A peer-reviewed version of this preprint was published in PeerJ on 6 August 2015.

View the peer-reviewed version (peerj.com/articles/1158), which is the preferred citable publication unless you specifically need to cite this preprint.

Ploughman M, Harris C, Wallack EM, Drodge O, Beaulieu S, Mayo N, Health Lifestyle and Aging with MS Canadian Consortium. 2015. Predictors of exercise participation in ambulatory and non-ambulatory older people with multiple sclerosis. PeerJ 3:e1158 https://doi.org/10.7717/peerj.1158

Predictors of exercise participation are different depending on ambulatory status among older people with multiple sclerosis

Michelle Ploughman, Chelsea Harris, Elizabeth M Wallack, Olivia Drodge, Serge Beaulieu, Stephen Hogan

Background: Exercise at moderate intensity may confer neuroprotective benefits in multiple sclerosis (MS), however it has been reported that people with MS (PwMS) exercise less than national guideline recommendations. We aimed to determine predictors of moderate to vigorous exercise among a sample of older Canadians with MS who were divided into ambulatory (less disabled) and non-ambulatory (more disabled) groups.Methods: We analysed data collected as part of a national survey of health, lifestyle and aging with MS. Participants (n=743) were Canadians over 55 years of age with MS for 20 or more years. We identified 'a priori' variables (demographic, personal, socioeconomic, physical health, exercise history and health care support) that may predict exercise at moderate to vigorous intensity (>6.75 metabolic equivalent hours/week). Predictive variables were entered into stepwise logistic regression, adding and deleting correlated variables until best fit was achieved for each of the two groups (ambulatory and non-ambulatory). Results: Seventy-seven percent (77%) of participants in the ambulatory group (n=351) and 35% of the non-ambulatory group (n=392) were classified as exercisers. In the ambulatory group, exercise predictors included degree of disability (OR 1.95, 95%CI 1.18-3.25), depressive symptoms (OR 0.51, 95%CI 0.29-0.89) and perseverance (OR 1.8, 95%CI 1.04-3.10). In the non-ambulatory group, exercise predictors included degree of disability (OR 5.3, 95%CI 3.22-8.71) and perseverance (OR 2.1, 95%CI 1.27-3.54). It was also notable that the factors, age, gender, years with MS, co-morbid conditions, social support, health care support and financial status were not predictive of exercise. Conclusions: This is the first examination of exercise and exercise predictors among older, more disabled PwMS. Disability and perseverance are major predictors of exercise participation (at moderate to vigorous levels) in both ambulatory and non-ambulatory groups. Presence of depressive symptoms was only predictive in the ambulatory group. Our results suggest that more exercise options must be developed for people with greater disability. Perseverance and depression are both characteristics that are modifiable and are potential targets for exercise adherence interventions.

Michelle Ploughman PT, PhD*, Chelsea Harris BKin MPH*, Elizabeth M. Wallack BA*, Olivia Drodge BKin*, Serge Beaulieu**, Stephen Hogan BScP.T.*

Health Lifestyle and Aging with MS Canadian Consortium: John D. Fisk PhD[§], A. Dessa Sadovnick PhD[†], Paul O'Connor, MD, FRCPC[‡], Sarah A. Morrow, MD[¶], FRCPC, Luanne M. Metz MD, FRCPC[ϕ], Penelope Smyth MD, FRCPC[#], Nancy Mayo, PhD[§§] , Ruth Ann Marrie, MD, PhD[††], Penelope W. Alderdice PhD*, Mark Stefanelli MD FRCPC[¶¶], Marshall Godwin, MD[##]

*Recovery and Performance Laboratory, Rehabilitation Research Unit, Faculty of Medicine, Memorial University, St. John's NL Canada

**Eastern Health Authority, St. John's NL Canada

[§]Dalhousie University, Halifax NS, Canada

†Department of Medical Genetics and Division of Neurology, Faculty of Medicine University of British Columbia, Vancouver BC, Canada

[‡]Department of Neurology, St. Michaels Regional Hospital, Toronto ON, Canada

[¶]London Health Science Centre, London ON, Canada

[#]Department of Neurology, University of Alberta, Edmonton AB, Canada

[ϕ]Clinical Neurosciences, University of Calgary, Calgary AB, Canada

[§§]Clinical Epidemiology, McGill University, Montreal QC, Canada

††Departments of Internal Medicine and Community Health Sciences, University of Manitoba, Winnipeg MB, Canada

[¶¶]Neurology, Faculty of Medicine, Memorial University, St. John's NL Canada

[##]Primary Health Care Research Unit, Faculty of Medicine, Memorial University, St. John's NL, Canada

Corresponding Author/Research Site
Dr. Michelle Ploughman, Recovery and Performance Laboratory, Rehabilitation Research Unit, Faculty of Medicine, Memorial University, Rm 400, L.A. Miller Centre, 100 Forest Rd., St. John's NL Canada. Ph 709 777 2099; fax 709 777 2082; email mploughm@mun.ca

INTRODUCTION

Exercise training has the potential to mitigate the symptoms of multiple sclerosis (MS), a neurological disease characterized by unpredictable progressive episodes of inflammation and demyelination of the central nervous system (Latimer-Cheung et al. 2013; Prakash et al. 2010). The potential role of exercise to slow MS progression, preserve neuronal integrity and promote healthy aging is gaining interest (Dalgas & Stenager 2012), however people with MS engage in lower levels of exercise when compared to the general population (Motl & McAuley 2009; Stroud et al. 2009; van der Ploeg et al. 2007). With high exercise drop-out rates (Kayes et al. 2011; Ploughman et al. 2012a), nearly 80% of relapsing-remitting MS patients are not reaching the public health recommended guidelines of moderate-to-vigorous physical activity (Klaren et al. 2013). Understanding the factors predicting exercise participation among people with MS-related disability is the first step in developing new strategies to promote exercise.

Most studies examining predictors of exercise in MS do not distinguish between physical activity and exercise (Boslaugh & Andresen 2006; Dalgas & Stenager 2012). Although the terms are sometimes used interchangeably, they are different in that physical activity is any activity that is part of everyday life, while exercise is planned and structured intended to improve or maintain physical fitness (ACSM 2010). Since emerging evidence suggests that exercise at moderate to high intensity (as opposed to light physical activity) is neuroprotective (Austin et al. 2014; Klaren et al. 2014; Ploughman et al. 2014a), predictors specific to higher intensity training may be important for exercise prescription. Previous studies have reported that exercise barriers in MS are primarily level of disability, fatigue (Asano et al. 2013) and self-efficacy (Stroud et al. 2009) while physical activity predictors are level of disability, enjoyment, and social support (Motl et al. 2006). In one study of moderate to vigorous exercise activity predictors among people with spinal cord injury (SCI; mean age 47 and average 15 years post-injury), strongest exercise predictors were positive exercise intentions

and number of years post-injury. Greater social integration, physical independence and employment were also associated with exercise (Ginis et al. 2012). Whether these factors also apply to people with MS-related disability is not known. Considering the importance of exercise, understanding the barriers to participation in exercise at intensities high enough to induce a training effect is imperative for future MS clinical trials.

Almost all studies in MS and exercise recruit subjects at the early phase of the disease (Rietberg et al. 2005). Older people with MS are often excluded from MS research (Ploughman et al. 2012a; Ploughman et al. 2012b; Ploughman et al. 2014b). Several authors in systematic reviews have expressed an urgent need to examine exercise interventions among people with more advanced MS-related disability (Latimer-Cheung et al. 2013; Rietberg et al. 2005). In this study we aimed to determine the factors predicting exercise adherence (at American College of Sports Medicine (ACSM) recommended levels) among older people with MS in order to design more tailored interventions across disability levels. We hypothesize that predictors of exercise will be different between people with MS who are ambulatory and those who are non-ambulatory.

METHODS

Survey Design

We accessed and performed secondary analysis of data collected from 743 people with MS as part of a national survey; the 'Canadian Survey of Health, Lifestyle and Aging with MS' (Ploughman et al. 2014b) which was approved by 11 health research ethics boards across Canada. The database included health and lifestyle variables obtained from questionnaires mailed to participants over the age of 55 years with MS symptoms for more than 20 years. Complete survey methods are described elsewhere (Ploughman et al. 2014b).

Potential predictive variables

Based on previous research (Asano et al. 2013; Kayes et al. 2011; Motl et al. 2006; Ploughman et al. 2012a; Ploughman et al. 2012b; Stroud et al. 2009) a list of 'a priori' factors potentially associated with exercise adherence were categorized into six domains; (1) demographic, (2) personal, (3) socioeconomic, (4) physical health, (5) exercise history and (6) healthcare support (Table 1). Demographic information included age, gender, years of education, type of MS at diagnosis and years with MS symptoms. Personal factors included stress, measured as part of the Simple Lifestyle Indicator Questionnaire (SLIQ) (Godwin et al. 2008), mood, measured using the Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith 1983), and resilience (the Resilience Scale) (Wagnild 2009). HADS and the Resilience Scale were separated into subcomponents; HADS into anxiety (HADS-A) and depression (HADS-D) and resilience into five aspects (equanimity, perseverance, self-reliance, meaningfulness, and existential aloneness) (Wagnild 2009).

Physical health variables included disability, measured by the Barthel Index (Mahoney & Barthel 1965), fatigue (rated with a visual analogue scale), and co-morbid conditions determined using the Co-morbidity Questionnaire developed by Marie and Horwitz (Marrie & Horwitz 2010) (Table 1). Socioeconomic variables included financial situation and social support. Level of social support was measured using the Personal Resource Questionnaire-2000 which consists of 15 items with a score range from a low of 7 to high of 105 (Weinert & Brandt 1987). To determine health care support, participants identified and ranked the helpfulness of health care providers on a scale of 1 (not helpful) to 5 (very helpful). Participation in exercise and other lifestyle habits (smoking, alcohol, diet) was collected from responses to the Simple Lifestyle Indicator Questionnaire (SLIQ) (Godwin et al. 2008). In addition to describing their current level of exercise, respondents were also asked to describe the type and intensity of exercise they had engaged between the ages of 20 and 30 years (past exercise experience) (Table 1).

Table 1 about here.

Data Analysis

The dependent variable (exercise or no exercise) was calculated by recoding the descriptive exercise information from SLIQ into metabolic equivalents (METS); a measure that quantifies exercise intensity based on the ACSM guidelines (ACSM 2010). After calculating MET-hours per week (MET intensity x number of 1 hour intervals of exercise per week), we classified respondents as 'Exercisers' (>6.75 MET-hours per week) or 'Non-exercisers' (<6.75 MET hours per week). These cut-off values were based on the ACSM recommendation that in order to improve or maintain fitness people with MS should be active three times weekly for 20-30 minutes at a moderate intensity (~4.5METs x 3 x 30 minute sessions = 6.75 MET-hours/week)(ACSM 2010).

In order to examine predictors of exercise among people with different degrees of MS-related disability the cohort was split into two categories based on the response to the ambulation question in the Barthel Index. Those who scored 0 or 5 (answers walk independently with or without a cane >150 meters) were categorized as 'Ambulators'. Respondents who scored 10 or 15 on Barthel Index ambulatory question (answers use of wheelchair/walking aid indoors only) were categorized as 'Non-Ambulators'. Descriptive statistics (t-test and chi-square for binary variables) were used to compare the characteristics of the Ambulatory and Non-ambulatory groups. In the first step of building an explanatory model, each 'a priori' variable (independent variable) was separately entered into a simple binary logistic regression with the dependent variable (exercise, no exercise). Data from the Ambulatory and Non-Ambulatory groups were assessed separately. In the second step, only those variables that significantly predicted exercise, ($p<0.05$) were entered into stepwise logistic regression. In the third step, variables from the previous step were transformed into binary variables and re-entered into the model. In all steps, colinearity between variables was checked. Correlated variables were

added and deleted in the models until best fit was achieved. We used the Hosmer and Lemeshow Test to assess model fit in which a non-significant p value indicates a good fit. Analysis was performed in SPSS v20 with significance set at $p<0.05$.

RESULTS

Participant Characteristics

Respondents were on average 64.6 (±6.18) years of age and lived with MS symptoms for 32.9 years (±9.5) with the ratio of females to males 3.5:1. In comparing the characteristics of the Ambulatory (n=351) and Non-Ambulatory groups (n=392), the Non-Ambulatory group were older and more disabled (as measured by the Barthel Index) (Table 2). They were more likely to be diagnosed with primary progressive disease and less likely to be diagnosed with benign MS (on initial diagnosis) (Table 2). Seventy-seven percent (76.8%) of participants in the Ambulatory group were classified as exercisers; almost twice that of the Non-Ambulatory group (35.2% exercisers). When describing their past exercise experience, 368/743 (50%) respondents reported that they were previously active but are now inactive. One hundred and four respondents (14%) reported being inactive for most of their life (not active during the ages 20-30 and not currently active) and 271 (36.5%) reported that they were active when they were young and are still currently active. Those who described their current exercise reported participating in activities such as swimming and water fitness (n=82), gardening and housework (n=114), yoga, stretching or Tai Chi (n=84) and most commonly, walking (n=266).

Table 2 about here

Predictors of Exercise in Ambulatory and Non-Ambulatory Groups

Of the 14 proposed factors, six were significantly associated with exercise participation (exercise, no exercise) in the Ambulatory group and four in the Non-Ambulatory group (Table 1).

There were expected correlations between predictor variables (>0.3); resilience, depressive symptoms, anxiety symptoms and social support. In order to build predictive models with the fewest explanatory factors, we conducted model fit analysis by adding and deleting correlated factors until we achieved best fit. Correlations of the explanatory variables are in Tables 3 (Ambulatory) and 4 (Non-Ambulatory). In the final model, degree of disability was split into a binary variable, with "high disability" including those categorized as having a Barthel score of 0-90 and "low disability" including those with a Barthel score of 91-100 (Balu 2009). Perseverance was also split into "high" and "low" perseverance, with "high" perseverance including those with a score of 11-14 in the perseverance sub-category of the Resilience Scale, and "low" perseverance including those with a score of 1-10. Depression was split into "depressive symptoms" and "no depressive symptoms", with "no depressive symptoms" including scores of 0-7 on the HADS depression scale and "depressive symptoms" including scores of 8-21 (Stern 2014).

Two final predictive models were created (one for Ambulatory group and another for Non-Ambulatory group) (Table 5). In the Ambulatory group, people with lower levels of disability (<91 Barthel Index) were almost twice as likely to exercise at moderate to vigorous levels (OR 1.95, 95%CI 1.18-3.25). Those with more depressive symptoms (>7 HADS Depression score) were half as likely to exercise (OR 0.51, 95%CI 0.29-0.89) and those with high perseverance (>10 perseverance subscore of the Resilience Scale) almost twice as likely to exercise (OR 1.8, 95% CI 1.04-3.10). The model fit was excellent (Hosmer and Lemeshow χ-square 1.24 p=0.87) with only one exerciser and one non-exerciser unable to be classified.

In the Non-Ambulatory group, the predictive model included level of disability and perseverance with excellent model fit (Hosmer and Lemeshow χ-square 0.001 p=1.0) and no participants unable to be classified. In this group, people with lower level of disability (>90 Barthel

Index) were 5.3 times more likely (OR 5.3 95%CI 3.22-8.71) and those with higher perseverance almost twice as likely (OR 2.1 95%CI 1.27-3.54) to participate in moderate to vigorous exercise (Table 5).

Tables 3, 4 and 5 about here

DISCUSSION

To our knowledge this is the first examination of exercise predictors in a sample of people with a full range of MS-related disability; from independently ambulatory to completely dependent for activities of daily living (ADL). We divided the sample of 743 older Canadians with MS into ambulatory (low disability) and non-ambulatory (higher disability and more progressive disease) groups in order to determine if the predictors would differ between the groups; critical knowledge in order to promote exercise compliance in future MS clinical exercise trials. We also applied strict criteria to delineate exercise levels based on ACSM guidelines since a growing body of research suggests that moderate exercise (not light physical activity) may be neuroprotective (Austin et al. 2014; Dalgas & Stenager 2012).

Level of disability a major predictor

Level of disability was the major predictor of exercise in both Ambulatory and Non-Ambulatory groups. Older people with MS reporting Barthel Score greater than 90, indicating independence for most ADL, were about five times more likely (Non-Ambulatory) and twice as likely (Ambulatory) to participate in exercise. This suggests that respondents who needed assistance or who had walking disability may have few exercise options. Development of seated and modified exercise programs followed by effectiveness research is required. Programs that are individually tailored, guided by qualified personnel such as a physiotherapist, focusing on goal-setting and independence

using remote technology such as Blue Prescription, hold promise (Hale et al. 2013). Several systematic reviews examining exercise in MS suggest a critical need for rehabilitation research among more disabled groups (Latimer-Cheung et al. 2013; Rietberg et al. 2005). Although our sample were on average 64 years of age with MS symptoms for about 33 years, our finding of the critical role of disability in exercise concurs with findings from a sample of 417 ambulatory participants who were on average 43 years old with symptoms for about 8 years (Asano et al. 2013) and among 68 people with relapsing-remitting MS (Suh et al. 2014). Although Asano and group (Asano et al. 2013) reported fatigue (feeling too tired) as an exercise barrier, the role of fatigue in exercise was not supported in our study. This may be due to the difference in MS chronicity of the samples examined or the method of measuring subjective fatigue.

Our findings also suggest that the predictors of exercise participation in MS differ somewhat from those of people with SCI (Ginis et al. 2012). Martin Ginis and group showed that physical independence and injury severity were not strongly predictive of exercise participation in middle-aged people with chronic spinal cord injury (Ginis et al. 2012), suggesting that interventions to promote exercise compliance in SCI may not be entirely applicable to MS.

Perseverance

A novel finding in this study was the role of resilience, specifically perseverance, in predicting exercise participation. People who reported higher perseverance were about twice as likely to exercise whether they were ambulatory or not. In our previous qualitative research (Ploughman et al. 2012a; Ploughman et al. 2012b), perseverance, or commitment to an outcome despite challenges, had previously emerged as a characteristic of people who maintained exercise into old age despite their MS-related symptoms. A closer examination of our survey data showed that a surprising six percent of the ‘exercisers’ who fell into the ‘total dependence’ and ‘severe disability’ category (according to

Barthel Index) maintained physical activity at least three times weekly despite their impairments. Previous results of the 'Canadian Survey of Health Lifestyle and Aging with MS' database showed that this sample of older people with MS exercise more than other older Canadians (Ploughman et al. 2014b).

Other studies have shown that self-efficacy (Kasser & Kosma 2012; Kosma & Kasser 2012; Nickel et al. 2014; Schmitt et al. 2014), perceived exercise benefits (Kosma & Kasser 2012; Suh et al. 2014) and positive exercise intentions (Ginis et al. 2012) are associated with exercise participation in people with MS and SCI-related mobility disability. Self-efficacy, resilience and perseverance are overlapping constructs that impact health behaviors (Pilutti et al. 2014; Sinnakaruppan et al. 2010). Resilience is believed to be an innate characteristic but research suggests that it can also be learned (McAllister & McKinnon 2009). Researchers have used focused cognitive behavioural techniques to encourage optimism and dispute pessimistic thinking as a method to improve individual resilience and self-efficacy (Graziano et al. 2014). Resilience can be improved using optimism training, as well as teaching control and empowerment, educating individuals about their illness, and involving patients in support groups (Ng et al. 2013). These techniques are clearly important in promoting exercise participation and should be considered in the design of exercise trials especially among people with significant MS-related barriers.

Depressive symptoms: an exercise predictor only in ambulatory participants

Our findings showed that PwMS in the ambulatory group with more depressive symptoms (>7 HADS Depression score) were half as likely to exercise. Motl et al. also showed that depression was a symptom inversely associated with exercise in a group of ambulatory subjects with relapsing–remitting MS (Suh et al. 2010). The fact that depressive symptoms were not predictive in the non-ambulatory group was a novel finding. Depression is also not predictive of exercise among people with chronic

SCI (Martin-Ginis 2012). We do not know why this disparity exists between the walking disability groups, however we propose that older people with MS who are non-ambulatory may have adjusted to the changes earlier in their disease course. This phenomenon is often termed the 'disability paradox' which has been reported previously in qualitative research of aging with MS (Ploughman et al. 2012a; Ploughman et al. 2012b).

Depression is a common disorder in MS with prevalence about 20% depending on the study (Viner et al. 2014; Wood et al. 2013). Importantly, since depression greatly impacts exercise, is treatable and modifiable, depression screening and treatment should become part of routine management of MS. It is also a factor that should be measured and adjusted for in exercise and rehabilitation research.

Factors that do not predict exercise

Previous research suggests that as individual's age they experience a progressive loss of cognitive and physical skills and abilities, which act as barriers for engagement in healthy lifestyle practices, like physical activity (Widerstrom-Noga & Finlayson 2010)(Crocker, 2011; Motl et al, 2006; Prakash et al, 2009). Our findings did not support age or years with MS as exercise predictors. This disparity may be due to the fact that our sample included only older people over the age of 55 with MS for more than 20 years. The effect of age may be more pronounced in a younger cohort.

Based on previous qualitative and quantitative we had expected that gender (Anens et al. 2014), social support (Ploughman et al. 2012a), financial resources (Ginis et al. 2012), previous exercise behaviors and the support of health care professionals (Ploughman et al. 2012b) would be predictive of exercise participation but they were not. When subjected to rigorous analysis in a large cohort with MS-related disability, the influence of these factors were negligible and even absent. On the other

hand, our cohort of older people with MS was unique so the impact of gender (Anens et al. 2014) and other differences may not be as applicable in this group.

Limitations

Although this unique cohort may provide new insights into maintaining exercise participation among people with MS as they age, there are some study limitations. The cross-sectional design limits our ability to assess change and the effects of variables on predicting exercise participation overtime. By nature of the volunteer survey design, our sample may be biased in that active participants and those without cognitive impairment may have been more likely to respond. We did not examine cognitive impairment, nor did we have access to data about sleep patterns and pain; potential moderators of exercise and physical activity. We also did not include objective measurement; rather subjects self-reported the health and lifestyle behaviors.

CONCLUSION

This study sought to determine the factors predicting exercise adherence among older people with MS-related disability. We found level of disability and perseverance to be strong predictors whether participants were ambulatory or not. Clearly, in order for older people with MS to maintain exercise participation as they age they need exercise tailored to their abilities paired with techniques to overcome challenges that arise. Most importantly, in the ambulatory group, who likely have more exercise options, they require specific management of depressive symptoms in order to participate in exercise.

296 **ACKNOWLEDGEMENTS**

297

298 Support was received from the MS Society of Canada and local chapters; provincial MS clinic

299 neurologists, MS nurses, administrative and research staff; and the Rehabilitation and Continuing Care

300 Program, Eastern Health Authority. We specifically acknowledge the work of site coordinators: Trudy

301 Campbell, Heather Rosehart, Amy Cuthbertson, Darren Nickel, Pam Dumont, Madonna de Lemos,

302 Deborah Goldberg, Irene Yee, Nicholas Hall, Maureen Perera, Sarah Williamson, Carolina Moriello

303 and Vanessa Bouchard.

304

References

Anens E, Emtner M, Zetterberg L, and Hellstrom K. 2014. Physical activity in subjects with multiple sclerosis with focus on gender differences: a survey. *Bmc Neurology* 14.

Asano M, Duquette P, Andersen R, Lapierre Y, and Mayo NE. 2013. Exercise barriers and preferences among women and men with multiple sclerosis. *Disabil Rehabil* 35:353-361.

Austin MW, Ploughman M, Glynn L, and Corbett D. 2014. Aerobic exercise effects on neuroprotection and brain repair following stroke: A systematic review and perspective. *Neurosci Res* 87C:8-15.

Balu S. 2009. Differences in psychometric properties, cut-off scores, and outcomes between the Barthel Index and Modified Rankin Scale in pharmacotherapy-based stroke trials: systematic literature review. *Curr Med Res Opin* 25:1329-1341.

Boslaugh SE, and Andresen EM. 2006. Correlates of physical activity for adults with disability. *Prev Chronic Dis* 3:A78.

Dalgas U, and Stenager E. 2012. Exercise and disease progression in multiple sclerosis: can exercise slow down the progression of multiple sclerosis? *Ther Adv Neurol Disord* 5:81-95.

Ginis KA, Arbour-Nicitopoulos KP, Latimer-Cheung AE, Buchholz AC, Bray SR, Craven BC, Hayes KC, McColl MA, Potter PJ, Smith K et al. . 2012. Predictors of leisure time physical activity among people with spinal cord injury. *Ann Behav Med* 44:104-118.

Godwin M, Streight S, Dyachuk E, van den Hooven EC, Ploemacher J, Seguin R, and Cuthbertson S. 2008. Testing the Simple Lifestyle Indicator Questionnaire: Initial psychometric study. *Can Fam Physician* 54:76-77.

Graziano F, Calandri E, Borghi M, and Bonino S. 2014. The effects of a group-based cognitive behavioral therapy on people with multiple sclerosis: a randomized controlled trial. *Clinical Rehabilitation* 28:264-274.

Hale LA, Mulligan HF, Treharne GJ, and Smith CM. 2013. The feasibility and short-term benefits of Blue Prescription: a novel intervention to enable physical activity for people with multiple sclerosis. *Disabil Rehabil* 35:1213-1220.

Kasser SL, and Kosma M. 2012. Health beliefs and physical activity behavior in adults with multiple sclerosis. *Disabil Health J* 5:261-268.

Kayes NM, McPherson KM, Taylor D, Schluter PJ, and Kolt GS. 2011. Facilitators and barriers to engagement in physical activity for people with multiple sclerosis: a qualitative investigation. *Disabil Rehabil* 33:625-642.

Klaren RE, Motl RW, Dlugonski D, Sandroff BM, and Pilutti LA. 2013. Objectively quantified physical activity in persons with multiple sclerosis. *Arch Phys Med Rehabil* 94:2342-2348.

Klaren RE, Motl RW, Woods JA, and Miller SD. 2014. Effects of exercise in experimental autoimmune encephalomyelitis (an animal model of multiple sclerosis). *J Neuroimmunol* 274:14-19.

Kosma M, and Kasser S. 2012. Psychosocial Predictors of Physical Activity among Adults with Multiple Sclerosis. *Annals of Behavioral Medicine* 43:S203-S203.

Latimer-Cheung AE, Pilutti LA, Hicks AL, Martin Ginis KA, Fenuta AM, MacKibbon KA, and Motl RW. 2013. Effects of exercise training on fitness, mobility, fatigue, and health-related quality of life among adults with multiple sclerosis: a systematic review to inform guideline development. *Arch Phys Med Rehabil* 94:1800-1828 e1803.

Mahoney FI, and Barthel DW. 1965. Functional Evaluation: The Barthel Index. *Md State Med J* 14:61-65.

Marrie RA, and Horwitz RI. 2010. Emerging effects of comorbidities on multiple sclerosis. *Lancet Neurol* 9:820-828.

McAllister M, and McKinnon J. 2009. The importance of teaching and learning resilience in the health disciplines: a critical review of the literature. *Nurse Educ Today* 29:371-379.

American College of Sports Medicine. 2010. *ACSM's Guidelines for Exercise Testing and Prescription*. Philidelphia, PA: Lippincott Williams & Wilkins.

Motl RW, and McAuley E. 2009. Pathways between physical activity and quality of life in adults with multiple sclerosis. *Health Psychol* 28:682-689.
Motl RW, Snook EM, McAuley E, Scott JA, and Douglass ML. 2006. Correlates of physical activity among individuals with multiple sclerosis. *Ann Behav Med* 32:154-161.
Ng A, Kennedy P, Hutchinson B, Ingram A, Vondrell S, Goodman T, and Miller D. 2013. Self-efficacy and health status improve after a wellness program in persons with multiple sclerosis. *Disabil Rehabil* 35:1039-1044.
Nickel D, Spink K, Andersen M, and Knox K. 2014. Attributions and self-efficacy for physical activity in multiple sclerosis. *Psychol Health Med* 19:433-441.
Pilutti LA, Dlugonski D, Sandroff BM, Klaren R, and Motl RW. 2014. Randomized controlled trial of a behavioral intervention targeting symptoms and physical activity in multiple sclerosis. *Multiple Sclerosis Journal* 20:594-601.
Ploughman M, Austin MW, Glynn L, and Corbett D. 2014a. The Effects of Poststroke Aerobic Exercise on Neuroplasticity: A Systematic Review of Animal and Clinical Studies. *Transl Stroke Res*.
Ploughman M, Austin MW, Murdoch M, Kearney A, Fisk JD, Godwin M, and Stefanelli M. 2012a. Factors influencing healthy aging with multiple sclerosis: a qualitative study. *Disabil Rehabil* 34:26-33.
Ploughman M, Austin MW, Murdoch M, Kearney A, Godwin M, and Stefanelli M. 2012b. The path to self-management: a qualitative study involving older people with multiple sclerosis. *Physiother Can* 64:6-17.
Ploughman M, Beaulieu S, Harris C, Hogan S, Manning OJ, Alderdice PW, Fisk JD, Sadovnick AD, O'Connor P, Morrow SA et al. . 2014b. The Canadian survey of health, lifestyle and ageing with multiple sclerosis: methodology and initial results. *BMJ Open* 4:e005718.
Prakash RS, Snook EM, Motl RW, and Kramer AF. 2010. Aerobic fitness is associated with gray matter volume and white matter integrity in multiple sclerosis. *Brain Res* 1341:41-51.
Rietberg MB, Brooks D, Uitdehaag BM, and Kwakkel G. 2005. Exercise therapy for multiple sclerosis. *Cochrane Database Syst Rev*:CD003980.
Schmitt MM, Goverover Y, Deluca J, and Chiaravalloti N. 2014. Self-efficacy as a predictor of self-reported physical, cognitive, and social functioning in multiple sclerosis. *Rehabil Psychol* 59:27-34.
Sinnakaruppan I, Macdonald K, McCafferty A, and Mattison P. 2010. An exploration of the relationship between perception of control, physical disability, optimism, self-efficacy and hopelessness in multiple sclerosis. *International Journal of Rehabilitation Research* 33:26-33.
Stern AF. 2014. The hospital anxiety and depression scale. *Occup Med (Lond)* 64:393-394.
Stroud N, Minahan C, and Sabapathy S. 2009. The perceived benefits and barriers to exercise participation in persons with multiple sclerosis. *Disabil Rehabil* 31:2216-2222.
Suh Y, Joshi I, Olsen C, and Motl RW. 2014. Social cognitive predictors of physical activity in relapsing-remitting multiple sclerosis. *Int J Behav Med* 21:891-898.
Suh Y, Motl RW, and Mohr DC. 2010. Physical activity, disability, and mood in the early stage of multiple sclerosis. *Disabil Health J* 3:93-98.
van der Ploeg HP, Streppel KR, van der Beek AJ, van der Woude LH, Vollenbroek-Hutten MM, van Harten WH, and van Mechelen W. 2007. Successfully improving physical activity behavior after rehabilitation. *Am J Health Promot* 21:153-159.
Viner R, Fiest KM, Bulloch AGM, Williams JVA, Lavorato DH, Berzins S, Jette N, Metz LM, and Patten SB. 2014. Point prevalence and correlates of depression in a national community sample with multiple sclerosis. *General Hospital Psychiatry* 36:352-354.
Wagnild G. 2009. A review of the Resilience Scale. *J Nurs Meas* 17:105-113.
Weinert C, and Brandt PA. 1987. Measuring social support with the Personal Resource Questionnaire. *West J Nurs Res* 9:589-602.

Widerstrom-Noga E, and Finlayson ML. 2010. Aging with a disability: physical impairment, pain, and fatigue. *Phys Med Rehabil Clin N Am* 21:321-337.
Wood B, van der Mei IAF, Ponsonby AL, Pittas F, Quinn S, Dwyer T, Lucas RM, and Taylor BV. 2013. Prevalence and concurrence of anxiety, depression and fatigue over time in multiple sclerosis. *Multiple Sclerosis Journal* 19:217-224.
Zigmond AS, and Snaith RP. 1983. The hospital anxiety and depression scale. *Acta Psychiatr Scand* 67:361-370.

Table 1: Potential factors predicting exercise at moderate to vigorous intensity

Domain	Description	Survey Questionnaire	Ambulatory Exp (β) (95% CI)	Non-Ambulatory Exp (β) (95% CI)
1. Demographic	Age	Custom variable	**0.98** (0.94-1.02)	**0.99** (0.95-1.02)
	Education	Custom variable	**1.00** (0.91-1.11)	**1.05** (0.98-1.14)
	Gender	Custom variable	**0.87** (0.47-1.61)	**1.47** (0.89-2.44
	MS diagnosis type	Custom variable	**0.88** (0.74-1.05)	**0.94** (0.83-1.07)
	Years with MS	Custom variable	**0.98** (0.96-1.01)	**0.98** (0.96-1.00)
2. Personal	Resilience ▪ Self-Reliance ▪ Meaningfulness ▪ Equanimity ▪ Perseverance ▪ Existential Aloneness	Resilience Scale	**1.04*** (1.02-1.06) **1.09*** (1.04-1.14) **1.18*** (1.08-1.28) **1.15*** (1.03-1.29) **1.20*** (1.08-1.33) **1.15*** (1.04-1.27)	**1.02*** (1.01-1.04) **1.07*** (1.03-1.11) **1.03** (0.97-1.10) **1.08** (0.99-1.19) **1.15*** (1.05-1.27) **1.07** (0.98-1.16)
	Stress	Simple Lifestyle Indicator Questionnaire subcomponent	**1.17** (0.96-1.43)	**1.12** (0.95-1.33)
	Mood ▪ Depression ▪ Anxiety	Hospital Anxiety and Depression Scale	**0.86*** (0.80-0.93) **0.96** (0.90-1.03)	**0.91*** (0.86-0.97) **0.98** (0.93-1.04)
3. Physical health	Degree of disability	Barthel Index	**1.06*** (1.03-1.10)	**1.04*** (1.03-1.05)
	Fatigue	Visual Analog Scale	**0.99*** (0.98-0.10)	**0.99*** (0.99-1.0)
	Cardiorespiratory Co-morbid conditions Musculoskeletal Co-morbid conditions	Co-morbidity Questionnaire	**0.79** (0.62-1.01) **0.81** (0.57-1.16)	**0.92** (0.75-1.14) **1.08** (0.79-1.46)
4. Socio-economic	Social support	Personal Resources Questionnaire	**1.02*** (1.01-1.03)	**1.01** (1.00-1.03)

	Financial situation	Custom variable	**0.85** (0.52-1.40)	**1.10** (0.75-1.60)
5. Exercise history	Past exercise experience	Custom variable	**1.19** (0.72-1.98)	**1.51** (0.92-2.48)
6. Health care support	Perceived helpfulness of health care providers	Custom variable		
	▪ Family Doctor		**0.99** (0.86-1.11)	**0.94** (0.85-1.06)
	▪ Physiotherapist		**1.03** (0.91-1.17)	**1.06** (0.96-1.17)
	▪ Neurologist		**0.96** (0.83-1.12)	**1.00** (0.89-1.12)
	▪ MS Nurse		**0.96** (0.81-1.10)	**0.924** (0.82-1.04)

*** p<0.05**

Table 2: Characteristics of ambulatory and non-ambulatory groups

Self-Reported Characteristics		Ambulatory mean (±SD)	Non-Ambulatory mean (±SD)
Age		64.1 (± 5.8)	65.1 (± 6.5)*
Total Education		13.6 (± 2.4)	13.2 (± 2.7)*
Gender	Male	72	94
	Female	279	298
Years with MS symptoms		32.2 (± 9.3)	33.4 (± 9.5)
Barthel Index		92.9 (± 7.6)	61.1 (± 25.1)**
Number of comorbid conditions		2.5 (± 2.0)	2.5 (± 2.1)
Type of MS (Initial Diagnosis)	Relapsing-Remitting	205	181
	Primary Progressive	25	74**
	Secondary Progressive	21	44
	Progressive Relapsing	6	10
	Benign	33	10**
	Unknown	57	69
Total		**351**	**392**

*** p< 0.05; **p<0.01**

Table 3: Correlation between explanatory variables (Ambulatory Group)

		Resilience					Depression	Anxiety	Degree of Disability	Fatigue
		Self-Reliance	Meaningfulness	Equanimity	Perseverance	Existential Aloneness				
Resilience	Self-Reliance	1								
	Meaningfulness	.68**	1							
	Equanimity	.71**	.69**	1						
	Perseverance	.75**	.63**	.59**	1					
	Existential Aloneness	.71**	.75**	.76**	.61**	1				
Depression		-.49**	-.57**	-.51**	-.37**	-.50**	1			
Anxiety		-.35**	-.38**	-.41**	-.28**	-.42**	.53**	1		
Degree of Disability		.17**	.16**	.11*	.00	.09	-.17**	-.18**	1	
Fatigue		-.27**	-.29**	-.23**	-.18**	-.23**	.41**	.28**	-.16**	1
Social Support		.44**	.61**	.54**	.37**	.52**	-.47**	-.31**	.15**	-.31**

*** p< 0.05; **p<0.01**

Table 4: Correlation between explanatory variables (Non-Ambulatory Group)

	Perseverance	Self - Reliance	Depression	Social Support
Perseverance	1			
Self-Reliance	.66**	1		
Depression	-.37**	-.43**	1	
Social Support	.40**	.50**	-.52**	1
Degree of Disability	.06	.22**	-.21**	.08

*** p< 0.05; **p<0.01**

Table 5: Factors predicting exercise at moderate to vigorous intensity

Non-Ambulatory Group

Model Components	β	Exp(β)	95% CI
1. Degree of Disability	1.64	5.30*	3.22-8.73
2. Perseverance	0.70	2.12***	1.27-3.54

*p<0.001, ** p<0.01, ***p<0.05

Ambulatory Group

Model Components	β	Exp(β)	95% CI
1. Depression	-0.68	0.51*	0.29-0.89
2. Degree of Disability	0.67	1.95**	1.18-3.25
3. Perseverance	0.59	1.80*	1.04-3.10

*** p< 0.05; **p<0.01; ***p<0.001**