Abstract

There is an obvious disconnect between evidence of benefits and rates of participation in exercise and physical activity among people living with multiple sclerosis (MS). We propose that the problem with exercise behavior in MS (i.e., lack of broad or increasing participation by people with MS despite evidence of meaningful benefits) might be ameliorated through the inclusion of behavior change theory in the design of exercise programs and promotion efforts, as has been undertaken in other populations such as breast cancer survivors. This paper reviews Social Cognitive Theory as an example approach for informing interventions for increasing exercise and physical activity behavior outside of MS and provides an overview of current knowledge regarding the application of this theory for physical activity in MS. We then outline future research necessary for informing trials that design, implement, and test theory-based interventions for physical activity promotion in MS. If theories of behavior change are adopted for informing exercise and physical activity research in MS, we can take a major step forward in addressing the problem of exercise and physical activity participation that has plagued the field for more than 25 years.

Keywords: Behavioral science, exercise, theory

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Introduction

The prevalence of multiple sclerosis (MS) exceeds 1 million people in the United States and 2.5 million people worldwide.\(^1\) MS is characterized by relapses, lesions, and progression of neurological disability brought about by periods of inflammatory demyelination and transection of axons, as well as neurodegeneration involving loss of neurons (central nervous system (CNS) atrophy).\(^2\) The disease activity and resulting damage manifest as symptoms (e.g., fatigue and depression) and dysfunction (e.g., walking and cognition) that can compromise quality of life (QOL). MS is typically treated through disease-modifying drugs (DMDs) that target immunological signaling proteins (e.g., interferons, cytokines) and/or populations of immune cells (e.g., lymphocytes). The DMDs control inflammatory activity, but not neurodegenerative processes, and individuals with MS still experience residual symptoms and dysfunction, as there is no cure for the disease. Other approaches such as participation in physical activity, particularly exercise training,\(^3\) are recommended for managing symptoms, restoring function, and improving QOL.

There has been an increasing amount of research examining the general benefits of exercise training and physical activity as part of a healthy lifestyle in MS.\(^4\) Physical activity may be protective against developing MS,\(^5\) and meta-analyses and systematic reviews indicate that exercise training can improve aerobic and muscular fitness,\(^6\) fatigue,\(^7\) depression,\(^8\) walking,\(^9\) balance,\(^10\) cognition,\(^11\) and QOL\(^12\) in MS. There may be additional benefits on structures within the CNS (e.g., hippocampus),\(^13\) sleep quality,\(^14\) and cardiovascular/metabolic comorbidity.\(^15\)

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Exercise has been associated with reduced rates of MS relapses\(^\text{16}\) and slowed disability progression.\(^\text{17}\) The evidence base has yielded guidelines for prescribing exercise behavior in patients with MS who have mild or moderate neurological disability\(^\text{18}\) that can be implemented within comprehensive MS care.\(^\text{19}\)

There is a problem, however, in that the majority of people with MS do not engage in appropriate amounts of health-promoting physical activity or exercise. One meta-analysis indicated that people with MS engage in substantially less physical activity than healthy controls from the general population.\(^\text{20}\) There is additional evidence from waist-worn accelerometry that individuals with MS engage in lower amounts of moderate-to-vigorous physical activity (MVPA) than the general population,\(^\text{21}\) and physical activity levels decrease over time as the disease develops.\(^\text{22}\) Some data suggest that fewer than 20% of adults with MS from the United States engage in recommended amounts of MVPA necessary for health benefits.\(^\text{23}\) Of note, the difference in physical activity levels between MS and healthy controls has not changed over the past 25 years,\(^\text{20}\) even though the evidence base for MS-related benefits has expanded considerably over the past 10 years.\(^\text{4}\)

This presents an obvious disconnect between evidence of benefits and rates of participation in exercise and physical activity among those living with MS. This disconnect is critically important, as the chasm between benefits and participation may be even larger in MS than the general population, and exercise and physical activity might be particularly important in a disease wherein people are facing functional declines and other outcomes.\(^\text{24}\) The disconnect may reflect core problems with either poor quality of the scientific evidence (i.e. underpowered and unblinded studies without intention-to-treat analyses) or insufficient promotion of physical activity and exercise in MS. Regarding the latter problem, one recent scoping review indicates that few studies have applied principles and theories of behavior change within exercise and physical activity interventions as an approach for maximizing participation.\(^\text{4}\)

Behavioral science and application of theories of behavior change can provide the missing link in the promotion of exercise and physical activity participation in MS. The science of behavior change involves the study of human actions/behaviors, habits, and intentions based on the fields of psychology, sociology, and anthropology. This informs the development of theory that identifies principles of behavior change based on assumptions and rules with associated malleable factors that can be targeted for behavior change. Such theory is important for identifying, developing, and teaching self-regulatory strategies for behavior change. Essentially, behavior theory may improve a behavior change intervention by linking relevant causal factors of the behavior with appropriate change methods or techniques.\(^\text{25}\) Behavioral theory must further be integrated throughout the design, implementation, and evaluation of behavioral interventions for maximizing the intensity of theory application and its influence on behavior change.\(^\text{26}\) This is important for promotion of behavior change in clinical trials and home-based approaches involving exercise and physical activity in MS—a situation that requires considerable self-regulatory support considering the broad manifestations of MS.

We propose that the problem with exercise behavior in MS (i.e. lack of broad or increasing participation by people with MS despite evidence of meaningful benefits) can be addressed through the inclusion of behavior change theory in the design of exercise programs and promotion efforts, as has been undertaken in other populations such as breast cancer survivors.\(^\text{26}\) To that end, this paper reviews Social Cognitive Theory (SCT)\(^\text{27}\) as an example theory that has informed interventions for increasing exercise and physical activity behavior outside of MS, and then provides an overview of current knowledge regarding the application of SCT for physical activity in MS. We further outline future research necessary for informing trials that design, implement, and test theory-based interventions for promotion of physical activity in MS. If these theories are adopted for designing, implementing, and evaluating exercise and physical activity research in MS, we can take a major step forward in addressing the problem of exercise and physical activity participation that has plagued the field for more than 25 years.\(^\text{24}\)

**SCT**

SCT evolved from Bandura’s original social-learning theory for describing the learning of violent and aggressive behaviors in humans, particularly children (i.e. Bobo Doll experiment), through observation, modeling/imitation, and reinforcement. The application of SCT for understanding other behaviors has expanded considerably over time, and has been particularly helpful for understanding health behaviors,\(^\text{27}\) including exercise and physical
activity. One of the primary tenets of SCT is triadic reciprocal determinisms wherein the environment, person, and behavior coalesce into reciprocal determinants of one another; this is important as it considers the influence of the environment on health behaviors and how this might interact with personal characteristics such as functional limitations. Another primary tenet of SCT is human agency—intentionally exerting control over the nature and quality of one’s life. The characteristic features of human agency include intentionality (acts performed deliberately or intentionally based on a plan), forethought (setting goals, anticipating outcomes, and selecting courses of action), self-reactiveness (motivation and self-regulation of one’s course of action), and self-reflectiveness (self-examining one’s actions, functioning, and purpose). Such features of agency directly informed the key components of Bandura’s sociocognitive causal structure for health-promoting behaviors, and this structure includes self-efficacy (perceived control over one’s health behaviors), outcome expectations (multidimensional expected costs and benefits of health behaviors), sociostructural factors (facilitators and impediments for health behaviors), and goals (concrete plans and strategies for one’s health behaviors) as predictors of behavior itself (see Figure 1). Self-efficacy is a primary or focal determinant of health behavior as it operates both directly and indirectly through the other determinants. Self-efficacy, for example, influences goals and aspirations, beliefs about outcomes of behavior change, and perceived impediments/obstacles and strategies for overcoming such difficulties. There further are key sources of self-efficacy, including performance accomplishment, vicarious experience, verbal or social persuasion, and affective/physiological states. Such a causal structure can be enhanced in its utility for promotion of health behavior through the consideration of a stepwise implementation process, whereby the level and type of guidance based on key components of SCT is tailored for a person’s self-management capabilities and motivational preparedness.

There has been abundant cross-sectional research examining the four key components of SCT for explaining physical activity behavior in MS. One early cross-sectional study reported that self-efficacy and enjoyment (i.e. facilitator) were directly associated with physical activity in 196 patients with MS. Another cross-sectional study reported that self-efficacy partially explained the association between symptoms (i.e. source of efficacy information) and physical activity in 80 individuals with MS. One recent study reported that self-efficacy and goal setting were associated with physical activity in pediatric-onset MS. Those studies had a common limitation of not testing Bandura’s full sociocognitive causal structure for health-promoting behaviors, and this is a limitation in most SCT-based research on physical activity. Subsequent research reported that self-efficacy had an indirect effect on physical activity via impediments (i.e. functional limitations), outcome expectations, and/or goal-setting in samples of 218 and 68 people with relapsing–remitting MS. The results regarding Bandura’s full sociocognitive causal structure for health-promoting behaviors have been replicated in samples of African Americans with MS and patients with MS who report elevated depressive symptomology.

We are further aware of prospective/longitudinal studies examining the four key components of SCT for explaining physical activity behavior in patients with MS. One early prospective study reported that self-efficacy for continued physical activity and

Figure 1. The sociocognitive causal structure for health-promoting behaviors. Adapted from Bandura.
self-efficacy for overcoming barriers were prospectively associated with physical activity three months later in 16 people with MS. Another study reported that changes in self-efficacy predicted changes in physical activity, after controlling for other variables, over a 2.5-year period in 269 people with relapsing–remitting MS. One final study adopted Bandura’s full sociocognitive causal structure for health-promoting behaviors and reported that change in self-efficacy and goal-setting predicted changes in physical activity over a 18-month period in 218 patients with relapsing–remitting MS.

There has been an emerging focus on randomized controlled trials (RCTs) developed based on the tenets of SCT and delivered as behavioral interventions for changing exercise and physical activity in patients with MS. The first RCT examined the effect of an efficacy-enhancement exercise condition compared with a control exercise condition for increasing exercise adherence in 26 individuals with MS. Those in the efficacy-enhancement condition attended more exercise sessions (24.2 vs 18.6 of the 36 possible sessions) and exercised for more total minutes (576.8 vs 425.6 minutes) during the 12-week program than did those in the control condition. Importantly, those with higher baseline self-efficacy scores demonstrated greater compliance with the exercise program, regardless of condition.

That study served as the basis for a series of trials (Phase I and II) that tested the efficacy of a behavioral intervention based on SCT and delivered through the Internet for increasing physical activity among people with MS. The first trial included a dedicated Internet website and indicated that the intervention group self-reported a large increase in physical activity over three months, whereas the waitlist control group had minimal change, the change in physical activity was mediated by goal-setting, but not self-efficacy, outcome expectations, or impediments. Such positive results regarding behavior change were replicated in a follow-up trial using objectively measured physical activity based on body-worn accelerometry. The next trials refined the dedicated Internet website and added one-on-one video chat sessions for delivering the SCT content, and the modifications resulted in a larger increase in physical activity that was sustained even after removal of the intervention materials. The subsequent trial included the Internet website and one-on-one video coaching for delivery of content based on SCT and demonstrated a moderate improvement (\(d = .43\)) in minutes/day of MVPA (20 vs 14 minutes/day of MVPA for intervention and controls, respectively).

The most recent trial examined the efficacy of a newly developed website based on e-learning approaches that delivered the SCT-based behavior intervention for increasing physical activity in patients with MS. The results of the study provided evidence for the efficacy of an internet-based behavioral intervention with content delivered through interactive video courses grounded in e-learning principles for increasing physical activity.

We are aware of two other RCTs examining the efficacy of SCT-based interventions for increasing physical activity and exercise behavior in MS. One pilot trial examined the efficacy of a six-week behavioral intervention based on SCT delivered by newsletters and phone calls for increasing physical activity in individuals with MS who were physically inactive and had moderate levels of self-efficacy. The SCT-based intervention group had a significant increase in self-reported physical activity over the six weeks, but the controls had a nonsignificant change. Goal-setting, but not other SCT variables, increased in the intervention group and was a mediator of change in self-reported physical activity. The other study involved an RCT for examining the feasibility of a four-month, home-based exercise-training program designed using recent physical activity guidelines for MS and supplemented by SCT strategies for compliance in individuals with MS. Of note, there was a moderate increase in self-reported exercise behavior for the intervention participants as measured by the Godin Leisure-Time Exercise Questionnaire.

Summary

There is evidence that components from SCT serve as correlates of physical activity based on cross-sectional and prospective/longitudinal studies of individuals with MS, and the strongest and most consistent evidence supports self-efficacy and goal-setting as primary correlates of physical activity in MS. There is additional evidence that SCT-based interventions can increase exercise adherence and physical activity behavior in MS through goal-setting and perhaps self-efficacy as intervention mediators.

Future research

We adopted the perspective that behavioral science and the application of theories of behavior change can provide the missing link in the promotion and
sustainability of exercise and physical activity participation in MS. To date, the existing research in this area has largely focused on examining the application of SCT for understanding exercise and physical activity in MS, and there is cross-sectional, longitudinal, and experimental evidence supporting the application of SCT in this population. By comparison, much less is known about the application of other theories such as the Transtheoretical Model (TTM) and Health Action Process Approach (HAPA) for understanding physical activity and exercise in MS; the existing research is limited both in quantity and quality of scientific evidence. Such observations suggest that future research should focus on TTM and HAPA constructs within cross-sectional and longitudinal studies of determinants of physical activity and exercise in MS, and then consider the design of interventions for behavior change based on the results of these preliminary efforts. Such efforts will substantially improve our understanding of those theories for addressing the promotion and sustainability of physical activity and exercise behavior in MS.

Researchers might consider applying theories other than SCT, TTM, and HAPA for understanding and changing physical activity and exercise in MS. One approach might involve a focus on middle-range theories such as the Theory of Unpleasant Symptoms (TUS). This might be appropriate considering the centrality of symptoms and functional limitations as influences of performance and behavioral outcomes in MS. The TUS suggests that physiological, psychological, and situational factors interact and influence the expression of symptoms (type, frequency, intensity, and duration), and symptoms influence performance and behavioral outcomes. This theory might be quite pertinent in MS, whereby symptoms such as fatigue, depression, anxiety, and pain often form a cluster or complex of symptoms that can profoundly influence a variety of outcomes, including physical activity and exercise. We note that this middle-range theory and others have tremendous face validity for application in MS, but have not been well articulated for informing the design and delivery of interventions for promoting and sustaining behavior change. Consequently, the application of the TUS and other middle-range theories will require substantial research for applications involving exercise and physical activity in MS.

The majority of theories applied for understanding physical activity in MS have been individual-level models that focus on intrapersonal factors such as a person’s motivation. This may provide an incomplete picture of the factors that influence physical activity in MS and that might become the focus on multilevel intervention approaches. For example, social ecological models identify five levels of influence on health and health behaviors, including individual/personal factors through environmental constraints (e.g. accessibility) and public policy. Of note, there might be considerable benefit when focusing on the individual and interpersonal levels, as this provides an opportunity for inclusion of family and friends who may encourage or enable physical activity in MS as well as health care providers such as neurologists, nurses, physical therapists, and occupational therapists into the mix of factors for changing physical activity. There might further be opportunity for targeting environmental level factors such as proximity and accessibility. Such an approach should be driven by theory and then inform a multilevel intervention.

Researchers might further consider using a variety of experimental designs for understanding the application of theory for physical activity and exercise behavior change in MS. For example, qualitative research might focus on the relevance of constructs from SCT, TTM, and HAPA as targets for understanding physical activity and exercise in MS. The focus on such constructs will be particularly salient for the design of future behavioral interventions, and this might further capitalize on participatory action research wherein stakeholders are included in the design and delivery of behavior interventions based on theory. We envision an abundance of research from a cross-sectional and longitudinal perspective on the explanation of physical activity and exercise in MS using the TTM and HAPA. Such research will further support the veracity of these theories for application in the context of a behavioral intervention for changing physical activity and exercise in MS. We further envision a long-term objective of designing behavioral interventions based on SCT, TTM, and HAPA for head-to-head, direct comparison in modifying physical activity and exercise behavior in MS. This will be important for identifying the “best” approach for targeting physical activity and exercise behavior change in MS, and for possibly refining these theories for application in MS and other populations.

There has been some recognition that selecting a single, critical theory of behavior change might be challenging considering the large number of available theories. Moreover, as no single theory can be
applied for fully explaining behavior change, there may be little basis for selecting a single theory. Accordingly, there has been a recent and expanding effort for integrating theories and constructs under a single, existing framework, namely the Theoretical Domains Framework (TDF). The TDF maps theoretical constructs into domains or sets of similar theoretical constructs for maximizing the accessibility and usefulness of theory by identifying domains or explanations that matter rather than relying on just a single theory. This approach identifies opportunities and methods for interventions and overcomes the problems of selecting one theory and/or applying it fully. The TDF can then be extended into the design of interventions by mapping the domains with behavior change techniques. This will be necessary for mapping approaches for behavior change with the mechanisms of behavior change.

The design, delivery, and success of interventions depend on the actual strategies or techniques for behavior change and the link with theory. There are countless techniques for behavior change that can be implemented in interventions, and these techniques have recently been characterized and classified under a Behavior Change Technique Taxonomy. This taxonomy consists of 93 distinct behavior change techniques classified into 16 groups or clusters, and can inform the selection and inclusion of behavior change techniques into behavior change interventions. The next steps will involve mapping the taxonomy with causal mechanisms based on the TDF. Such a combined effort will link the actual “techniques” or approaches of change with the causal agents necessary for behavior change that can align the taxonomy with the framework. This will further facilitate the understanding of developing, implementing, and evaluating the intensity of interventions driven by theory for changing physical activity in MS.

One issue that must be confronted when designing and delivering interventions based on a theory involves the distinction between theory-informed interventions and theory-driven interventions. Theory-informed interventions are those that vaguely describe the use of theory, whereas theory-driven interventions are those that integrate theory throughout program planning, design, and evaluation. This is important as few interventions describe using theory for informing the intervention, and even fewer provide explicit details that would support an integrated use of theory. One recent review of physical activity interventions in breast cancer survivors, however, reported the largest intervention effects on physical activity are seen when the study meets six of eight characteristics for evaluating the intensity of theory application: (1) theory mentioned, (2) relevant constructs targeted, (3) intervention techniques explicitly linked with a theoretical construct, (4) participants screened/selected on a prespecified theoretical construct, (5) interventions tailored for subgroups, (6) one theory construct measured postintervention, (7) all measures of theory had some evidence of reliability, and (8) the results were discussed in relationship with theory. This suggests that future RCTs of theory-based behavioral interventions should include a more focused, consistent application of theory during the development, implementation, and evaluation of the intervention considering the aforementioned criteria for optimizing the efficacy in producing physical activity and exercise change in MS.

Conclusion
This paper argues that the problem with exercise behavior in MS (i.e. lack of broad or increasing participation by people with MS despite evidence of meaningful benefits) might be ameliorated through the inclusion of behavior change theory in the design of exercise programs and promotion efforts. This paper reviewed SCT as a common approach that has successfully informed interventions for increasing exercise and physical activity behavior outside of MS and provided an overview of current knowledge regarding the application of this theory for physical activity in MS. We further outlined future research necessary for informing trials that design, implement, and test theory-based interventions for promotion of behavior change in MS. The thoughtful application of behavioral theory and inclusion of appropriate behavior change techniques in all phases of exercise and physical activity research involving MS will result in more efficacious programs addressing the consistently low rates of exercise and physical activity participation in this target population.

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References
1. Multiple Sclerosis Trust. Prevalence and incidence of multiple sclerosis, https://www.mstrust.org.uk/a-z/prevalence-and-incidence-multiple-sclerosis (accessed 13 March 2017).
2. Trapp BD and Nave KA. Multiple sclerosis: An immune or neurodegenerative disorder? Annu Rev Neurosci 2008; 31: 247–269.
3. Caspersen CJ, Powell KE and Christenson GM. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. Public Health Rep 1985; 100: 126–131.
4. Lai B, Young HJ, Bickel CS, et al. Current trends in exercise intervention research, technology, and behavioral change strategies for people with disability: A scoping review. Am J Phys Med Rehabil 2017; 96: 748–761.
5. Wesness K, Myhr KM, Riise T, et al. Physical activity is associated with a decreased multiple sclerosis risk: The EnviMS study. Mult Scler 2018; 24: 150–157.
6. Platta M, Pilutti LA, Ensari E, et al. The effect of exercise training on fitness, mobility, and physical fitness effects on cognition in persons with multiple sclerosis: A meta-analysis. Neuropsychol Rev 2016; 26: 271–294.
7. Latimer-Cheung AE, Pilutti LA, Hicks AL, et al. 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 2013; 94: 1800–1828.
8. Ensari I, Motl RW and Pilutti LA. Exercise training improves depressive symptoms in people with multiple sclerosis: Results of a meta-analysis. J Psychosom Res 2014; 76: 465–471.
9. Pearson M, Dieberg G and Smart N. Exercise as therapy for improvement of walking ability in adults with multiple sclerosis: A meta-analysis. Arch Phys Med Rehabil 2015; 96: 1339–1348.
10. Paltamaa J, Sjogren T, Peurala SH, et al. Effects of physiotherapy interventions on balance in multiple sclerosis: A systematic review and meta-analysis of randomized controlled trials. J Rehabil Med 2012; 44: 811–823.
11. Sandroff BM, Motl RW, Scudder MR, et al. Systematic, evidence-based review of exercise, physical activity, and physical fitness effects on cognition in persons with multiple sclerosis. Neuropsychol Rev 2016; 26: 271–294.
12. Latimer-Cheung AE, Pilutti LA, Hicks AL, et al. 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 2013; 94: 1800–1828.
13. Sandroff BM, Johnson CL and Motl RW. Exercise training effects on memory and hippocampal viscoelasticity in multiple sclerosis: A novel application of magnetic resonance elastography. Neuroradiology 2017; 59: 61–67.
14. Pilutti LA, Dlugonski D, Sandroff BM, et al. Randomized controlled trial of a behavioral intervention targeting symptoms and physical activity in multiple sclerosis. Mult Scler 2014; 20: 594–601.
15. Wens I, Eijnde BO and Hansen D. Muscular, cardiac, ventilatory and metabolic dysfunction in patients with multiple sclerosis: Implications for screening, clinical care and resistance exercise therapy, a scoping review. J Neurol Sci 2016; 367: 107–121.
16. Pilutti LA, Platta ME, Motl RW, et al. The safety of exercise training in multiple sclerosis: A systematic review. J Neurol Sci 2014; 343: 3–7.
17. Motl RW, Dlugonski D, Pilutti L, et al. Premorbid physical activity predicts disability progression in relapsing-remitting multiple sclerosis. J Neurol Sci 2012; 323: 123–127.
18. Latimer-Cheung AE, Martin Ginis KA, Hicks AL, et al. Development of evidence-informed physical activity guidelines for adults with multiple sclerosis. Arch Phys Med Rehabil 2013; 94: 1829–1836.
19. Vollmer T, Benedict R, Bennett S, et al. Exercise as prescriptive therapy in multiple sclerosis. A consensus conference white paper. Int J MS Care 2012; 14: 2-14.
20. Kinnett-Hopkins D, Adamson B, Rougeau K, et al. People with MS are less physically active than healthy controls but as active as those with other chronic diseases: An updated meta-analysis. Mult Scler Relat Disord 2017; 13: 38–43.
21. Klaren RE, Motl RW, Dlugonski D, et al. Objectively quantified physical activity in persons with multiple sclerosis. Arch Phys Med Rehabil 2013; 94: 2342–2348.
22. Klaren RE, Sasaki JE, McAuley E, et al. Patterns and predictors of change in moderate-to-vigorous physical activity over time in multiple sclerosis. J Phys Act Health 2017; 14: 183–188.
23. Motl RW, McAuley E, Sandroff BM, et al. Descriptive epidemiology of physical activity rates in multiple sclerosis. Acta Neurol Scand 2015; 131: 422–425.
24. Motl RW, Sandroff BM, Kwakkel G, et al. Exercise in patients with multiple sclerosis. Lancet Neurol 2017; 16: 848–856.
25. Bartholomew LK and Mullen PD. Five roles for using theory and evidence in the design and testing or behavior change interventions. J Pub Health Dent 2011; 71 (Suppl 1): S20–S33.
26. Bluetman SM, Bartholomew LK, Murphy CC, et al. Use of theory in behavior change interventions: An analysis of programs to increase physical activity in posttreatment breast cancer survivors. Health Educ Behav 2017; 44: 245–253.
27. Bandura A. Health promotion by social cognitive means. Health Educ Behav 2004; 31: 143–164.
28. McAuley E and Blissmer B. Self-efficacy determinants and consequences of physical activity. *Exerc Sport Sci Rev* 2000; 28: 85–88.

29. Bandura A. Social cognitive theory: An agentic perspective. *Ann Rev Psychol* 2001; 52: 1–26.

30. Motl RW, Snook EM, McAuley E, et al. Correlates of physical activity among individuals with multiple sclerosis. *Ann Behav Med* 2006; 32: 154–161.

31. Snook EM and Motl RW. Physical activity behavior in individuals with multiple sclerosis: Roles of overall and specific symptoms, and self-efficacy. *J Pain Symptom Manage* 2008; 36: 46–53.

32. Grover SA, Sawicki CP, Kinnett-Hopkins D, et al. Physical activity and its correlates in youth with multiple sclerosis. *J Pediatr* 2016; 179: 197–203.

33. Suh Y, Weikert M, Dlugonski D, et al. Social cognitive correlates of physical activity: Findings from a cross-sectional study of adults with relapsing–remitting multiple sclerosis. *J Phys Act Health* 2011; 8: 626–635.

34. Suh Y, Yoshi I, Olsen C, et al. Social cognitive predictors of physical activity in relapsing–remitting multiple sclerosis. *Int J Behav Med* 2014; 21: 891–898.

35. Kinnett-Hopkins D and Motl RW. Social cognitive correlates of physical activity in black individuals with multiple sclerosis. *Arch Phys Med Rehabil* 2016; 97: 590–595.

36. Ensari I, Kinnett-Hopkins D and Motl RW. Social cognitive correlates of physical activity among persons with multiple sclerosis: Influence of depressive symptoms. *Disabil Health J* 2017; 10: 580–586.

37. Motl RW, McAuley E, Doerksen S, et al. Preliminary evidence that self-efficacy predicts physical activity in multiple sclerosis. *Int J Rehabil Res* 2009; 32: 260–263.

38. Motl RW, McAuley E and Sandroff BM. Longitudinal change in physical activity and its correlates in relapsing–remitting multiple sclerosis. *Phys Ther* 2013; 93: 1037–1048.

39. Suh Y, Weikert M, Dlugonski D, et al. Social cognitive variables as correlates of physical activity in persons with multiple sclerosis: Findings from a longitudinal, observational study. *Behav Med* 2011; 37: 87–94.

40. McAuley E, Motl RW, Morris KS, et al. Enhancing physical activity adherence and well-being in multiple sclerosis: A randomised controlled trial. *Mult Scler* 2007; 13: 652–659.

41. Motl RW, Dlugonski D, Wójcicki TR, et al. Internet intervention for increasing physical activity in persons with multiple sclerosis. *Mult Scler* 2011; 17: 116–128.

42. Dlugonski D, Motl RW and McAuley E. Increasing physical activity in multiple sclerosis: Replicating Internet intervention effects using objective and self-report outcomes. *J Rehabil Res Dev* 2011; 48: 1129–1136.

43. Dlugonski D, Motl RW, Mohr DC, et al. Internet-delivered behavioral intervention to increase physical activity in persons with multiple sclerosis: Sustainability and secondary outcomes. *Psychol Health Med* 2012; 17: 636–651.

44. Pilutti LA, Dlugonski D, Sandroff BM, et al. Randomized controlled trial of a behavioral intervention targeting symptoms and physical activity in multiple sclerosis. *Mult Scler* 2014; 20: 594–601.

45. Motl RW, Hubbard EA, Bollaert RE, et al. Randomized controlled trial of an e-learning designed behavioral intervention for increasing physical activity behavior in multiple sclerosis. *Mult Scler J Exp Trans Clin* 2017; 3: 2055217317734886.

46. Suh Y, Motl RW, Olsen C, et al. Pilot trial of a social cognitive theory-based physical activity intervention delivered through non-supervised technology in persons with multiple sclerosis. *J Phys Act Health* 2015; 12: 924–930.

47. Adamson BC, Learmonth YC, Kinnett-Hopkins D, et al. Feasibility study design and methods for Project GEMS: Guidelines for Exercise in Multiple Sclerosis. *Contemp Clin Trials* 2016; 47: 32–39.

48. Streber R, Peters S and Pfieffer K. Systematic review of correlates and determinants of physical activity in persons with multiple sclerosis. *Arch Phys Med Rehabil* 2016; 94: 633–645.

49. Casey B, Coote S, Shirazi-pour C, et al. Modifiable psychosocial constructs associated with physical activity participation in people with multiple sclerosis: A systematic review and meta-analysis. *Arch Phys Med Rehabil* 2017; 98: 1453–1475.

50. Prochaska JO and DiClemente CC. Stages and processes of self-change of smoking: Toward an integrative model of change. *J Consult Clin Psychol* 1983; 51: 390–395.

51. Schwarzer R. Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Appl Psychol* 2008; 57: 1–29.

52. Motl RW, Weikert M, Suh Y, et al. Symptom cluster and physical activity in relapsing–remitting multiple sclerosis. *Res Nurs Health* 2010; 33: 398–412.

53. Learmonth YC and Motl RW. Physical activity and exercise training in multiple sclerosis: A review and content analysis of qualitative research identifying perceived determinants and consequences. *Disabil Rehabil* 2016; 38: 1227–1242.

54. Michie S, Johnston M, Abraham C, et al. Making psychological theory useful for implementing evidence based practice: A consensus approach. *Qual Saf Health Care* 2005; 14: 26–33.

55. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Ann Behav Med* 2013; 46: 81–95.