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## Review Article

## Yoga as an intervention to manage multiple sclerosis symptoms

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## ABSTRACT

Multiple sclerosis (MS) is an autoimmune, demyelinating, inflammatory disease of central nervous system (CNS) which is characterized by spasticity, fatigue, depression, anxiety, bowel and bladder dysfunction, impaired mobility, cognitive impairment etc. and affects approximately 2.5 million people worldwide. Disease modifying therapies for MS which help in preventing accumulation of lesions in white matter of CNS are costly and have significant adverse effects. Therefore, patients with MS are using complementary and alternative medicine (CAM) and Yoga is one of the most popular form of CAM which is being used immensely to reduce or overcome the symptoms of MS. In the current review attempted to present the potential impact of yoga practices on reducing MS related symptoms.

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## 1. Introduction

Multiple sclerosis (MS) is an incurable neurodegenerative and chronic inflammatory disease which occurs due to the demyelination of the nerve cells and affects the central nervous system (CNS) and also leads to various consequences like physical, emotional, and cognitive impairment [1–3]. MS was recognized as a disease by a French neurologist, Jean-Martin Charcot in 1868 [4]. In MS, CD8<sup>+</sup> T-lymphocytes (a type of autoreactive T-cells) damage myelin sheath of nerve cells which lead to inhibition in nerve transmission [5–7]. Brain inflammation is induced only when extreme number of CD8<sup>+</sup> T-lymphocytes are passively transferred in central nervous system (CNS) followed by destruction of myelin antigen presenting oligodendrocytes which lead to demyelination in CNS [8–10]. The lesions (demyelination) in MS are heterogeneous in nature and are more prominent in white matter or can be present throughout the CNS [11]. For diagnosis, lesions are detected by the neuroimaging and analysis of cerebrospinal fluid [12]. The lesions in younger people can be remyelinated more effectively [13]. Failed remyelination in older people might be due to impairment in differentiation and

maturation of oligodendrocyte precursor, energy homeostasis, axo–glial interaction and clearance of cytotoxic inflammation [14–19]. It has also been reported that in each patient of MS, a single immuno effector mechanism operates majorly which in an adaptive immune response removes pathogens [20]. Although, etiology is unknown in MS but the associated factors, for example HLA-DRB1\*1501 haplotype (odds ratio around 3) tops the list of gene variants that increases the risk of MS [13].

MS is characterized by fatigue, chronic pain, walking disability, ataxia, muscle paralysis, muscle weakness, epilepsy, trouble in speaking, asthenia, sensory disturbance, depression, impaired mobility, cognitive impairment, bowel dysfunction, neurogenic bladder dysfunction (NBD) [2,21–30]. Various studies have shown that pain, depression and fatigue affect sexual function and physical activities in MS patients [31,32]. It has also been reported that 65–87% MS patients have mobility impairment [33], 85% have trouble in walking [34], 50–60% have depression [35–38], 25–40% have anxiety [39,40], 85% have chronic pain [41] which affects the quality of life in MS patients. Approximately 2.5 million people in the world are affected with MS and for unknown reasons women are mostly affected [4,13,42,43]. MS symptoms generally begin to appear at the age of 20–40 years [42–44].

Although, MS is an incurable disease but medication helps in the improvement of various MS symptoms [4]. The Food and Drug Administration, USA allows the use of some medication like interferon β-1a, glatiramer acetate, fingolimod, dimethyl fumarate,

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teriflunomide, dalfampridine, daclizumab, alemtuzumab to reduce the accumulation of lesions in white matter of brain but the cost of these medication is around \$10 billion annually in United States and have severe side effects like nausea, fever, headache, fatigue, depression, asthenia, allergy and psychological imbalance [4,39,45–47]. American Neurological Institute reported that MS not only affects the patient but also affects the patient's family both mentally and economically [48]. So, an alternative method to avoid costly medication becomes very important which can be done through complementary and alternative medicine (CAM). National Institute of Health (NIH) defined complementary and alternative medicine as “a group of diverse medical and health care systems, practices and products that are not presently considered to be part of conventional medicine” [49]. Worldwide, 27–100% MS patients are using CAM as an alternative method [49–51].

Yoga is defined as a form of complementary and alternative medical therapies by National Center for Complementary and Alternative Medicine of NIH and is one of the most popular form of CAM [52]. Various studies have been done on MS patients to check the effect of yoga with or without using other forms of CAM on reducing MS related symptoms. Harirchian et al., showed that among 119 MS patients, 60% agreed to use CAM, 42% used CAM; out of which 41% were convinced with its effectiveness and 18% reported aggravation of symptoms [52]. Many reviews and meta-analysis suggested positive impact of yoga on MS patients like reduced depression level, pain, fatigue, neurogenic bladder dysfunction and improvement in quality of life and strength [4,41,53] and there was only one study which exhibited no effect of yoga in symptom management in MS patients [54]. In the present review, we are focusing on yogic practices like *Hatha yoga*, *Pranayama*, *Dhyana* and different *Asanas* like *Adasana*, *Garudasana*, *Trikonasana* etc. which are beneficial for the MS patients.

## 2. Impact of yoga on aspects of multiple sclerosis

Yoga is derived from a Sanskrit word *yuj* which means “to join” and that symbolizes the union of body, mind, spirit [55]. Yoga is a traditional method which is originated in India over 5000 years ago which comprises of various forms like *Hatha yoga* especially *Asanas* (physical postures), *Pranayama* (breathing techniques), *Dhyana* (meditation) [31,56]. Maharshi Patanjali described one more form of yoga i.e. *Astanga yoga* (Raj yoga). It has eight aspects of yoga which has two parts external (*Bahirang*) and internal (*Antaranga*) yoga. First five aspects (*Yamas*, *Niyamas*, *Asana*, *Pranayama*, *Pratyahara*) are included in *Bahirang* yoga and last three aspects (*Dharana*, *Dhyana*, *Samadhi*) are included in *Antaranga* yoga. Many studies showed that yoga based interventions reduced pain, stress, fatigue, anxiety, depression and enhanced limbs strength, balance, self-efficacy, kinesiphobia levels, walking speed, step length, hip and pelvis angles, ankle movements [14,43,57,58,59].

Various studies have been done to analyze the impact of yogic interventions on MS symptoms as given in [Supplementary](#). The effect of yoga on: a) mental and physical health, b) sexual and neurogenic bladder dysfunction, c) motor symptoms and balance in MS patients is being described here.

### 2.1. Impact of yoga on mental and physical health

A study conducted on 24 female patients with MS in Iran showed that 8 weeks of yoga training which includes *Tadasana*, *Garudasana*, *Trikonasana* etc. had increased Adrenocorticotropic hormone (ACTH) levels and decreased cortisol levels as determined by biochemical analysis [60]. In Germany, Chobe et al., done a pilot study on 11 patients in which they used brain fit device to measure audiovisual reaction time and Hospital Anxiety

and Depression Scale (HADS) to measure anxiety, depression. The study showed that Integrated Yoga and Physical therapy (IYP) intervention for 3 weeks significantly improved visual reaction time ( $p = 0.01$ ;  $-32.89\%$ ), anxiety ( $p = 0.02$ ;  $-32.09\%$ ), depression ( $p = 0.04$ ;  $-41.51\%$ ) and also reduced auditory reaction time ( $p = 0.058$ ;  $-25.6\%$ ) [2]. In 2016, Nejadi et al., showed that Mindfulness-based Stress Reduction (MBSR) and yoga program reduced fatigue ( $p < 0.001$ ) and improved quality of life ( $p < 0.05$ ) among 24 patients suffering from MS in their quasi-experimental study which was done in Iran [43]. In 2010, a randomized prospective study done on 20 MS patients in Slovenia showed that Hatha yoga had impact on selective attention but had no impact on mood, fatigue, spasticity, and executive functions as measured by Center for Epidemiologic Studies Depression scale (CES-D), Modified Fatigue Impact Scale (MFIS), Modified Ashworth Scale (MAS) and mazes subtest of executive module, respectively [61].

The 8 weeks yoga program and mindfulness based intervention had been shown to improve quality of life as measured by Multiple Sclerosis Quality of Life Inventory, mental health measured by Mental Health Inventory (MHI) and physical functioning measured by 36-item Short Form Health Status Survey (SF-36) among patients suffering from MS in USA [57,62]. Another study done in USA by Cohen et al., showed that yoga philosophy, *Pranayama*, *Asanas*, deep relaxation, meditation for 8 weeks improved expiratory muscle strength, balance, walking ability and concentration among 14 people having moderate MS as measured by respiratory pressure meter (MicroRPM-Micro Direct Inc, Lewiston, ME), Multidirectional Reach Test (MDRT), 12-item Multiple Sclerosis Walking Scale (MSWS-12), Timed 25-Foot Walk test (T25FW), 6 Minute Walk Test (6MWT), Paced Auditory Serial Addition Test-3” (PASAT-3”) [62]. A study conducted among 57 MS patients, had shown that level of fatigue as measured by Multi-Dimensional Fatigue Inventory (MFI) was significantly reduced ( $p < 0.01$ ) and energy level was also significantly improved ( $p < 0.001$ ) among patients who performed yoga (*Iyengar* yoga) and exercise for 6 months in America [63].

In Switzerland, a randomized controlled trial study on 54 female MS patients in which they measured fatigue, depression and paresthesia by Fatigue Severity Scale (FSS), Beck Depression Inventory (BDI), 10-point Visual Analogue Scale (VAS), respectively and showed significant reduction ( $p < 0.001$ ) in these measures after 8 weeks of *Hatha* yoga practices and aquatic exercising (relay races, strength training, crossing the pool) [64]. A qualitative case study on a female MS patient done by Powell and Cheshire reported that individualized yoga program (*Hatha* yoga) for 6 months was beneficial for MS patient as it improved muscle tone, strength, confidence, stamina, psychological wellbeing [65].

### 2.2. Impact of yoga on sexual and neurogenic bladder dysfunction

Injury in sensory-motor nerves leads to sexual disorders in women with MS, so yoga practices like *Hatayoga*, *Pranayama* and *Rajayoga* are beneficial for these women. A study performed on 60 Iranian women with MS showed that yogic interventions as measured by standard questionnaires significantly improved ( $p = 0.001$ ) sexual satisfaction and physical activities in these women [31]. Yogic practices like *Sukshma Vyayama* and deep relaxation have shown to improve symptoms associated with neurogenic bladder dysfunction in MS patients. A pilot study on 11 MS patients having neurogenic bladder dysfunction through ultrasound scanning observed improved micturition rates (25%,  $p < 0.05$ ) and Post void Residual urine volume (PVR) (62.34%,  $p < 0.05$ ) because of regular practice of aforementioned yoga *Asanas* [21].

### 2.3. Impact of yoga on motor symptoms and balance

A pilot study on 12 MS patients of Brazil showed that various yoga practices for 6 months (*Asanas, Pranayama, Dhyana* and *Nidra*) made a significant improvement ( $p = 0.01$ ) in postural balance and also decreased the impact of improper postural balance on daily living activities as measured by Influence of Postural Balance on Daily Living Structured Questionnaire (IPBDLSQ) in women [66].

### 3. Limitations

In some case studies, there were no control groups [2,21,57,59–61,63] and yoga was combined with other interventions [2,21,57,64]. So, it is difficult to assess the effect of yoga alone. Also the participants were not blinded to the intervention which means they were expecting improvement which might have affected the final outcome. Duration of interventions varied from weeks to months, so the long-term use of yoga for symptom management needs to be further explored [2,21,57,59–61,63]. Yoga along with mind body interventions reduced some symptoms related with MS, but not all of them [2,43] which suggested that some other yogic practices can be explored for further improvement of conditions in MS patients. These studies lack relationship between yoga intervention and the progression of disease which can be analyzed by neuro-imaging and analysis of cerebrospinal fluid.

### 4. Probable mechanism

The exact mechanism behind the effect of yoga on MS patients is still not clear but on the basis of indicated studies covered in this review, we hypothesize that the influence of yoga on the levels of biological markers like ACTH and Cortisol plays an important role. Also the covered studies suggested that specific yoga types manage specific symptoms like *Hatha yoga* reduced anxiety, fatigue and pain symptoms associated with MS. Another possibility could be that yoga also improves the levels of opioid peptide  $\beta$  endorphins and thus, help in decreasing inflammation via immunosuppression. Meditation and *Pranayama* further improved the quality of life, physical activity, sexual satisfaction, concentration and attention, walking ability and balance in MS patients.

### 5. Conclusion and future directions

Yoga has impact on overall health of MS patients that can be analyzed by looking at the levels of biomarkers. But it will be important to examine how yogic interventions are helpful in prognosis of MS by analyzing the status of these biological markers. Future studies should focus on examining the long-term impact of yoga in controlling MS and thus, the change in markers would be helpful to analyze the relapsed of MS. In many studies, self-reported measures like questionnaires are used for the evaluation of impact of yoga on MS patients without taking into account the control groups. Appropriate control groups are obligatory for making a sound conclusion. Furthermore, inclusion of clinical imaging techniques and quantifiable parameters for physical assessment would be advantageous to correlate with self-reported measures of enhancement.

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### Conflict of interest

None.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jaim.2019.04.005>.

### References

- [1] Mostert S, Kesselring J. Effects of a short-term exercise training program on aerobic fitness, fatigue, health perception and activity level of subjects with multiple sclerosis. *Mult Scler* 2002;8:161–8.
- [2] Chobe S, Bhargav H, Raghuram N, Garner C. Effect of integrated yoga and physical therapy on audiovisual reaction time, anxiety and depression in patients with chronic multiple sclerosis: a pilot study. *J Complement Int Med* 2016;13:301–9.
- [3] National Multiple Sclerosis Society. What is MS?. 2014. Online document at: <http://www.nationalmssociety.org/What-is-MS>. [Accessed 20 June 2014].
- [4] Frank R, Larimore J. Yoga as a method of symptom management in multiple sclerosis. *Front Neurosci* 2015;9:133.
- [5] Babbe H, Roers A, Waisman A, Lassmann H, Goebels N, Hohlfeld R, et al. Clonal expansion of CD81 T cells dominate the T cell infiltrate in active multiple sclerosis lesions as shown by micromanipulation and single cell polymerase chain reaction. *J Exp Med* 2000;192:393–404.
- [6] Compston A, Coles A. Multiple sclerosis. *Lancet* 2008;372:1502–17.
- [7] Moreno B, Villoslada P. Neuroprotective therapies for multiple sclerosis. *Euro Neurol Rev* 2012;7:189–95.
- [8] Huseby ES, Liggitt D, Brabb T, Schnabel B, Ohlen C, Goverman J. A pathogenic role for myelin-specific CD81 T-cells in a model for multiple sclerosis. *J Exp Med* 2001;194:669–76.
- [9] Na SY, Cao Y, Toben C, Nitschke L, Stadelmann C, Gold R, et al. Naive CD8 T-cells initiate spontaneous autoimmunity to a sequestered model antigen of the central nervous system. *Brain* 2008;131:2353–65.
- [10] Saxena A, Bauer J, Scheikl T, Zappulla J, Audebert M, Desbois S, et al. Cutting edge: multiple sclerosis-like lesions induced by effector CD8 T cells recognizing a sequestered antigen on oligodendrocytes. *J Immunol* 2008;181:1617–21.
- [11] Lucchinetti C, Bruck W, Parisi J, Scheithauer B, Rodriguez M, Lassman H. Heterogeneity of multiple sclerosis lesions: implications for the pathogenesis of demyelination. *Ann Neurol* 2000;47:707–17.
- [12] Airas L, Kaaja R. Pregnancy and multiple sclerosis. *Obstet Med* 2012;5:94–7.
- [13] Reich DS, Lucchinetti CF, Calabresi PA. Multiple sclerosis. *N Engl J Med* 2018;378:169–80.
- [14] Kuhlmann T, Miron V, Cui Q, Wegner C, Antel J, Bruck W. Differentiation block of oligodendroglial progenitor cells as a cause for remyelination failure in chronic multiple sclerosis. *Brain* 2008;131:1749–58.
- [15] Chang A, Tourtellotte WW, Rudick R, Trapp BD. Premyelinating oligodendrocytes in chronic lesions of multiple sclerosis. *N Engl J Med* 2002;346:165–73.
- [16] Kotter MR, Stadelmann C, Hartung HP. Enhancing remyelination in disease – can we wrap it up? *Brain* 2011;134:1882–900.
- [17] Kremer D, Aktas O, Hartung HP, Kury P. The complex world of oligodendroglial differentiation inhibitors. *Ann Neurol* 2011;69:602–18.
- [18] Shechter R, Schwartz M. CNS sterile injury: just another wound healing? *Trends Mol Med* 2013;19:135–43.
- [19] Franklin RJ, Gallo V. The translational biology of remyelination: past, present, and future. *Glia* 2014;62:1905–15.
- [20] Metz I, Weigand SD, Popescu BF, Frischer JM, Parisi JE, Guo Y, et al. Pathologic heterogeneity persists in early active multiple sclerosis lesions. *Ann Neurol* 2014;75:728–38.
- [21] Patil NJ, Nagaratna R, Garner C, Raghuram NV, Crisan R. Effect of integrated Yoga on neurogenic bladder dysfunction in patients with multiple sclerosis-A prospective observational case series. *Complement Ther Med* 2012;20:424–30.
- [22] Hasanpour-Dehkordi A, Jivad N, Solati K. Effects of yoga on physiological indices, anxiety and social functioning in multiple sclerosis patients: a randomized trial. *J Clin Diagn Res* 2016;10:VC01.
- [23] Motl RW, Pilutti LA. The benefits of exercise training in multiple sclerosis. *Nat Rev Neurol* 2012;8:487–97.
- [24] Motl RW, Sandroff BM. Benefits of exercise training in multiple sclerosis. *Curr Neurol Neurosci Rep* 2015;15:62.
- [25] Shabas D, Heffner M. Multiple sclerosis management for low-income minorities. *Mult Scler* 2005;11:635–40.

- [26] Smedal T, Lygren H, Myhr KM. Balance and gait improved in patients with multiple sclerosis after physiotherapy based on the Bobath concept. *Physiother Res Int* 2006;11:104–16.
- [27] Foley JF, Brandes DW. Redefining functionality and treatment efficacy in multiple sclerosis. *Neurology* 2009;72:S1–11.
- [28] Fulk GD. Locomotor training and virtual reality-based balance training for an individual with multiple sclerosis: a case report. *J Neurol Phys Ther* 2005;29:34–42.
- [29] White LJ, Dressendorfer RH. Exercise and multiple sclerosis. *Sports Med* 2004;34:1077–100.
- [30] Williams NP, Roland PS, Yellin W. Vestibular evaluation in patients with early multiple sclerosis. *Am J Otol* 1997;18:93–100.
- [31] Najafidoulatabad S, Mohebbi Z. Yoga effects on physical activity and sexual satisfaction among Iranian women with multiple sclerosis: a randomized controlled trial. *Afr J Tradit Complement Altern Med* 2014;11:78–82.
- [32] Motl RW, Mcauley E, Snook EM. Physical activity and multiple sclerosis: a meta-analysis. *Mult Scler* 2005;11:459–63.
- [33] Olgiasi R, Burgunder JM, Mumenthaler M. Increased energy cost of walking in multiple sclerosis: effect of spasticity, ataxia, and weakness. *Arch Phys Med Rehabil* 1988;69:846–9.
- [34] McCabe MP. Mood and self-esteem of persons with multiple sclerosis following an exacerbation. *J Psychosom Res* 2005;59:1616.
- [35] Maggie M, Carol H, David H. Nursing knowledge and practice: a decision-making approach. Bailliere Tindall; 1995.
- [36] Patten SB, Beck CA, Williams JV, Barbui C, Metz LM. Major depression in multiple sclerosis: a population-based perspective. *Neurology* 2003;61:1524–7.
- [37] Schubert DS, Foliart RH. Increased depression in multiple sclerosis patients: a meta-analysis. *Psychosomatics* 1993;34:124–30.
- [38] Minden SL, Orav J, Reich P. Depression in multiple sclerosis. *Gen Hosp Psychiatr* 1987;9:426–34.
- [39] Ahmadi A, Arastoo AA, Nikbakht M. The effects of a treadmill training programme on balance, speed and endurance walking, fatigue and quality of life in people with multiple sclerosis. *Int J Sports Med* 2010;11:389–97.
- [40] Korostil M, Feinstein A. Anxiety disorders and their clinical correlates in multiple sclerosis patients. *Mult Scler* 2007;13:67–72.
- [41] Rogers KA, MacDonald M. Therapeutic yoga: symptom management for multiple sclerosis. *J Altern Complement Med* 2015;21:655–9.
- [42] Ponichtera-Mulcare JA. Exercise and multiple sclerosis. *Med Sci Sports Exerc* 1993;25:451–65.
- [43] Nejati S, Rajezi Esfahani S, Rahmani S, Afrookhteh G, Hoveida Sh. The effect of group mindfulness-based stress reduction and consciousness yoga program on quality of life and fatigue severity in patients with MS. *J Caring Sci* 2016;5:325–35.
- [44] Popescu CD. Multiple sclerosis and pregnancy. *Rev Med Chir Soc Med Nat Iasi* 2014;118:28–32.
- [45] Niino M, Sasaki H. Update on the treatment options for multiple sclerosis. *Expert Rev Clin Immunol* 2010;6:77–88.
- [46] Adelman G, Rane SG, Villa KF. The cost burden of multiple sclerosis in the United States: a systematic review of the literature. *J Med Econ* 2013;16:639–47.
- [47] Petajan JH, Gappmaier E, White AT, Spencer MK, Mino L, Hicks RW. Impact of aerobic training on fitness and quality of life in multiple sclerosis. *Ann Neurol* 1996;39:432–41.
- [48] Hassanpour-Dehkordi A, Jivad N. Comparison of regular aerobic and yoga on the quality of life in patients with multiple sclerosis. *Med J Islam Repub Iran* 2014;28:141.
- [49] Apel-Neu A, Zettl UK. Complementary and alternative medicine in multiple sclerosis. *J Neurol* 2008;255:82–6.
- [50] Olsen SA. A review of complementary and alternative medicine (CAM) by people with multiple sclerosis. *Occup Ther Int* 2009;16:57–70.
- [51] Hughes C, Howard JM. Spasticity management in multiple sclerosis. *Phys Med Rehabil Clin* 2013;24:593–604.
- [52] Harirchian MH, Sahraian MA, Hosseinkhani A, Amirzargar N. Level of attitude toward complementary and alternative medicine among Iranian patients with multiple sclerosis. *Iran J Neurol* 2014;13:13–8.
- [53] Senders A, Wahbeh H, Spain R, Shinto L. Mind-body medicine for multiple sclerosis: a systematic review. *Autoimmune Dis* 2012;2012:567324.
- [54] Cramer H, Lauche R, Azizi H, Dobos G, Langhorst J. Yoga for multiple sclerosis: a systematic review and meta-analysis. *PLoS One* 2014;9(11):e112414.
- [55] Mohammad A, Thakur P, Kumar R, Kaur S, Saini RV, Saini AK. Biological markers for the effects of yoga as a complementary and alternative medicine. *J Complement Int Med* 2019. <https://doi.org/10.1515/jcim-2018-0094>. <http://j/jcim.ahead-of-print/jcim-2018-0094/jcim-2018-0094.xml>.
- [56] Feuerstein G. The yoga tradition. Prescott, AZ: Hohm Press; 1998.
- [57] Gilbertson RM, Klatt MD. Mindfulness in motion for people with multiple sclerosis: a feasibility study. *Int J MS care* 2017;19:225–31.
- [58] Kahraman T, Ozdogar AT, Yigit P, Hosgel I, Mehdiyev Z, Ertekin O, et al. Feasibility of a 6-month yoga program to improve the physical and psychosocial status of persons with multiple sclerosis and their family members. *Explore* 2018;14:36–43.
- [59] Guner S, Inanici F. Yoga therapy and ambulatory multiple sclerosis assessment of gait analysis parameters, fatigue and balance. *J Bodyw Mov Ther* 2015;19:72–81.
- [60] Najafi P, Moghadasi M. The effect of yoga training on enhancement of Adrenocorticotropic hormone (ACTH) and cortisol levels in female patients with multiple sclerosis. *Complement Ther Clin Pract* 2017;26:21–5.
- [61] Velikonja O, Curic K, Ozura A, Jazbec SS. Influence of sports climbing and yoga on spasticity, cognitive function, mood and fatigue in patients with multiple sclerosis. *Clin Neurol Neurosurg* 2010;112:597–601.
- [62] Cohen ET, Kietrys D, Fogerite SG, Silva M, Logan K, Barone DA, et al. Feasibility and impact of an 8-week integrative yoga program in people with moderate multiple sclerosis-related disability: a pilot study. *Int J MS Care* 2017;19:30–9.
- [63] Oken BS, Kishiyama S, Zajdel D, Bourdette D, Carlsen J, Haas M, et al. Randomized controlled trial of yoga and exercise in multiple sclerosis. *Neurology* 2004;62(11):2058–64.
- [64] Razazian N, Yavari Z, Farnia V, Azizi A, Kordavani L, Bahmani DS, et al. Exercising impacts on fatigue, depression, and paresthesia in female patients with MS. *Med Sci Sports Exerc* 2016;48(5):796–803.
- [65] Powell L, Cheshire A. An individualized yoga programme for multiple sclerosis: a case study. *Int J Yoga Therap* 2015;25(1):127–33.
- [66] de Oliveira G, Tavares Mda C, de Faria Oliveira JD, Rodrigues MR, Santaella DF. Yoga training has positive effects on postural balance and its influence on activities of daily living in people with multiple sclerosis: a pilot study. *Explore (NY)* 2016;12:325–32.