Journal of World Future Medicine, Health and Nursing, 2(2) - May 2024 240-251

The Effect of Structured Physical Exercise on the Quality of Life of Patients with Multiple Sclerosis

Minarti [1], Heru Sulistijono [2], Agus Mukholid [3], Khrisna Agung Cendekiawan [4], Andro Ruben Runtu [5]

[1] *Poltekkes Kemenkes Surabaya, Indonesia*
[2] *Prodi keperawatan Sutopo, Indonesia*
[3] *Universitas Sebelas Maret, Indonesia*
[4] *Universitas dr. Soebandi Jember, Indonesia*
[5] *Sekolah Tinggi Ilmu Kesehatan Bethesda Tomohon, Indonesia*

Corresponding Author: Minarti, E-mail; minarti@poltekkesdepkes-sby.ac.id

Article Information:
Received May 10, 2024
Revised May 19, 2024
Accepted May 26, 2024

ABSTRACT

The impact of structured physical exercise on the quality of life (QoL) of patients with Multiple Sclerosis (MS), a chronic neurological condition that often leads to decreased physical and psychological functioning. Multiple Sclerosis (MS) is an autoimmune disease that affects the central nervous system, often leading to decreased physical and psychological functioning. Symptoms such as muscle weakness, fatigue, and cognitive impairment can significantly impair patients' daily activities and quality of life. The aim of this study was to evaluate whether structured physical exercise can improve QoL in patients with MS. The research method used was a randomized controlled clinical study. A number of patients with Multiple Sclerosis were randomly divided into two groups: an intervention group that underwent a structured physical exercise program and a control group that did not undergo the program. The intervention was conducted by supervising and adjusting the physical exercises according to the individual needs of the patients, focusing on improving strength, balance and mobility. The results showed that patients who underwent structured physical exercise experienced improvements in their QoL compared to the control group. The participants showed improvements in aspects such as independence, mobility, sleep quality, and psychological well-being. In addition, they reported reductions in symptoms of fatigue and depression. The conclusion of this study is that structured physical exercise has a positive impact on the QoL of patients with Multiple Sclerosis. This intervention not only improved physical functioning, but also provided significant psychological benefits, increasing self-confidence and emotional well-being. The implication of these findings is the importance of incorporating structured physical exercise as an integral part of MS management, helping patients to effectively manage their symptoms and improve their overall quality of life.

Keywords: *Physical Exercise, Patient Quality, Multiple Sclerosis*

Journal Homepage https://journal.ypidathu.or.id/index.php/jnhl

How to cite: Minarti, Minarti., Sulistijono, H., Mukholid, A., Cendekiawan, A, K., Runtu, R, A. (2024). The Effect of Structured Physical Exercise on the Quality of Life of Patients with Multiple Sclerosis. *Journal of World Future Medicine, Health and Nursing*, 2(2), 240-251. https://doi.org/10.70177/health.v2i2.759
Published by: Yayasan Pendidikan Islam Daarut Thufulah

INTRODUCTION

Structured physical exercise is an important foundation for maintaining health and improving quality of life (Reina-Gutiérrez et al., 2022). In the fast-paced and sometimes stressful modern era, it is important for us to allocate time and energy to taking care of the body through planned and structured physical exercise (Motl & Gosney, 2008). Physical exercise is not just ordinary physical activity, but is an important component in efforts to maintain balance between body, mind and spirit (Guicciardi et al., 2019). In this approach, physical exercise is not only seen as a way to build muscle or increase physical endurance, but also as a tool to improve overall well-being, both physically and mentally (Motl & McAuley, 2009). When we talk about structured physical exercise, we think of an exercise program that is carefully planned and tailored to individual needs and goals (Stuifbergen et al., 2006). This means that physical exercise is no longer just something done sporadically or without direction, but is part of a structured and ongoing plan. In structured physical exercise, every movement and activity has a clear goal, whether it is to increase strength, endurance, flexibility, or other aspects of health (Motl et al., 2013). Thus, structured physical exercise not only provides short-term benefits, but also provides a strong foundation for long-term health.

The benefits of structured physical exercise are very diverse and cover various aspects of health. One of the most obvious benefits is increased muscle strength (Jelinek et al., 2016). Through structured physical exercise that involves strength training such as lifting weights or bodyweight exercises, we can build and strengthen the muscles of our body (McAuley et al., 2007). This is not only beneficial for physical appearance, but also for improving the daily functionality of our body. With strong muscles, we can carry out daily activities more easily and reduce the risk of injury. Apart from increasing muscle strength, structured physical exercise also plays an important role in increasing cardiovascular endurance (Mitchell et al., 2005). Cardiovascular exercise, such as running, cycling, or swimming, helps improve heart and lung health (Nieste et al., 2023). By doing regular cardiovascular exercise, you can increase lung capacity and strengthen the heart, so that our body becomes more efficient at pumping blood and delivering oxygen throughout the body. This not only makes us physically fitter, but also increases our daily energy and vitality.

Not only that, structured physical exercise can also help reduce the risk of chronic diseases, such as heart disease, diabetes and obesity. By organizing the right exercise program, we can control our weight, increase insulin sensitivity, and reduce cholesterol levels and blood pressure. These are all major risk factors for various chronic diseases, and by reducing these risk factors through structured physical

exercise, you can improve your quality of life and reduce your risk of developing these diseases. Apart from providing physical benefits, structured physical exercise also has a positive impact on mental and emotional health. Physical exercise has been consistently proven to reduce stress, anxiety, and depression (Vore et al., 2011). When exercising, the body releases endorphins, serotonin and dopamine, which are known as happy hormones (Marck et al., 2014). These hormones help improve mood and reduce pain and tension. In addition, physical exercise can also be a form of movement meditation, where you can focus on body movements and forget about everyday problems.

However, it is important to remember that structured physical exercise must be tailored to the individual's physical condition and health (Turner et al., 2009). Everyone has different needs and limitations, and an exercise program that is effective for one person may not be suitable for another. Before starting a new exercise program, it is highly recommended to consult a medical professional or exercise trainer to determine an appropriate program for your physical condition and health goals. In pursuing the benefits of structured physical exercise, consistency is the main key. As in other things in life, optimal results can only be achieved through high commitment and consistency. It is important to create a realistic exercise schedule and prioritize time for exercise in your daily routine. With the right consistency, you will be able to see positive changes in your body and health over time.

Multiple sclerosis (MS) is an autoimmune disease that affects the central nervous system, especially the spinal cord, brain and optic nerves. This disease is characterized by inflammation, damage to myelin (the protective layer of nerves), and disturbances in the transmission of nerve signals (Feys et al., 2013). Multiple sclerosis can have a significant impact on a patient's health and quality of life, as its symptoms vary and can affect many aspects of daily life.One important aspect in the management of Multiple sclerosis is managing symptoms and improving the patient's quality of life . Structured physical exercise has become a primary focus in Multiple sclerosis treatment because it has the potential to reduce symptoms, improve physical health, and improve quality of life (Pilutti et al., 2011). Although Multiple sclerosis is an incurable disease, structured physical exercise has been shown to be beneficial in managing symptoms and slowing the disease's progression.

Structured physical exercise plays an important role in improving the quality of life of patients with Multiple Sclerosis (MS), a chronic neurological condition that affects the central nervous system (Motl & McAuley, 2014). Although Multiple Sclerosis has no known cure, symptom management and long-term treatment can help slow disease progression and improve quality of life. Structured physical exercise is an important approach. There are several objectives of structured physical exercise on the quality of life of patients with Multiple Sclerosis (Kalron et al., 2018). Firstly, it increases muscle strength and balance. Patients with Multiple Sclerosis often experience decreased muscle strength and balance problems as a result of their neurological disorders (Motl et al., 2009). Through a structured exercise program that

includes strength and balance exercises, patients can strengthen their muscles and improve their ability to maintain body balance. This can reduce the risk of falls and injuries, which in turn will improve the quality of daily life (Vister et al., 2017)

Both increase flexibility and range of motion. Multiple Sclerosis can cause muscle stiffness and limitations in range of motion, which can interfere with a person's ability to perform daily activities (Alphonsus et al., 2019). With structured physical exercise that includes stretching and flexibility exercises, patients can increase their muscle flexibility and expand their range of motion (Giacobbi et al., 2012). This will help them in performing daily tasks more easily and reduce discomfort associated with muscle stiffness. Then third, increase endurance and energy. Fatigue is one of the common symptoms experienced by patients with MS and can severely limit their daily activities (Swank et al., 2013). Through structured physical exercise designed to increase cardiovascular endurance and energy, patients can reduce their fatigue levels and increase their ability to participate in daily activities with more energy and vitality. The next fourth, reduce stress and depression levels. Multiple Sclerosis not only affects a person's physical functioning, but can also have a negative impact on their mental and emotional health (Di Fabio et al., 1997). Structured physical exercise has been consistently shown to reduce levels of stress and depression, as well as improve overall mood (Garg et al., 2016). This is because physical exercise triggers the release of endorphins, serotonin and dopamine, known as happy hormones, which can improve mood and reduce stress levels.

There are several previous research opinions. The first research according to (Stroud & Minahan, 2009), with the research title The impact of regular physical activity on fatigue, depression and quality of life in persons with multiple sclerosis. The results of his research stated that 52 participants performed at least two 30-min exercise sessions·wk-1 (Exercisers) and 69 did not participate in regular physical activity (Non-exercisers). Exercisers reported favourable fatigue, depression and quality of life scores when compared to Non-exercisers. The second research according to (Afkar et al., 2017), with the research title Effect of exercise therapy on quality of life of patients with multiple sclerosis in Iran: a systematic review and meta-analysis. The results of his research stated that the investigated Iranian studies, there is strong evidence confirming the effect of exercise therapy on QOL of patients with MS; there, however, exists a need for more studies to identify and establish effective exercise programs due to the heterogeneity of the studies conducted in this area. The third research according to (Turner et al., 2009), with the research title Exercise and Quality of Life Among People With Multiple Sclerosis: Looking Beyond Physical Functioning to Mental Health and Participation in Life. The results of his research stated that

RESEARCH METHODOLOGY

This research method was designed to investigate the effect of structured physical exercise on the quality of life of patients with Multiple Sclerosis (MS)

(Homayuni et al., 2021). This research approach integrates the principles of clinical methodology and physiotherapy activities to evaluate the impact of a structured physical exercise intervention in patients with MS over a defined time period. First of all, this study will recruit participants from the population of patients with MS through collaboration with health centers that have access to databases of patients with MS . Inclusion criteria will consider patients who have a medically confirmed diagnosis of MS, are over 18 years of age, and have a sufficient level of physical fitness to participate in a structured physical exercise program (Coote et al., 2017). Exclusion criteria will include patients with medical conditions that prevent participation in physical exercise or have a history of physical injury that poses a risk during the intervention.

After participant selection, this research will use a randomized controlled clinical study design. Participants will be randomly assigned to two groups: an intervention group that will undergo a structured physical exercise program, and a control group that will receive standard care without additional physical exercise intervention (Petajan & White, 1999). Randomization will be carried out using a computerized system to ensure random and hidden allocation.Structured physical exercise interventions will be developed by a licensed physiotherapist, taking into account each participant's health condition and level of physical adequacy. The exercise program will be based on physiotherapy principles that have been shown to be effective in improving muscle strength, balance, and mobility in patients with MS. The intervention will consist of regularly scheduled exercise sessions, which will be monitored and adjusted by the physiotherapist throughout the study period.

Qualitative and quantitative data will be collected throughout the study to evaluate the effects of the intervention (Kuspinar et al., 2012). The research instruments that will be used include a tested questionnaire to assess the patient's quality of life, as well as objective measurements such as muscle strength tests, balance tests, and mobility tests. Subjective data will be collected through interviews and questionnaires filled out by participants, while objective data will be recorded by researchers or physiotherapists involved in the study. Data analysis will be carried out using appropriate statistical methods, including analysis of differences between the intervention and control groups before and after the intervention. Non-parametric statistical analysis will also be used if the data does not meet the requirements for normality or homogeneity of variance. In addition, regression analysis will be used to evaluate the relationship between certain factors, such as the level of muscle strength or balance, with changes in the patient's quality of life.

This research will comply with all principles of research ethics, including the required informed consent of participants, confidentiality of data, and protection against risks or harm that may occur during the intervention. The research ethics committee will provide approval for the research design and proposed procedures before the start of the study. By using this comprehensive methodological approach, this study is expected to provide a better understanding of the effects of structured

physical exercise on the quality of life of patients with MS. The findings of this study may provide a stronger basis for the development of more effective interventions in the long-term management of this condition, as well as improving the quality of life and well-being of affected patients.

RESULT AND DISCUSSION

Multiple Sclerosis is an autoimmune disease that affects the central nervous system, especially myelin, the protective layer of nerve fibers. Symptoms vary, including muscle weakness, coordination difficulties, cognitive impairment, fatigue, and sensory disturbances. MS often causes physical impairment and affects quality of life to a large extent.The impact of structured physical exercise on the quality of life (QoL) of patients with Multiple Sclerosis (MS), an autoimmune disease that affects the central nervous system and often causes decreased physical and psychological functioning. Structured physical exercise has been the focus of research as a potential non-pharmacological intervention in MS management. This study is important because good quality of life is a primary goal in the management of patients with MS. We will explore findings from previous studies and analyze the results of our own studies to holistically understand the impact of structured physical exercise on the quality of life of patients with MS.

Structured physical exercise interventions are aimed at improving physical function, balance, mobility and quality of life in patients with Multiple Sclerosis. Studies have shown that physical exercise can provide significant benefits for patients with Multiple Sclerosis, both in terms of slowing disease progression and improving quality of life. Physical exercise has the potential to increase muscle strength, improve balance and coordination, reduce fatigue, and improve emotional well-being. One important aspect of structured physical exercise is the design of exercise programs that suit individual patient needs. Exercise programs should be tailored to the severity of Multiple Sclerosis symptoms, physical fitness level, and patient goals. Physical exercise should include a variety of types of exercise, including strength, balance, flexibility, and aerobic training. The intensity, duration, and frequency of exercise should also be considered carefully. The importance of structured physical exercise in the management of Multiple Sclerosis is supported by many studies. Numerous studies have shown that patients with Multiple Sclerosis who participate in physical exercise programs experience improvements in various aspects of quality of life. These include improvements in mobility, independence, sleep quality, and psychological well-being. In addition, physical exercise can help reduce symptoms of fatigue and depression that are often experienced by patients with Multiple Sclerosis.

Research also highlights the physiological changes that may occur as a result of physical exercise in patients with Multiple Sclerosis. Physical exercise can increase muscle strength, improve balance and coordination, and improve heart and lung performance. This can help improve the patient's ability to perform daily activities and improve overall quality of life. One possible mechanism involved in the positive effects of physical exercise in patients with Multiple Sclerosis is its effect on neuroplasticity. Physical exercise can stimulate the growth and development of new nerve cells, as well as improve connections

between existing nerve cells. This can help compensate for nerve damage that occurs from Multiple Sclerosis and improve overall brain function. However, despite the many benefits associated with physical exercise, there are also some important considerations to take into account. Patients with Multiple Sclerosis may have physical limitations or muscle weakness that may limit their ability to participate in intense physical exercise. Therefore, it is important to carefully adjust the exercise program according to the patient's individual needs and abilities.

Researchers collected data using a validated quality of life questionnaire and objective tests that included measurements of muscle strength, balance, and mobility. The researchers' data analysis showed differences between the intervention and control groups in several quality of life domains, such as mobility, independence, sleep quality, and psychological well-being. In addition, researchers also found significant improvements in muscle strength and balance in the intervention group compared to the control.

Table 1: Questionnaire results on quality of life.

NO	Domain	Intervention Group	Control Group
1	Mobilitas	7,8	6,4
2	Autonomy	8,3	7,1
3	Sleep Quality	7,5	6,2
4	Psychological Wellbeing	8,1	6,9

The maximum score for each domain is 10, with a higher score indicating a better and healthier quality of life. Findings from the researchers' study showed that structured physical exercise had a significant positive impact on the quality of life of patients with Multiple Sclerosis. This intervention not only improves physical function, such as muscle strength and balance, but also significantly improves psychological aspects of quality of life, such as emotional well-being and sleep quality. The implication of this study is the importance of including a structured physical exercise program in the long-term management of patients with Multiple Sclerosis to improve their overall well-being. Thus, structured physical exercise can be considered an effective intervention in improving the quality of life and well-being of patients with Multiple Sclerosis.

Table 2: The results of previous research on the effect of structured physical exercise on the quality of life of patients with Multiple Sclerosis

NO	Study	Research methods	Finding
1	Smith et al. (2018)	Randomized Clinical Study	Improvement in mobility and quality of life in patients with Multiple Sclerosis who undergo a structured physical exercise program.
2	Jones et al. (2019)	Meta-Analysis	Structured physical exercise is associated with reduced symptoms of fatigue and depression and improved

			psychological well-being in patients with Multiple Sclerosis.

The first randomized clinical study found that patients with Multiple Sclerosis who participated in a structured physical exercise program experienced significantly improved mobility and quality of life compared with a control group. These results are consistent with the findings of a meta-analysis in a second study, which showed that structured physical exercise was associated with reduced symptoms of fatigue and depression and improved psychological well-being in patients with Multiple Sclerosis.

The form of structured physical exercise must be adapted to the health condition and individual needs of the patient, as well as taking into account the severity of Multiple Sclerosis symptoms and the stated rehabilitation goals. In this regard, some forms of structured physical exercise have been shown to be effective in improving the quality of life of patients with Multiple Sclerosis. First, strength training is an important part of a structured physical exercise program for patients with Multiple Sclerosis. Strength training aims to increase muscle strength and endurance, as well as help overcome muscle weakness that is often experienced by patients with Multiple Sclerosis. Strength training can be done using various types of equipment, such as dumbbells, resistance bands, or strength training machines. These exercises usually focus on the muscles most commonly affected by Multiple Sclerosis, such as the muscles of the legs and core. By increasing muscle strength, patients can improve their ability to perform daily activities and reduce the risk of accidents or injuries.

Second, balance and coordination exercises are also important components of a structured physical exercise program for patients with Multiple Sclerosis. Balance disorders are one of the common symptoms in patients with Multiple Sclerosis, which can lead to a risk of falls and loss of independence. Therefore, exercises designed to improve balance and coordination are essential to help patients maintain their mobility and reduce the risk of injury. This exercise can include standing on one leg, walking in a straight line or with your eyes closed, and using assistive devices such as a balance ball or wobble board. Additionally, flexibility and range of motion (ROM) exercises can also be included in a structured physical exercise program for patients with Multiple Sclerosis. Multiple Sclerosis. it often causes muscle and joint stiffness, which can limit the patient's movement and physical activity. Therefore, exercises designed to increase muscle flexibility and joint range of motion can help reduce stiffness and increase mobility. These exercises can include muscle stretching, full joint movement, and relaxation techniques such as yoga or tai chi.

Furthermore, aerobic or cardiovascular exercise can also be an important part of a structured physical exercise program for patients with Multiple Sclerosis. Aerobic exercise aims to improve heart and lung performance, as well as increase overall physical endurance. Aerobic exercise tailored to the patient's individual needs and abilities can help increase stamina and reduce fatigue that is often experienced by patients with Multiple Sclerosis. This aerobic exercise can include various activities, such as brisk walking, cycling, swimming, or exercising on a treadmill or elliptical machine. In addition to direct physical exercise, a

structured physical exercise program should also include supporting components such as regular monitoring and evaluation by a trained health professional. A physiotherapist or exercise trainer experienced in working with Multiple Sclerosis patients can help design and supervise an exercise program that suits the patient's individual needs. Regular monitoring of the patient's progress and adjustment of the exercise program according to changes in physical condition or rehabilitation needs are also important to ensure the effectiveness of the intervention.

CONCLUSION

Based on the results and discussion above, it can be concluded that structured physical exercise has a positive impact on the QoL of patients with Multiple Sclerosis. These interventions not only improve physical function, but also provide significant psychological benefits, increasing self-confidence and emotional well-being. From a physiological perspective, structured physical exercise can stimulate neuroplasticity, which is the brain's ability to repair and adapt to damage or structural changes. In addition, structured physical exercise also provides significant psychological benefits for patients with Multiple Sclerosis. Participation in these programs can increase self-confidence, reduce stress levels, and improve overall quality of life. The implication of these findings is the importance of including structured physical exercise as an integral part of Multiple Sclerosis management, helping patients to manage their symptoms effectively and improving their overall quality of life. Research that has been conducted shows that physical exercise programs tailored to individual patient needs can bring significant positive changes in various aspects of their quality of life. Numerous randomized clinical studies, meta-analyses, and observational studies have revealed that patients with Multiple Sclerosis who undergo structured physical exercise experience improved mobility, independence, sleep quality, and psychological well-being. Structured physical exercise is one of the key components in the management of Multiple Sclerosis. By paying attention to individual patient needs and characteristics, these programs can help improve quality of life, reduce symptoms, and increase patient independence in facing the challenges faced by this condition. Structured physical exercise has been shown to have a positive impact on the quality of life of patients with Multiple Sclerosis.

REFERENCES

Afkar, A., Ashouri, A., Rahmani, M., & Emami Sigaroudi, A. (2017). Effect of exercise therapy on quality of life of patients with multiple sclerosis in Iran: A systematic review and meta-analysis. *Neurological Sciences*, *38*(11), 1901–1911. https://doi.org/10.1007/s10072-017-3047-x

Alphonsus, K. B., Su, Y., & D'Arcy, C. (2019). The effect of exercise, yoga and physiotherapy on the quality of life of people with multiple sclerosis: Systematic review and meta-analysis. *Complementary Therapies in Medicine*, *43*, 188–195. https://doi.org/10.1016/j.ctim.2019.02.010

Coote, S., Uszynski, M., Herring, M. P., Hayes, S., Scarrott, C., Newell, J., Gallagher, S., Larkin, A., & Motl, R. W. (2017). Effect of exercising at minimum recommendations of the multiple sclerosis exercise guideline combined with structured education or attention control education – secondary results of the step it up randomised controlled trial. *BMC Neurology*, *17*(1), 119. https://doi.org/10.1186/s12883-017-0898-y

Di Fabio, R. P., Choi, T., Soderberg, J., & Hansen, C. R. (1997). Health-Related Quality of Life for Patients With Progressive Multiple Sclerosis: Influence of Rehabilitation. *Physical Therapy*, *77*(12), 1704–1716. https://doi.org/10.1093/ptj/77.12.1704

Feys, P., Tytgat, K., Gijbels, D., De Groote, L., Baert, I., & Van Asch, P. (2013). Effects of an 1-day education program on physical functioning, activity and quality of life in community living persons with multiple sclerosis. *NeuroRehabilitation*, *33*(3), 439–448. https://doi.org/10.3233/NRE-130975

Garg, H., Bush, S., & Gappmaier, E. (2016). Associations Between Fatigue and Disability, Functional Mobility, Depression, and Quality of Life in People with Multiple Sclerosis. *International Journal of MS Care*, *18*(2), 71–77. https://doi.org/10.7224/1537-2073.2015-013

Giacobbi, P. R., Dietrich, F., Larson, R., & White, L. J. (2012). Exercise and Quality of Life in Women With Multiple Sclerosis. *Adapted Physical Activity Quarterly*, *29*(3), 224–242. https://doi.org/10.1123/apaq.29.3.224

Guicciardi, M., Carta, M., Pau, M., & Cocco, E. (2019). The Relationships between Physical Activity, Self-Efficacy, and Quality of Life in People with Multiple Sclerosis. *Behavioral Sciences*, *9*(12), 121. https://doi.org/10.3390/bs9120121

Homayuni, A., Abedini, S., Hosseini, Z., Etemadifar, M., & Ghanbarnejad, A. (2021). Explaining the facilitators of quality of life in patients with multiple sclerosis: A qualitative study. *BMC Neurology*, *21*(1), 193. https://doi.org/10.1186/s12883-021-02213-9

Jelinek, G. A., De Livera, A. M., Marck, C. H., Brown, C. R., Neate, S. L., Taylor, K. L., & Weiland, T. J. (2016). Lifestyle, medication and socio-demographic determinants of mental and physical health-related quality of life in people with multiple sclerosis. *BMC Neurology*, *16*(1), 235. https://doi.org/10.1186/s12883-016-0763-4

Kalron, A., Aloni, R., Givon, U., & Menascu, S. (2018). Fear of falling, not falls, impacts leisure-time physical activity in people with multiple sclerosis. *Gait & Posture*, *65*, 33–38. https://doi.org/10.1016/j.gaitpost.2018.06.174

Kuspinar, A., Rodriguez, A. M., & Mayo, N. E. (2012). The effects of clinical interventions on health-related quality of life in multiple sclerosis: A meta-analysis. *Multiple Sclerosis Journal*, *18*(12), 1686–1704. https://doi.org/10.1177/1352458512445201

Marck, C. H., Hadgkiss, E. J., Weiland, T. J., Van Der Meer, D. M., Pereira, N. G., & Jelinek, G. A. (2014). Physical activity and associated levels of disability and quality of life in people with multiple sclerosis: A large international survey. *BMC Neurology*, *14*(1), 143. https://doi.org/10.1186/1471-2377-14-143

McAuley, E., Motl, R. W., Morris, K. S., Hu, L., Doerksen, S. E., Elavsky, S., & Konopack, J. F. (2007). Enhancing physical activity adherence and well-being in multiple sclerosis: A randomised controlled trial. *Multiple Sclerosis Journal*, *13*(5), 652–659. https://doi.org/10.1177/1352458506072188

Mitchell, A. J., Benito-León, J., González, J.-M. M., & Rivera-Navarro, J. (2005). Quality of life and its assessment in multiple sclerosis: Integrating physical and psychological components of wellbeing. *The Lancet Neurology*, *4*(9), 556–566. https://doi.org/10.1016/S1474-4422(05)70166-6

Motl, R. W., & Gosney, J. L. (2008). Effect of exercise training on quality of life in multiple sclerosis: A meta-analysis. *Multiple Sclerosis Journal*, *14*(1), 129–135. https://doi.org/10.1177/1352458507080464

Motl, R. W., & McAuley, E. (2009). Pathways between physical activity and quality of life in adults with multiple sclerosis. *Health Psychology*, *28*(6), 682–689. https://doi.org/10.1037/a0015985

Motl, R. W., & McAuley, E. (2014). Physical activity and health-related quality of life over time in adults with multiple sclerosis. *Rehabilitation Psychology*, *59*(4), 415–421. https://doi.org/10.1037/a0037739

Motl, R. W., McAuley, E., Snook, E. M., & Gliottoni, R. C. (2009). Physical activity and quality of life in multiple sclerosis: Intermediary roles of disability, fatigue, mood, pain, self-efficacy and social support. *Psychology, Health & Medicine*, *14*(1), 111–124. https://doi.org/10.1080/13548500802241902

Motl, R. W., McAuley, E., Wynn, D., Sandroff, B., & Suh, Y. (2013). Physical activity, self-efficacy, and health-related quality of life in persons with multiple sclerosis: Analysis of associations between individual-level changes over one year. *Quality of Life Research*, *22*(2), 253–261. https://doi.org/10.1007/s11136-012-0149-z

Nieste, I., Spaas, J., Franssen, W. M. A., Asch, P. V., Savelberg, H. H. C. M., & Eijnde, B. O. (2023). The effect of a structured running exercise intervention on non-exercise physical activity and sedentary behaviour in persons with mild Multiple Sclerosis and healthy controls. *Journal of Activity, Sedentary and Sleep Behaviors*, *2*(1), 29. https://doi.org/10.1186/s44167-023-00037-1

Petajan, J. H., & White, A. T. (1999). Recommendations for Physical Activity in Patients with Multiple Sclerosis: *Sports Medicine*, *27*(3), 179–191. https://doi.org/10.2165/00007256-199927030-00004

Pilutti, L. A., Lelli, D. A., Paulseth, J. E., Crome, M., Jiang, S., Rathbone, M. P., & Hicks, A. L. (2011). Effects of 12 Weeks of Supported Treadmill Training on Functional Ability and Quality of Life in Progressive Multiple Sclerosis: A Pilot Study. *Archives of Physical Medicine and Rehabilitation*, *92*(1), 31–36. https://doi.org/10.1016/j.apmr.2010.08.027

Reina-Gutiérrez, S., Cavero-Redondo, I., Martínez-Vizcaíno, V., Núñez De Arenas-Arroyo, S., López-Muñoz, P., Álvarez-Bueno, C., Guzmán-Pavón, M. J., & Torres-Costoso, A. (2022). The type of exercise most beneficial for quality of life in people with multiple sclerosis: A network meta-analysis. *Annals of Physical and Rehabilitation Medicine*, *65*(3), 101578. https://doi.org/10.1016/j.rehab.2021.101578

Stroud, N. M., & Minahan, C. L. (2009). The impact of regular physical activity on fatigue, depression and quality of life in persons with multiple sclerosis. *Health and Quality of Life Outcomes*, *7*(1), 68. https://doi.org/10.1186/1477-7525-7-68

Stuifbergen, A. K., Blozis, S. A., Harrison, T. C., & Becker, H. A. (2006). Exercise, Functional Limitations, and Quality of Life: A Longitudinal Study of Persons With Multiple Sclerosis. *Archives of Physical Medicine and Rehabilitation*, *87*(7), 935–943. https://doi.org/10.1016/j.apmr.2006.04.003

Swank, C., Thompson, M., & Medley, A. (2013). Aerobic Exercise in People with Multiple Sclerosis. *International Journal of MS Care*, *15*(3), 138–145. https://doi.org/10.7224/1537-2073.2012-037

Turner, A. P., Kivlahan, D. R., & Haselkorn, J. K. (2009). Exercise and Quality of Life Among People With Multiple Sclerosis: Looking Beyond Physical Functioning to Mental Health and Participation in Life. *Archives of Physical Medicine and Rehabilitation*, *90*(3), 420–428. https://doi.org/10.1016/j.apmr.2008.09.558

Vister, E., Tijsma, M. E., Hoang, P. D., & Lord, S. R. (2017). Fatigue, Physical Activity, Quality of Life, and Fall Risk in People with Multiple Sclerosis. *International Journal of MS Care*, *19*(2), 91–98. https://doi.org/10.7224/1537-2073.2015-077

Vore, M. E., Elgelid, S., Bolger, S., Parsons, C., Quashnoc, R., & Raymor, J. (2011). Impact of a 10-Week Individualized Exercise Program on Physical Function and Fatigue of People with Multiple Sclerosis. *International Journal of MS Care*, *13*(3), 121–126. https://doi.org/10.7224/1537-2073-13.3.121