Motl: Conceptualization, Methodology, Formal Analysis, Resources, Supervision, Writing – Original Draft, Funding acquisition

Declaration of Interest
None.

activity that can then inform the design and delivery of behavioral interventions. Such research often has been conducted in heterogeneous samples of persons with MS without a focus on those with a specific symptom, such as fatigue, that may be targeted by physical activity behavioral interventions. To that end, this study examined SCT variables (i.e., self-efficacy, barriers, outcome expectations, goal-setting, planning, social support, and functional limitations) as correlates of physical activity in persons with MS who self-reported elevated fatigue.

Methods: Persons with MS (N=210; aged 49.6[13.2] years) who ambulated with or without assistance participated in the study. Participants completed self-report measures of fatigue, physical activity, and SCT variables and wore an ActiGraph GT3X+ accelerometer on a belt around the waist for 7 days. The accelerometer data were processed and delineated into time spent in light and moderate-to-vigorous physical activity (MVPA) based on MS-specific cut-points. We generated groups of fatigued (n=134) and non-fatigued (n=76) persons with MS based on the cut-off score of 4 for the Fatigue Severity Scale.

Results: There were differences in physical activity and SCT variables between fatigued and non-fatigued persons with MS. Among those with fatigue, functional limitations (ρ=0.52), self-efficacy (ρ=0.31), and goal-setting (ρ=0.25) were associated with device-measured MVPA, and all SCT variables except outcome expectations were associated with self-reported physical activity. The regression analyses indicated self-efficacy, functional limitations, and goal-setting as significant correlates of MVPA in those with fatigue.

Conclusion: Self-efficacy, goal-setting, social support, and barriers may be important targets of SCT-based behavioral interventions for increasing physical activity among persons with MS who have fatigue.

Keywords

multiple sclerosis; fatigue; physical activity; behavior change; social-cognitive theory

1. Introduction

Multiple sclerosis (MS) is an immune-mediated disease of the central nervous system (CNS) with an estimated prevalence of nearly 1 million adults in the U.S.[1] The disease manifests as demyelination and transection of axons in the CNS,[2, 3] and, depending on the location of damage, results in a variety of symptoms.[3–5] Fatigue is one of the most common, severe, and debilitating symptoms of MS, and it has effects on psychological, social, and behavioral outcomes.[6, 7] One approach for managing fatigue is pharmacological therapy (e.g., medications such as Amantadine and Modafinil); however, a meta-analysis that included pharmacological interventions reported mixed or weak results for the benefits of medications for fatigue management in MS.[8] Alternatively, physical activity may be a non-pharmacological approach for managing fatigue in persons with MS, as noted in that same meta-analysis,[8] but very little research has focused on approaches for changing physical activity in this section of persons with MS.

There is a bidirectional association between fatigue and physical activity in MS.[9] On the one hand, some researchers have examined the effects of physical activity, particularly participation in exercise training, on fatigue in persons with MS.[8, 10] The meta-analyses of such studies generally support that physical activity can reduce symptoms of fatigue by 0.53 – 0.57 standard deviations in persons with MS.[8, 10] One caveat, however, is that the studies generally do not include persons with MS who are prescreened for the presence of severe fatigue, and we do not know if persons with severe fatigue can participate in sufficient levels of physical activity for accrual of the beneficial effects of physical activity on fatigue.

On the other hand, researchers have examined the effects of fatigue on physical activity levels in persons with MS. Persons with MS who have severe fatigue engage in significantly less physical activity than persons with MS who do not have elevated fatigue.[11, 12] For example, one study examined the relationships among fatigue, physical activity, and sedentary behavior in a sample of 252 persons with MS.[12] The sample was separated into subgroups of fatigued and non-fatigued based on the cut-off score of 4 for the Fatigue Severity Scale (FSS). Results from that study indicated that the fatigued group spent a greater percentage of time in sedentary behavior as well as a lower percentage of time in light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) compared to the non-fatigued group.[12]

To date, there is little understanding of theory-based factors that explain variation in levels of physical activity as a function of fatigue in MS. Such research is important for the design of behavioral interventions that target physical activity among adults with MS who present with severe fatigue, and thereby examining if persons with severe fatigue can participate in sufficient physical activity for reduction in fatigue. Social Cognitive Theory (SCT) has commonly and successfully been applied for identifying correlates of physical activity in MS and has informed the design and delivery of theory-based behavioral interventions.[13–17] One primary assumption of SCT is human agency – intentionally exerting control over the nature and quality of one's life,[18] and this directly aligns with the key components of Bandura's socio-cognitive causal structure for health-promoting behaviors. The causal structure includes the SCT variables of self-efficacy, barriers, outcome expectations, goal-setting, planning, social support, and functional limitations.[19] These variables have consistently been associated with physical activity in MS[15, 20] and theoretically exert a stronger association with physical activity under challenging conditions such as engaging in physical activity by persons with severe fatigue. To that end, SCT serves as an ideal starting place for identifying theory-based variables as correlates of physical activity among fatigued adults with MS (i.e., score of 4 or higher on the FSS).

The present study examined SCT variables as correlates of physical activity in fatigued persons with MS based on the cut-off score of 4 or higher on the Fatigue Severity Scale. To do so, we initially compared physical activity levels and levels of SCT variables between fatigued and non-fatigued samples, and then examined the correlation between SCT variables and physical activity behavior within the separate samples of fatigued and non-fatigued persons with MS. We expected that self-efficacy and goal-setting would be the strongest SCT correlates of physical activity in fatigued persons with MS based on previous research in persons with MS who had elevated depressive symptoms,[14] as depressive symptoms often co-occur with fatigue.[21–23]

2. Methods

2.1 Participants

Persons with MS were recruited through flyers in the community, advertisements through the National MS Society and local MS chapters, and mailing lists of persons with MS in databases from the MS Center and a local therapeutic recreation organization. Interested persons were screened based on the following inclusion criteria: (1) self-reported diagnosis of MS; (2) age between 20–79 years; (3) ability to ambulate with or without assistance; (4) willingness to complete the testing procedures. We excluded participants who had a relapse in the last 30 days. Of the 567 persons who contacted us, 477 persons were assessed for eligibility, and 217 persons with MS were enrolled. Of the 217 participants who completed the protocol, 210 persons with MS had complete data and were divided into fatigued and non-fatigued groups based on FSS scores. The sample size was adequate for detecting differences in mean scores between groups with an independent samples *t*-test based on assumptions of a two-sided alpha of .05, beta of .80, Cohen's *d* of 0.5, and approximate 1/1 group allocation ratio; those parameters yielded an estimated sample of 128 based on G*Power 3.1 (G*Power, Düsseldorf, Germany). The sample was further adequate for detecting a correlation coefficient of .3 based on two-sided alpha of .05 and beta of .80 using G*Power 3.1.

2.2. Measures

2.2.1. Demographic and Clinical Characteristics—Participants completed a questionnaire regarding self-reported demographic (i.e., age, sex, race, education, income) and clinical characteristics (i.e., MS type, disease duration, ambulatory disability status based on Patient Determined Disease Steps [PDDS]).[24]

2.2.2. Fatigue—The FSS provided a measure of fatigue severity. This scale is one of the most commonly used measures of fatigue, as there is no gold standard of fatigue specific to MS. The nine items were rated on a 7-point scale of 1 (strongly disagree) through 7 (strongly agree) regarding the severity of fatigue symptoms during the past 7-day period.[25] The scores for the items were averaged into a measure of fatigue severity that ranged between 1 and 7 with scores of 4 or above indicating severe MS-related fatigue. Based on the scores, participants were divided into two groups: fatigued (FSS score ≥ 4) and non-fatigued (FSS score < 4).

2.2.3. Physical Activity—The ActiGraph model GT3X+ (GT3X+, ActiGraph, Pensacola, Florida) accelerometer provided a device-based measure of physical activity. Participants wore the accelerometer on a belt around the waist above the non-dominant hip during waking hours for seven days, excluding water-based activities. Participants recorded the time that the accelerometer was worn in a daily log, and this log was used to verify wear time during processing of the data. Accelerometer data were recorded with a sample rate of 100Hz, downloaded in 1-minute epochs, processed with low frequency extension, and then scored for activity counts and minutes spent in LPA and MVPA per day,[26] A day of wear was considered valid if there was a minimum of 10 hours (i.e., 600 minutes) of total wear time without continuous zeros exceeding 30 minutes, and participants with 1 or more valid days of data were included in the analyses. We based our decision for including participants with 1 or more valid days on larger cohort trials from National Health and Nutrition Examination Survey that utilize only one valid day of accelerometry.[27]

The Godin Leisure-Time Exercise Questionnaire (GLTEQ) provided a self-report measure of physical activity.[28–30] Participants recorded the number of bouts greater than 15 minutes in duration of moderate and strenuous physical activity engaged in over the course of a typical week. The GTLEQ score was calculated into a health contribution score by multiplying the number of 15-minute bouts of moderate and strenuous physical activity by weights of 5 and 9, respectively, and then summed into a score where higher scores indicated higher levels of physical activity engagement.

2.2.4. Self-Efficacy—The Exercise Self-Efficacy Scale (EXSE) assessed an individual's self-efficacy engaging in 40+ minutes of moderate physical activity three times per week.[31] The eight items reflected confidence over increasing one-month increments and were rated on a scale from 0 (not at all confident) through 100 (completely confident), and averaged into a composite score ranging from 0 to 100. Higher scores indicated higher self-efficacy for physical activity (i.e., greater confidence in a person's ability to regularly engage in physical activity).

2.2.5. Barriers—The Barriers for Self-Efficacy Scale (BARSE) assessed confidence in overcoming barriers for engaging in exercise.[31, 32] The 13 items were rated on a scale from 0 (not at all confident) to 100 (completely confident), averaged into a total score with higher scores indicating more self-efficacy for overcoming barriers to exercise and maximum score of 100.

2.2.6. Outcome Expectations—Outcome expectations were assessed using the Multidimensional Outcome Expectations for Exercise Scale (MOEES).[33] Nineteen items were rated on a five-point scale from 1 (strongly disagree) to 5 (strongly agree) and summed for a total score with higher scores reflecting greater perceptions of positive benefits of regular exercise and physical activity.

2.2.7. Goal-Setting and Planning—Goal-setting for physical activity was measured using the 10-item Exercise Goal setting Scale (EGS), and planning for physical activity was measured using the 10-item Exercise Plans Scale (EPS).[34] Items were rated on a five-point scale from 1 (does not describe) to 5 (describes completely), yielding a total score from 10 to 50 per scale. Higher scores reflected a stronger tendency for setting goals or planning for exercise and physical activity participation.

2.2.8. Social Support—Social support was represented as a perceived facilitator for physical activity and was measured by the Social Provisions Scale (SPS).[35] The six-item scale assessed the degree to which current relationships support physical activity behaviors on a four-point scale from 1 (strongly disagree) to 4 (strongly agree). Scores ranged from 6 to 36 with higher scores representing more perceived support for physical activity.

2.2.9. Functional Limitations—Functional limitations represented as perceived limitations of physical activity and were assessed using the Functional Limitations component of the abbreviated Late-Life Function and Disability Instrument (LL-FDI).[36–38] The LL-FDI function component included 15 items that were rated on a five-point scale from 1 (none) to 5 (cannot do). Scores on the functional component ranged from 15 and 75, and higher scores reflected better levels of functioning.

2.3. Procedure

The procedure was approved by the University's Institutional Review Board. All participants provided written informed consent. Participants completed questionnaires regarding demographic and clinical characteristics, physical activity levels, and fatigue severity during a visit within a university-based laboratory. Participants were then provided with an accelerometer along with a belt, daily log, and instructions for wearing the device over the subsequent 7-day period as well as questionnaires regarding SCT variables for home-based completion. Those materials were returned through the United States Postal Service using a pre-stamped, pre-addressed envelope. Participants received remuneration after completion of the study.

2.4. Data Analysis

The data of those who completed the study procedures were analyzed using SPSS version 27.0 (SPSS, IBM SPSS Statistics, Armonk, New York). We initially performed descriptive analyses of the measures for the overall sample and subsamples of fatigued and non-fatigued. We conducted independent samples *t*-tests for examining differences in LPA, MVPA, and scores of the GLTEQ, EXSE, BARSE, MOEES, EGS, EPS, SPS, and LL-FDI between fatigued and non-fatigued groups. We performed Spearman rank-order bivariate correlation analyses on physical activity behavior variables and scores from the EXSE, BARSE, MOEES, EGS, EPS, SPS, and LL-FDI for the overall sample and then fatigued and non-fatigued subsamples. Values for correlation coefficients of 0.1, 0.3, and 0.5 were interpreted as small, moderate, and strong, respectively.[39] We further conducted stepwise multiple linear regression analyses, whereby we regressed metrics of physical activity behavior on SCT variables that were significant in the bivariate analyses; this identified independent correlates that explained significant variation in physical activity behavior for the overall sample and by subsamples of fatigued and non-fatigued. We adopted a study-wise alpha level of 0.05 for statistical significance, and this is consistent with research examining differences and associations based on a specific theory such as SCT.

3. Results

3.1. Sample characteristics

Descriptive characteristics of the overall sample with MS and subsamples of fatigued and non-fatigued persons with MS are presented in Table 1. There were no significant differences in age (t=–0.84), sex (χ^2=0.48), education level (χ^2=0.72), income level (χ^2=3.72) or disease duration (t=0.03) between groups; however, there was a significant difference in disease type (χ^2=8.06) and disability status based on PDDS scores (t=–4.67). The median PDDS scores of 0 for the non-fatigued group and 2 for the fatigued group correspond with Expanded Disability Status Scale (EDSS) scores of 0 and 3, respectively. These EDSS scores are both characteristic of relatively mild MS disease, as an EDSS score of 4 is a common benchmark of moderate disease in MS.

3.2. Physical Activity and SCT Variables

Descriptive statistics for physical activity and SCT variables in the overall sample and subsamples of fatigued and non-fatigued persons with MS are provided in Table 2. Device-measured MVPA (t=2.01, p=0.01) and GLTEQ scores (t=3.46, p<0.01) significantly differed between groups – fatigued persons with MS participated in less physical activity compared to non-fatigued persons with MS. Scores from the EXSE (t=5.11, p=0.01), BARSE (t=4.97, p<0.01), EGS (t=2.55, p=0.01), EPS (t=3.46, p<0.01), SPS (t=3.35, p<0.01), and LL-FDI (t=4.72, p<0.01) significantly differed between the two subsamples; this indicated that the fatigued group scored worse than the non-fatigued group in self-efficacy, goal-setting, planning, social support, and functional limitations.

3.3. Bivariate Correlation Analyses

Spearman's rank-order bivariate correlations between physical activity and SCT variables in the overall sample of persons with MS and subsamples of fatigued and non-fatigued persons with MS are presented in Table 3.

3.3.1. Overall Sample—There was a small, but statistically significant, association between device-measured LPA and SPS (ρ=0.15). Device-measured MVPA was strongly associated with LL-FDI (ρ=0.52) and moderately associated with EXSE (ρ=0.38). There was a weak, but statistically significant association between device-measured MVPA and BARSE (ρ=0.25), MOEES (ρ=0.15), and EGS (ρ=0.21). GLTEQ was moderately associated with EXSE (ρ=0.42), BARSE (ρ=0.38), EGS (ρ=0.41), and LL-FDI (ρ=0.39). There was a small-to-moderate association between GLTEQ and MOEES (ρ=0.28) and SPS (ρ=0.28).

3.3.2. Fatigued Sample—There were no associations between device-measured LPA and SCT variables. Device-measured MVPA was strongly associated with LL-FDI (ρ=0.52) and moderately associated with EXSE (ρ=0.31). There was a small correlation between MVPA and EGS (ρ=0.25). GLTEQ was moderately associated with EXSE (ρ=0.36), BARSE (ρ=0.34), EGS (ρ=0.37), and LL-FDI (ρ=0.42), whereas GLTEQ had a small association with EPS (ρ=0.25) and SPS (ρ=0.19).

3.3.3. Non-fatigued Sample—There were no associations between device-measured LPA and SCT variables. Device-measured MVPA was moderately associated with EXSE (ρ=0.41) and LL-FDI (ρ=0.40). GLTEQ was moderately associated with EXSE (ρ=0.34), BARSE (ρ=0.31), MOEES (ρ=0.36), EGS (ρ=0.38), and SPS (ρ=0.40). There was a small-to-moderate association between GLTEQ and EPS (ρ=0.28).

3.4. Multiple Linear Regression Analyses

Stepwise linear regression analyses were conducted for the overall sample with MS and the fatigued and non-fatigued groups. This involved analyses of regressing LPA, MVPA and

GLTEQ on SCT variables identified as statistically significant correlates for identifying the independent association with physical activity behavior (Tables 4, 5, and 6).

3.4.1. Overall Sample—
The model for the overall sample with MS identified SPS scores as a significant correlate of device-measured LPA, and it explained 4% of the variance in LPA. The other model for the overall sample included LL-FDI scores as a significant correlate of device-measured MVPA, and it explained 15% of the variance in MVPA. Regarding self-reported physical activity behavior, the model included EXSE and EGS as predictors of GLTEQ scores and explained 19% of the variance in GLTEQ scores.

3.4.2. Fatigued Sample—
The model included LL-FDI and EGS scores as significant correlates of device-measured MVPA, and explained 18% of the variance in MVPA. The other model identified EXSE and LL-FDI as significant correlates of GLTEQ, and explained 18% of the variance. However, EXSE was not a significant correlate in the model when EGS scores were included; the overall model then explained 21% of the variance in GLTEQ scores.

3.4.3. Non-fatigued Sample—
The model only included LL-FDI scores as a significant predictor of device-measured MVPA; LL-FDI scores explained 15% of the variance in MVPA. However, the other model identified both EXSE and EGS as significant correlates of GLTEQ scores, and it explained 19% of the variance in GLTEQ scores.

4. Discussion

This study examined SCT variables as correlates of physical activity in a sample of fatigued persons with MS. There were significant differences in device-measured MVPA, self-reported physical activity, and SCT variables of self-efficacy, barriers, goal-setting, planning, social support, and functional limitations between groups of fatigued and non-fatigued persons with MS. The bivariate correlation results further indicated that self-efficacy, goal-setting, and functional limitations were associated with device-measured MVPA, and that self-efficacy, barriers, goal-setting, planning, and functional limitations were associated with self-reported physical activity in fatigued persons with MS. The regression analyses identified functional limitations and goal-setting as significant correlates of device-measured MVPA and self-efficacy, functional limitations, and goal-setting as significant correlates of self-reported physical activity. Our preliminary results provide initial support for designing a SCT-based behavioral intervention for targeting physical activity in fatigued persons with MS.

We examined differences in physical activity variables between fatigued and non-fatigued persons with MS. Fatigued persons with MS participated in less MVPA based on accelerometry and self-reports (GLTEQ scores) compared to non-fatigued persons with MS. A previous study that reported significantly lower percentage of time spent in device-measured LPA and MVPA in the fatigued group compared to the non-fatigued group;[12] our somewhat similar results indicted no significant difference in minutes spent in LPA, but a significant difference in MVPA between fatigued and non-fatigued groups. Another study reported lower GLTEQ scores in persons with MS who had elevated depressive symptoms compared to those without elevated depressive symptoms,[14] similar to our sample of fatigued and non-fatigued persons with MS. It is unsurprising, as symptoms of depression and fatigue are commonly observed concurrently in persons with MS.[22, 40] This underscores the importance of the design and development of interventions that increase physical activity in fatigued persons with MS to possibly lower levels of fatigue.

Of the SCT variables, fatigued persons with MS scored worse on SCT measures (i.e., self-efficacy, barriers, goal-setting, planning, social support, and functional limitations) except outcome expectations compared to non-fatigued persons with MS. We further observed that SCT variables (i.e., functional limitations, exercise self-efficacy, and goal-setting) were significant correlates of physical activity in fatigued persons with MS. This is consistent with results of a previous study that reported self-efficacy and goal-setting as significant correlates of physical activity in persons with MS who had depressive symptoms.[14] In the aforementioned study, there was a significant relationship between functional limitations and self-reported physical activity; however, the regression model did not identify functional limitations as a significant correlate, whereas our model did. Furthermore, the relationship between self-efficacy and GLTEQ scores was attenuated and considered non-significant once goal-setting was entered into the model. Collectively, fatigued persons with MS participated in significantly less MVPA than non-fatigued persons with MS, consistent with previous research,[12] but increasing self-efficacy, reducing functional limitations, and setting goals to increase physical activity might help overcome this common and debilitating symptom of MS. To that end, it is important to develop efficacious and effective theory-based behavioral interventions that increase physical activity by focusing on SCT, particularly self-efficacy, functional limitations, and goal-setting, for fatigued persons with MS.

Interestingly, the only SCT variable that was significantly related with LPA was social support in our overall sample with MS, whereas SCT variables were mostly associated with MVPA and GLTEQ scores in the overall sample and subsamples. Social support might be the initial target in these SCT-based behavioral interventions that aim to increase physical activity in MS. For example, with a focus on social support, persons with MS who are sedentary may increase physical activity levels at light intensities and then progress to higher-intensity physical activities with the focus of other SCT variables that were associated with MVPA (i.e., functional limitations, exercise self-efficacy, and goal-setting). Of note, although the regression model only identified social support and functional limitations as significant correlates of device-measured physical activity and self-efficacy and goal-setting of self-reported physical activity, it is still important to consider other SCT variables when changing physical activity behavior.

5. Limitations

There are important limitations to consider when interpreting the results of this study. We utilized a cross-sectional design for this study; therefore, these results cannot be applied longitudinally. We note that only the inclusion of persons with only one valid day of accelerometer data might not provide a good index of regular physical activity. Our methods included self-reported diagnosis of MS, disease duration, and disability status. Moreover, we divided the sample into one group with elevated fatigued and another group without elevated fatigue using a self-report measure of fatigue severity in the last 7 days. Our sample of fatigued persons with MS had more progressive cases and greater disability compared to non-fatigued persons, and future research may consider examining these SCT variables in persons with MS who have progressive disease of moderate-to-severe disability. We note that the groups differed in fatigue as well as disease type and disability level, and that this might confound the result of the study. It may be important to identify SCT variables as correlates of persons with progressive MS, as correlates of physical activity may be different from persons with relapsing-remitting MS.[15] We further recognize that although fatigue often co-occurs with anxiety and depressive symptoms, we did not include those outcomes, and that these results may be driven by presence and/or severity of anxiety and depressive symptoms rather than fatigue itself. We did not include information on cognitive impairment; however, future studies should consider including this component. There may also an increased chance of type I error, as we applied a study-wide *p*-value of 0.05; however, we applied an *p*-value of 0.05 for examining differences and correlations on the basis of a specific theory – Social Cognitive Theory.

6. Conclusions

Overall, these findings identified differences in physical activity and SCT variables between fatigued and non-fatigued persons with MS. This study further reported lower levels of physical activity and worse scores in SCT measures in fatigued persons with MS. Goal-setting, self-efficacy, and functional limitations may be important targets of behavioral interventions for increasing physical activity among fatigued persons with MS, particularly as this subgroup demonstrates significantly lower levels of physical activity than non-fatigued persons with MS. These preliminary findings of such correlates may inform clinicians, researchers, and exercise specialists in the design and implementation of SCT-based behavioral interventions for increasing physical activity in this specific population with MS who have elevated fatigue to manage MS-related symptoms and other consequences.

Acknowledgements

Funding for this study was provided by the National Multiple Sclerosis Society [CA-1708-29059]. Research reported in this publication was supported, in part, by the Eunice Kennedy Shriver National Institute of Child Health & Human Development of the National Institutes of Health [NIH F32HD101214; F31HD097903; F31HD101281; T32HD071866], and the National Heart, Lung, and Blood Institute [NIH T32HL105349]. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Abbreviations

MS	multiple sclerosis
CNS	central nervous system
SCT	Social Cognitive Theory
FSS	Fatigue Severity Scale

LPA	light physical activity
MVPA	moderate-to-vigorous physical activity
GLTEQ	Godin Leisure-Time Exercise Questionnaire
EXSE	Exercise Self-Efficacy Scale
BARSE	Barriers for Self-Efficacy Scale
MOEES	Multidimensional Outcome Expectations for Exercise Scale
EGS	Exercise Goal setting Scale
EPS	Exercise Plans Scale
SPS	Social Provisions Scale
LL-FDI	Late-Life Function and Disability Instrument

REFERENCES

1. Wallin MT, Culpepper WJ, Campbell JD, Nelson LM, Langer-Gould A, Marrie RA et al. The prevalence of MS in the United States. Neurology 2019;92(10):e1029. [PubMed: 30770430]
2. Trapp BD, Nave KA. Multiple sclerosis: an immune or neurodegenerative disorder? Ann Rev Neurosci 2008;31:247–69. [PubMed: 18558855]
3. Bjartmar C, Trapp BD. Axonal and neuronal degeneration in multiple sclerosis: mechanisms and functional consequences. Curr Opin Neurol 2001;14(3):271–8. [PubMed: 11371748]
4. Samkoff LM, Goodman AD. Symptomatic management in multiple sclerosis. Neurol Clin 2011;29(2):449–63. [PubMed: 21439453]
5. Dendrou CA, Fugger L, Friese MA. Immunopathology of multiple sclerosis. Nat Rev Immunol 2015;15(9):545–58. [PubMed: 26250739]
6. Krupp L Fatigue is intrinsic to multiple sclerosis (MS) and is the most commonly reported symptom of the disease. Mult Scler 2006;12(4):367–8. [PubMed: 16900749]
7. Krupp LB, Serafin DJ, Christodoulou C. Multiple sclerosis-associated fatigue. Expert Rev Neurother 2010;10(9):1437–47. [PubMed: 20819014]
8. Asano M, Finlayson ML. Meta-analysis of three different types of fatigue management interventions for people with multiple sclerosis: exercise, education, and medication. Mult Scler Int 2014;2014:798285-. [PubMed: 24963407]
9. Motl RW, Suh Y, Weikert M, Dlugonski D, Balantrapu S, Sandroff B. Fatigue, depression, and physical activity in relapsing-remitting multiple sclerosis: Results from a prospective, 18-month study. Mult Scler Relat Disord 2012;1(1):43–8. [PubMed: 25876450]
10. Pilutti LA, Greenlee TA, Motl RW, Nickrent MS, Petruzzello SJ. Effects of exercise training on fatigue in multiple sclerosis: a meta-analysis. Psychosom Med 2013;75(6):575–80. [PubMed: 23788693]
11. Motl RW, Snook EM, Schapiro RT. Symptoms and physical activity behavior in individuals with multiple sclerosis. Res Nurs Health 2008;31(5):466–75. [PubMed: 18286635]
12. Neal WN, Cederberg KL, Jeng B, Sasaki JE, Motl RW. Is symptomatic fatigue associated with physical activity and sedentary behaviors among persons with multiple sclerosis? Neurorehabil Neural Repair 2020;34(6):505–11. [PubMed: 32340521]
13. Motl RW, Pekmezi D, Wingo BC. Promotion of physical activity and exercise in multiple sclerosis: Importance of behavioral science and theory. Mult Scler J Exp Transl Clin 2018;4(3):2055217318786745.

14. Ensari I, Kinnett-Hopkins D, Motl RW. Social cognitive correlates of physical activity among persons with multiple sclerosis: Influence of depressive symptoms. Disabil Health J 2017;10(4):580–6. [PubMed: 28363457]
15. Suh Y, Joshi I, Olsen C, Motl RW. Social cognitive predictors of physical activity in relapsing-remitting multiple sclerosis. Int J Behav Med 2014;21(6):891–8. [PubMed: 24407400]
16. Suh Y, Weikert M, Dlugonski D, Balantrapu S, Motl RW. Social cognitive variables as correlates of physical activity in persons with multiple sclerosis: findings from a longitudinal, observational study. Behav Med 2011;37(3):87–94. [PubMed: 21895426]
17. Pilutti L, Dlugonski D, Sandroff B, Klaren R, Motl R. Randomized controlled trial of a behavioral intervention targeting symptoms and physical activity in multiple sclerosis. Mult Scler 2014;20(5):594–601. [PubMed: 24009162]
18. Bandura A Human agency in social cognitive theory. Am Psychol 1989;44(9):1175–84. [PubMed: 2782727]
19. Bandura A Health promotion by social cognitive means. Health Educ Behav 2004;31(2):143–64. [PubMed: 15090118]
20. Uszynski MK, Casey B, Hayes S, Gallagher S, Purtill H, Motl RW et al. Social Cognitive Theory Correlates of Physical Activity in Inactive Adults with Multiple Sclerosis. Int J MS Care 2018;20(3):129–35. [PubMed: 29896049]
21. Motl RW, Suh Y, Weikert M. Symptom cluster and quality of life in multiple sclerosis. Journal of pain and symptom management 2010;39(6):1025–32. [PubMed: 20434872]
22. Motl RW, McAuley E. Symptom cluster as a predictor of physical activity in multiple sclerosis: preliminary evidence. J Pain Symptom Manage 2009;38(2):270–80. [PubMed: 19329276]
23. Dodd MJ, Miaskowski C, Lee KA. Occurrence of symptom clusters. J Natl Cancer Inst Monogr 2004;2004(32):76–8.
24. Learmonth YC, Motl RW, Sandroff BM, Pula JH, Cadavid D. Validation of patient determined disease steps (PDDS) scale scores in persons with multiple sclerosis. BMC Neurol 2013;13:37. [PubMed: 23617555]
25. Krupp LB, LaRocca NG, Muir-Nash J, Steinberg AD. The fatigue severity scale. Application to patients with multiple sclerosis and systemic lupus erythematosus. Arch Neurol 1989;46(10):1121–3. [PubMed: 2803071]
26. Sandroff BM, Motl RW, Suh Y. Accelerometer output and its association with energy expenditure in persons with multiple sclerosis. J Rehabil Res Dev 2012;49(3):467–75. [PubMed: 22773205]
27. Saint-Maurice PF, Troiano RP, Bassett DR Jr, Graubard BI, Carlson SA, Shiroma EJ et al. Association of Daily Step Count and Step Intensity With Mortality Among US Adults. JAMA 2020;323(12):1151–60. [PubMed: 32207799]
28. Godin Leisure-Time Exercise Questionnaire. Med Sci Sports Exerc 1997;29(6):36–8.
29. Godin G The Godin-Shephard Leisure-Time Physical Activity Questionnaire. Health Fit J Canada 2011;4(1):18–22.
30. Motl RW, Bollaert RE, Sandroff BM. Validation of the Godin Leisure-Time Exercise Questionnaire classification coding system using accelerometry in multiple sclerosis. Rehabil Psychol 2018;63(1):77–82. [PubMed: 28758772]
31. McAuley E. Self-efficacy and the maintenance of exercise participation in older adults. J Behav Med 1993;16(1):103–13. [PubMed: 8433355]
32. McAuley E The role of efficacy cognitions in the prediction of exercise behavior in middle-aged adults. J Behav Med 1992;15(1):65–88. [PubMed: 1583674]
33. Wójcicki TR, White SM, McAuley E. Assessing Outcome Expectations in Older Adults: The Multidimensional Outcome Expectations for Exercise Scale. J Gerontol B Psychol Sci Soc Sci 2009;64B(1):33–40.
34. Rovniak LS, Anderson ES, Winett RA, Stephens RS. Social cognitive determinants of physical activity in young adults: a prospective structural equation analysis. Ann Behav Med 2002;24(2):149–56. [PubMed: 12054320]
35. Chiu CY, Motl RW, Ditchman N. Validation of the Social Provisions Scale in people with multiple sclerosis. Rehabil Psychol 2016;61(3):297–307. [PubMed: 27088267]

36. McAuley E, Konopack JF, Motl RW, Rosengren K, Morris KS. Measuring Disability and Function in Older Women: Psychometric Properties of the Late-Life Function and Disability Instrument. J Gerontol A Biol Sci Med Sci 2005;60(7):901–9. [PubMed: 16079215]

37. Motl RW, McAuley E, Suh Y. Validity, invariance and responsiveness of a self-report measure of functional limitations and disability in multiple sclerosis. Disabil Rehabil 2010;32(15):1260–71. [PubMed: 20131947]

38. McAuley E, Jerome GJ, Elavsky S, Marquez DX, Ramsey SN. Predicting long-term maintenance of physical activity in older adults. Prev Med 2003;37(2):110–8. [PubMed: 12855210]

39. Cohen J Statistical power analysis for the behavioral science. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.

40. Motl RW, Weikert M, Suh Y, Dlugonski D. Symptom cluster and physical activity in relapsing-remitting multiple sclerosis. Res Nurs Health 2010;33(5):398–412. [PubMed: 20725947]

Author Manuscript

Author Manuscript

Author Manuscript

Highlights

- Fatigue is a common, severe, and debilitating symptom of MS.
- There is interest in theory-based programs for increasing physical activity in MS.
- Research often recruit mixed samples without a specific symptom such as fatigue.
- We examined Social Cognitive Theory variables as correlates of physical activity.
- Theory-based programs may promote physical activity in fatigued persons with MS.

Table 1.

Descriptive characteristics represented of the overall sample with multiple sclerosis (N=210) and subsamples of fatigued (n=134) and non-fatigued (n=76).

Characteristic	Overall	Fatigued	Non-Fatigued	*p*-value
Age, *years(SD)*	49.6(13.2)	50.2(13.5)	48.6(12.8)	0.40
Sex, *n(%)*				0.49
Female	157(75)	102(76)	55(72)	
Male	52(25)	31(23)	21(28)	
Race, *n(%)*				0.48
Caucasian	136(65)	91(68)	45(59)	
African American	65(31)	39(29)	26(34)	
Other	8(4)	4(3)	4(5)	
Education Level, *n(%)*				0.40
Non-college graduate	95(44)	61(45)	30(40)	
College graduate	122(56)	73(55)	46(60)	
Income Level, *n(%)*				0.05
≤ $40,000	76(35)	53(40)	20(26)	
> $40,000	135(62)	78(58)	54(71)	
MS type, *n(%)*				0.04
Relapsing-remitting	186(88)	113(84)	73(96)	
Progressive	18(9)	17(13)	1(1)	
Disease duration, *years(SD)*	12.8(9.5)	12.8(10.0)	12.8(8.4)	0.78
PDDS, *median(IQR)*	1(0–3)	2(1–4)	0(0–2)	0.00

Note: MS = multiple sclerosis; PDDS = Patient Determined Status Scale. Data are presented as mean (standard deviation) and number (percentage). Only PDDS scores are presented as median (interquartile range).

Author Manuscript

Author Manuscript

Author Manuscript

Table 2.

Descriptive statistics of physical activity and Social Cognitive Theory variables in the overall sample of persons with multiple sclerosis (N=207) and subsamples of fatigued (n=133) and non-fatigued (n=74).

Variable	Overall	Fatigued	Non-Fatigued	*t*-value	*p*-value	Cohen's *d*
LPA, *min/day*	293.0(84.0)	286.9(81.0)	302.5(88.2)	1.24	0.22	0.18
MVPA, *min/day*	20.3(19.8)	18.0(20.0)	24.0(19.0)	2.01	0.05	0.30
GLTEQ	22.1(25.5)	17.7(23.7)	30.2(26.8)	3.46	0.00	0.49
EXSE	62.2(35.7)	52.2(35.3)	77.7(30.4)	5.11	0.00	0.77
BARSE	48.1(26.4)	40.8(25.1)	59.3(24.6)	4.97	0.00	0.74
MOEES	58.6(7.2)	57.9(6.9)	59.8(7.6)	1.73	0.09	0.25
EGS	23.0(10.9)	21.4(10.7)	25.5(10.9)	2.55	0.01	0.38
EPS	24.7(8.7)	23.0(8.1)	27.4(9.0)	3.46	0.00	0.51
SPS	18.1(3.2)	17.5(3.0)	19.1(3.1)	3.35	0.00	0.50
LL-FDI	58.0(13.7)	54.4(13.5)	63.6(12.0)	4.72	0.00	0.72

Note: LPA = light physical activity, MVPA = moderate-to-vigorous physical activity, GLTEQ = Godin Leisure-Time Exercise Questionnaire, EXSE = Exercise Self-Efficacy Scale, BARSE = Barriers for Self-Efficacy Scale, MOEES = Multidimensional Outcome Expectations for Exercise Scale, EGS = Exercise Goal-Setting Scale, EPS = Exercise Planning Scale, SPS = Social Support Scale, LL-FDI = Late-Life Function and Disability Instrument.

Table 3.

Spearman's rank-order bivariate correlations between physical activity and the Social Cognitive Theory variables in the overall sample of persons with multiple sclerosis (N=206) and subsamples of fatigued (n=133) and non-fatigued (n=73).

	Overall			Fatigued			Non-Fatigued		
	LPA	**MVPA**	**GLTEQ**	**LPA**	**MVPA**	**GLTEQ**	**LPA**	**MVPA**	**GLTEQ**
EXSE	0.08	0.38**	0.42**	0.01	0.31**	0.36**	0.14	0.41**	0.34**
BARSE	0.06	0.25**	0.38**	−0.01	0.18	0.34**	0.13	0.23*	0.31**
MOES	0.03	0.15*	0.28**	0.00	0.04	0.16	0.08	0.21	0.36**
EGS	0.06	0.21**	0.41**	0.01	0.25**	0.37**	0.15	0.08	0.38**
EPS	−0.07	0.10	0.32**	−0.11	0.01	0.25**	−0.01	0.13	0.28*
SPS	0.15*	0.13	0.28**	0.24	0.11	0.19*	0.04	0.09	0.32**
LLFDI	0.09	0.52**	0.39**	0.12	0.52**	0.42**	−0.03	0.40**	0.18

Note:

* = significant at 0.05 level,

** = significant at 0.01 level.

LPA = light physical activity, MVPA = moderate-to-vigorous physical activity, GLTEQ = Godin Leisure-Time Exercise Questionnaire, EXSE = Exercise Self-Efficacy Scale, MOEES = Multidimensional Outcomes Expectations for Exercise Scale, EGS = Exercise Goal-Setting Scale, EPS = Exercise Planning Scale, LL-FDI = Late-Life Function and Disability Instrument.

Table 4.

Stepwise linear regression analyses of independent associations between physical activity and Social Cognitive Theory variables for the overall sample with multiple sclerosis (n=184).

Step	Variable	*B*	*SE B*	β
a: LPA				
Step 1	SPS	5.317	1.831	0.210 *
Note: R^2 = 0.044				
b: MVPA				
Step 1	LL-FDI	0.562	0.103	0.381 *
Note: R^2 = 0.145				
c: GLTEQ				
Step 1	EXSE	0.274	0.050	0.385 *
Step 2	EXSE	0.221	0.052	0.310 *
	EGS	0.489	0.170	0.211 *
Note: R^2 = 0.148 for Step 1; R^2 = 0.187 for Step 2				

Note: MVPA = moderate-to-vigorous physical activity, LL-FDI = Late-Life Function and Disability Instrument, GLTEQ = Godin Leisure-Time Exercise Questionnaire, EGS = Exercise Goal-Setting Scale, EXSE = Exercise Self-Efficacy Scale

* $p<0.05$ with two-tailed test.

Table 5.

Stepwise linear regression analyses of independent associations between physical activity and Social Cognitive Theory variables for the fatigued sample with multiple sclerosis (n=108).

Step	Variable	*B*	*SE B*	β
a: MVPA				
Step 1	LL-FDI	0.527	0.136	0.353 *
Step 2	LL-FDI	0.471	0.134	0.315 *
	EGS	0.440	0.171	0.231 *
Note: R^2 = 0.125 for Step 1; R^2 = 0.176 for Step 2				
b: GLTEQ				
Step 1	EXSE	0.260	0.062	0.377 *
Step 2	EXSE	0.182	0.071	0.264 *
	LL-FDI	0.407	0.186	0.225 *
Step 3	EXSE	0.131	0.074	0.190
	LL-FDI	0.414	0.183	0.228 *
	EGS	0.454	0.216	0.197 *
Note: R^2 = 0.143 for Step 1; R^2 = 0.181 for Step 2; R^2 = 0.214 for Step 3				

Note: MVPA = moderate-to-vigorous physical activity, LL-FDI = Late-Life Function and Disability Instrument, EGS = Exercise Goal-Setting Scale, GLTEQ = Godin Leisure-Time Exercise Questionnaire, EXSE = Exercise Self-Efficacy Scale

* $p<0.05$ with two-tailed test.

Table 6.

Stepwise linear regression analyses of independent associations between physical activity and Social Cognitive Theory variables for the non-fatigued sample with multiple sclerosis (n=73).

Step	Variable	*B*	*SE B*	β
a: MVPA				
Step 1	LL-FDI	0.646	0.186	0.381 *
Note: R^2 = 0.145				
b: GLTEQ				
Step 1	BARSE	0.317	0.121	0.304 *
Step 2	BARSE	0.283	0.119	0.272 *
	SPS	2.154	0.963	0.255 *
Note: R^2 = 0.092 for Step 1; R^2 = 0.157 for Step 2				

Note: MVPA = moderate-to-vigorous physical activity, LL-FDI = Late-Life Function and Disability Instrument, GLTEQ = Godin Leisure-Time Exercise Questionnaire, BARSE = Barriers for Self-Efficacy Scale; SPS = Social Provisions Scale

* p<0.05 with two-tailed test.