Original Article

Investigating Compliance with a Home Exercise Program in People with Multiple Sclerosis

Anıl TEKEOĞLU TOSUN[1] , Nergis YILMAZ[1] , Ezgi ERYILDIZ[1] , Çağdaş IŞIKLAR[1] , Hilal HOTAMAN KEKLİCEK[2]

[1]Department of Physiotherapy and Rehabilitation, Fenerbahçe University, Faculty of Health Sciences, İstanbul, Türkiye
[2]Division of Neurological Physiotherapy and Rehabilitation, Department of Physiotherapy and Rehabilitation, Trakya University, Faculty of Health Sciences, İstanbul, Türkiye
This study was presented as an oral abstract at the 4 Trakya Physiotherapy Days: Technology in Rehabilitation Symposium (28.05.2021, Online)

1

What is already known on this topic?

- *Multiple sclerosis is a chronic condition with complex treatment needs, including exercise-based rehabilitation.*
- *Compliance with home exercise programs is crucial for achieving the intended benefits of rehabilitation in individuals with MS.*
- *Despite the benefits of home-based exercise programs, adherence rates are often low due to barriers such as motivation, access to physiotherapy guidance, and program renewal frequency.*

What this study adds on this topic?

- *This study highlights that only a small percentage (12.9%) of individuals with MS in Turkey receive prescribed home exercise programs.*
- *Adherence to home exercise programs was found to be limited, with significant barriers such as inadequate motivation and lack of proper guidance.*
- *The findings emphasize the need for individualized, regularly updated, and supported home exercise programs to improve adherence and maximize health outcomes for individuals with MS.*

ABSTRACT

Objective: This study aims to evaluate the status of receiving home exercise programs and adherence among individuals with multiple sclerosis (MS), providing insights for clinical practice.

Methods: Individuals diagnosed with MS, aged 18 and over, literate, and reached through the social media platforms of the MS Society of Türkiye, were included in the study. Individuals who did not fully complete the questions asked and/or gave answers irrelevant to the topic, who reported comorbidities that may prevent participation in exercise along with MS, and those not meeting the specified age criteria were excluded from the study. Data were collected through an online questionnaire assessing MS patients' sociodemographic and clinical characteristics and their engagement and adherence to home exercise programs.

Results: A total of 217 people (n = 36) male, (n = 181) female, participated in the study. While the rate of having a prescribed home exercise program among all participants was 12.90%, this rate was 8.33% for men and 13.81% for women. When the compliance of the participants with home exercise programs was examined, all men stated they sometimes applied these programs. This rate was found to be 52% for women.

Conclusion: The study demonstrated that a considerable proportion of individuals with MS did not engage with the prescribed home exercise programme. Furthermore, the adherence rates and frequency of exercise updates were found to be inadequate. Since the MS population is increasing steadily in Türkiye, it is vital to facilitate access to effective exercises for people with MS and to ensure lifelong compliance with these exercises.

Keywords: Exercise adherence, home exercise, multiple sclerosis, patient compliance

Introduction

Multiple sclerosis (MS), defined as a chronic autoimmune disease affecting the central nervous system, progresses with demyelination and neuronal loss.[1] The worldwide prevalence of MS is approximately 2.3 million, and it is usually diagnosed between the ages of 20 and 50.[2] Multiple sclerosis causes motor, sensory, visual, and autonomic disorders in the central nervous system, impairs physical and cognitive functions in individuals, and negatively affects quality of life and employment.[3] The treatment of individuals with MS requires multifaceted applications, primarily drug and exercise rehabilitation.[4] The effectiveness of the treatment depends on the compatibility of the applied medical method with the etiology of the disease and comorbid factors, as well as patients' biopsychosocial characteristics, patient gender, and the level of compliance with the treatment processes.[5,6] The study by Craft et al[7] also indicated that exercise

Corresponding author: Anıl Tekeoğlu Tosun, e-mail: anil19@gmail.com

2

alone may not be beneficial for women under all circumstances. In order to maximize the benefits of exercise on quality of life, women may need to exercise under certain conditions and qualifications. These findings are particularly important for healthcare providers who prescribe exercise programs. It also suggests that it may not be necessary to consider exercise attributions when designing an exercise program for men. Apart from this, many studies have been conducted on the compliance of individuals with MS with medical treatment, and researchers have frequently emphasized that there are still factors that need to be defined.[8,9] No matter how good the recommended prescription is, if the patient cannot comply with it for any reason, the treatment cannot be successful. Therefore, studies affecting compliance are also important to increase the effectiveness of medical treatment.[8,9]

There are studies in the literature on the importance of compliance with exercise therapy in individuals with chronic neurological diseases.[10,11] Recommended exercise programs can take many forms, but they are divided into 2 types: supervised exercise programs and home exercise programs. There are some studies showing that supervised exercise programs increase compliance with exercise in neurological diseases, but their sustainability is difficult due to cost-effectiveness, lack of time, distance, transportation, disability, lack of specialists, insurance coverage, or the severity of the disease.[12-17] On the other hand, home-based structured exercise programs have been reported to be cheap, easy to implement, and effective. As in medical treatment, the key to achieving the targeted results in home exercise is patient compliance.[18] The situation is similar for individuals with MS. It has been reported that home exercise programs carried out in the comfort of home environments can eliminate factors that negatively affect exercise participation in individuals with MS, such as transportation difficulties, the compulsion to work due to economic deficiencies, or the need for caregivers. It has also been emphasized that such home exercise programs may increase the regularity and continuity of participation.[19]

A review of the literature indicated that there was no study on the examination of the status of patients with MS receiving a home exercise program and their compliance with the program. In this context, we aimed to define the status of receiving a home exercise program and compliance with this program in individuals with MS and to create a resource for clinical practice.

Methods

This research, designed as a cross-sectional study, began with obtaining individuals' informed consent, followed by data collection through an online questionnaire using Google Forms. The data collection phase was carried out in collaboration with the Turkish MS Association, which, as of 2020, has approximately 1200 members from many provinces of Türkiye. The population of the study reflects the characteristics of the MS population in the country well due to this diversity. The association's extensive patient network facilitated access to more participants, which promoted the study further. After obtaining permission from the MS Society of Türkiye, the survey link was shared with individuals on their official social media platforms. Individuals who answered all items on the questionnaire were included in the study. The study group consisted of individuals with MS who volunteered to participate and were selected using the random sampling method. The inclusion criteria were agreeing to participate in the study after being informed, having been diagnosed with MS, being aged ≥18 years, and having Turkish literacy. The exclusion criteria were not fully completing the questions and/or giving answers that were not relevant to the topic, reporting comorbidities that could prevent participation in exercise along with MS, and not meeting the specified age criteria. Accordingly, 217 individuals with MS (181 female and 36 male) were reached in the study. Ethical approval for the study was obtained from the Trakya University Scientific Research Ethics Committee (Approval no: 7/15, Date: March 01, 2021).

Data Collection Tools
Data were collected using an information form created by the researchers. The information form contained questions to determine the sociodemographic characteristics of individuals with MS, their status of receiving home exercise programs, and their compliance with these programs.

Information Form
This is a 16-question form created by the researchers to determine the participants' age, height, weight, gender, MS type, and time of MS diagnosis. "Has your doctor ever told you that exercising is not safe for you?" "Do you have any health problems that prevent you from exercising?" These questions were used to determine the exclusion criteria for the study. In addition to sociodemographic data, this form included the following questions: "Do you have a home exercise program?", "Do you follow your home exercise program regularly?", "I cannot follow the home exercise program regularly because…….?", "How often is your home exercise program renewed?", and "How would you best describe your home exercise program?" These items were used to question whether individuals with MS received a home exercise program and, if so, their knowledge about its application.

Sample Size
The sample size was determined using the Raosoft sample size calculator. Based on data from the Turkish MS Society, the population size of individuals with MS in Türkiye was estimated to be approximately 80 000. For this study, the margin of error ($\alpha = 0.05$) and a 90% confidence level were specified, resulting in a minimum required sample size of 270 individuals. The sample included in the study consisted of 217 participants, representing a confidence level of 85.9%.

Statistical Analysis
Descriptive statistics for categorical variables were presented using frequencies and percentages. The Shapiro–Wilk test was employed to examine the normality of numerical variables. Descriptive statistics of quantitative variables were given using mean-standard deviation ($\overline{X} \pm$ SD) values for normally distributed data and medians (min-max) for non-normally distributed data. Statistical analysis of the data was performed using the Statistical Package for Social Sciences version 27.0 software (IBM Corp.; Armonk, NY, USA).

Results

Findings about the descriptive characteristics of the participants included in the study are given in Table 1.

As shown in Table 2, the mean age of 217 participants, including 181 females and 36 males, was 35.73 ± 9.66 years. Participants' mean BMI was 23.06 ± 4.06, and 56.68% were classified as normal weight and 33.64% as overweight. When the distribution of MS types was examined, the relapsing-remitting type was the most frequently reported among those who knew their MS type, with a rate of 27.64%. The duration of MS diagnosis in male participants was ≥10 years in 36.11% and 5-10 years in 33.33%. The duration of the diagnosis in female participants was 1-5 years and ≥10 years in 30.93% and 5-10 years in 20.99%.

Descriptive statistics of individuals' status of receiving a home exercise program and their compliance with the program by gender are shown in Table 2.

It was found that 28 out of 217 participants received a home exercise program. When expressed proportionally, the rate of receiving a home

Table 1. Descriptive Statistics of Individuals' Demographic and MS Characteristics by Gender

	Male (n=36)		Female (n=181)		Total (n=217)	
	$\overline{X} \pm$ SD		$\overline{X} \pm$ SD		$\overline{X} \pm$ SD	
Age (year)	37.47 ± 9.98		35.39 ± 9.58		35.73 ± 9.66	
BMI (kg/m²)	24.33 ± 2.78		23.64 ± 0.27		23.06 ± 4.06	
	n	%	n	%	n	%
BMI group						
Underweight	1	2.77	11	6.07	12	5.52
Normal weight	18	50.00	105	58.01	123	56.68
Overweight	17	47.23	56	30.93	73	33.64
Obese	0	0.00	9	4.97	9	4.14
MS type						
Benign	0	0.00	2	1.10	2	0.92
Relapsing-remitting	7	19.44	53	29.28	60	27.64
Secondary progressive	2	5.55	11	6.07	13	5.99
Primary progressive	7	19.44	7	3.86	14	6.45
I do not know	20	55.55	108	59.66	128	58.98
Time since MS diagnosis (year)						
≤1	5	13.8	31	17.12	36	16.58
1-5	6	16.66	56	30.93	62	28.57
5-10	12	33.33	38	20.99	50	23.04
≥10	13	36.11	56	30.93	69	31.79
Status of smoking						
Yes	14	38.88	41	22.65	55	25.34
No	22	61.11	140	77.34	166	76.49

BMI, body mass index, SD, standard deviation, $\overline{X}$, mean.

exercise program was 12.90% for the general participants, while this rate was 8.33% for males and 13.81% for females. It was seen that 100% of the males who had a home exercise program practiced it "occasionally" and that 52% of the women did it "usually" and 36% "occasionally". The reasons stated by men for not doing home exercise regularly were "I do not have adequate tools for my exercises," "I lack motivation/desire," and "My muscle stiffness prevents me" in 66.66% and "I am not sure if I am doing my exercises correctly," "I cannot get the help I need while doing my exercises," and "I cannot make time for my exercises" in 33.33%. On the other hand, the reasons stated by women for not doing the exercises regularly were "I lack motivation/desire" in 24%, "I am not sure if I am doing my exercises correctly" and "I cannot make time for my exercises" in 12%, "I do not have adequate tools for my exercises" and "My pain prevents me" in 8%, and "I do not believe they are beneficial" and "My muscle stiffness prevents me" in 4%. While 67.85% of the participants stated the frequency of the renewal of their home exercise programs outside of the given options, it was once a month for 17.85% and every 3 months for 10.71%. Male participants chose the following statements that best described their home exercise program at a rate of 33.33%: "My home exercise program was prepared specifically for me," "My home exercise program was given by marking it on a form," and "An applied demonstration of my home exercise program was presented to me." On the other hand, female participants chose "I myself organized my own home exercise program" at a rate of 48%, "An applied demonstration of my home exercise program was presented to me" at a rate of 24%, and "My home exercise program was prepared specifically for me" at a rate of 20%. It was determined that 71.42% of 217 participants had not been doing any regular physical activity outside of the home exercise program, while this rate was 72.22% for men and 71.27% for women.

Discussion

The study demonstrated that a considerable proportion of individuals with MS did not engage with the prescribed home exercise program. Furthermore, the adherence rates and frequency of exercise updates were inadequate. This low rate is thought to reflect a critical situation that needs to be considered in terms of the MS population in Türkiye.

In recent years, it has been reported that the use of pharmacological agents, as well as the implementation of a rehabilitation program, is effective in controlling and modifying the symptoms, relapses, and attacks of MS.[20,21] It is also known that patient-specific rehabilitation programs can improve functional status in MS, reduce disability levels, and thus enhance the ability to adapt to daily life.[22] One of the most important components of a rehabilitation program is exercise. Exercise can play an active role in reducing neural apoptosis and neurodegeneration in MS, thereby contributing to the management of the disease by stimulating neuroplasticity.[23] Maintaining exercise programs in a clinical setting poses challenges, particularly for individuals with limited access to services, advanced disabilities, rural residency, or insufficient socioeconomic resources. It is thought that home-based exercise programs can be an alternative to eliminate these adverse effects and enable individuals with MS to obtain maximum health benefits from exercise.[24] In our study, it was found that individuals with MS who received a home exercise program constituted a very low rate (only 12.9%) of all participants. The data in a US report[25] showing that only 25% of people with MS receive a rehabilitation program may also indicate that the rate of receiving a rehabilitation program for MS is low, so it can be considered that this low rate found in our study is parallel to this information. It has been stated in the literature that a multidisciplinary team, which includes neurologists, nurses, physiotherapists, exercise physiologists, and other health professionals, plays a critical role in recommending exercise training and encouraging exercise in people with MS.[26] In line with both the results of our study and the recommendations in the literature, we can say that it is necessary to conduct studies on exercise recommendations for individuals with MS in our country and that beneficial results can be obtained in this patient population with individually planned, controlled home exercise programs.

In our study, the answers given to the questions asked of the people who received home exercise programs to determine the characteristics

Table 2. Descriptive Statistics of Individuals' Status of Receiving a Home Exercise Program and Adherence to the Program by Gender

	Male (n = 36)		Female (n = 181)		Total (n = 217)	
	n	%	n	%	n	%
Do you have a home exercise program?						
Yes	3	8.33	25	13.81	28	12.90
No	33	91.66	156	86.18	189	87.09
Do you practice your home exercise program regularly as recommended?						
Never	0	0.00	1	4.00	1	3.57
Occasionally	3	100	9	36.00	12	42.85
Usually	0	0.00	13	52.00	13	46.42
Always	0	0.00	2	8.00	2	7.14
***I cannot practice my home exercise program regularly because…**						
I am not sure if I am doing my exercises correctly.	1	33.33	3	12.00	4	14.28
I do not have adequate tools for my exercises.	2	66.66	2	8.00	4	14.28
I cannot get the help I need while doing my exercises.	1	33.33	0	0.00	1	3.57
I find my home exercises very tiring.	0	0.00	0	0.00	0	0.00
I cannot make time for my exercises.	1	33.33	3	12.00	4	14.28
I do not believe they are beneficial.	0	0.00	1	4.00	1	3.57
I lack motivation/desire.	2	66.66	6	24.00	8	28.57
My pain prevents me.	0	0.00	2	8.00	2	7.14
My muscle stiffness prevents me.	2	66.66	1	4.00	3	10.71
Other	0	0.00	2	8.00	2	7.14
How often is your home exercise program renewed?						
Once a month	0	0.00	5	20.00	5	17.85
Once every 3 months	0	0.00	3	12.00	3	10.71
Once every 6 months	0	0.00	1	4.00	1	3.57
Other	3	100	16	64.00	19	67.85
***Please check the box next to the sentence(s) that best describe your home exercise program.**						
My home exercise program was prepared specifically for me.	1	33.33	5	20.00	6	21.24
My home exercise program was given by marking it on a form.	1	33.33	1	4.00	2	7.14
An applied demonstration of my home exercise program was presented to me.	1	33.33	6	24.00	7	25.00
I myself organized my own home exercise program.	0	0.00	12	48.00	12	42.85
Other	0	0.00	2	8.00	2	7.14
Do you do any regular physical activity outside of your home exercise program?						
Yes	10	27.77	52	28.72	62	28.57
No	26	72.22	129	71.27	155	71.42

*Multiple responses were given.

of these programs and to examine people's adherence to them were examined, and it was seen that the rate of those who regularly applied the program as recommended was very low. Most of the participants reported that they "occasionally" or "usually" practiced the home exercise program given to them. The reasons that prevented them from doing the home exercise program regularly were mostly a lack of motivation for the program, a lack of necessary equipment for exercise, failure to spare time for exercise, and being unsure whether they applied the program correctly. The results of our study indicated that even if a home exercise program was given, adherence to the program was affected by many factors and that it was weak. The "other" response given to the question about the frequency of renewal of the home exercise program instead of the options, such as once a month, once every 3 months, or once every 6 months, showed that the follow-up and renewal process of the recommended home exercise program was disrupted. In addition, some of the individuals with MS who stated that they had a home exercise program were found to determine their own home exercise program. This situation may have been because individuals with MS believed in the importance of a home exercise program, but they did not have enough effective access to a physiotherapist who could provide home exercise consultancy. At the same time, this situation revealed that the home exercise program lacked the necessary components so that its health benefits could emerge. Our

findings were consistent with the results of the study by Ghahfarrokhi et al.[27] A review of the literature showed that home-based exercise programs performed with the help of mobile applications, internet-based training programs, and virtual reality were applicable and effective.[28-32] Considering that exercise programs performed in this way can also increase motivation and participation, it can be concluded that additional interventions are needed to prevent low motivation and participation in individuals with MS and to ensure that the home exercise program is continued correctly.

Our research also revealed that more than half of the individuals diagnosed with MS did not engage in any physical activity. Although the benefits of physical activity for MS have been proven, it is known that uncontrolled physical activity can cause severe fatigue and additional stress on muscles.[33-35] We think that the low number of people in our study engaging in physical activity may be due to this existing information about the harms of uncontrolled exercise and the fact that individuals with MS may not have received correct recommendations about physical activity. Even if they did receive such recommendations, they may have been insufficient or there may have been inadequate encouragement on the relevant subject. We can also say that organizing training programs on this issue may be beneficial.

Another issue we observed was that although approximately 80% of individuals with MS had been diagnosed for more than a year, the rate of those who still had not received a home exercise program was very high. Considering the progressive profile of MS, this situation is considered a threatening factor in terms of the progression of the disease and quality of life, and clinicians and researchers are recommended to make urgent action plans on the subject.

Multiple sclerosis is seen twice as often in women as in men, more frequently in middle age, and most frequently in the relapsing-remitting type.[3,34,35] In line with this information, the mean age of the MS population participating in our study was 35, our participants consisted of significantly more females, and the relapsing-remitting MS type was higher. In this regard, we can emphasize that our sample reflects the MS characteristics well, which is one of the strengths of our study and important for the generalizability of our results.

Our study has several limitations. The sample was formed from individuals who were members of the MS association. The status of individuals with MS who were not registered with the association was unknown. The information form did not have questions about the date of the first encounter with the home exercise program. Obtaining this information could be critical in interpreting the results. The 85.9% confidence level used in our study for sample size calculation provides a narrower CI, offering a specific estimate of the precision of the mean value. However, due to the 15% probability that the true population parameter may fall outside this interval, a higher confidence level might have been preferred. Our sample size was not large enough to make a gender-based comparison of participants' perspectives toward the program or the rate of implementing it. Some of the questions asked include reasons that can be changed by monitoring the exercise program regularly and at short intervals. Therefore, one of the limitations is not being able to determine whether the answers given to these questions change as a result of following the individuals for a long time.

Conclusion

This study showed that the rate of receiving a home exercise program in individuals with MS was quite low. Very few of those who had a home exercise program practiced their programs regularly, and the home exercise program was not updated frequently enough. The MS population in Türkiye is increasing, making it crucial to recommend and implement the essential and sustainable exercise component of MS rehabilitation in a manner that ensures equitable conditions for every individual with MS. The limited number of participants with a home exercise program in our study made it difficult to perform an in-depth examination of the factors affecting compliance with the program. It is recommended that future studies be conducted with a larger sample and that the effects of socio-cultural and gender characteristics on compliance with home exercise programs be investigated. It is also recommended that physicians and physiotherapists involved in MS neurorehabilitation develop monitoring protocols that will increase the compliance of individuals with MS with home exercise programs from the earliest stages and find a solution to improve these protocols by taking into account short-term responses that may reduce compliance with exercise.

References

1. Charabati M, Wheeler MA, Weiner HL, Quintana FJ. Multiple sclerosis: neuroimmune crosstalk and therapeutic targeting. *Cell*. 2023;186(7):1309-1327. [CrossRef]
2. Haki M, AL-Biati HA, Al-Tameemi ZS, Ali IS, Al-Hussaniy HA. Review of multiple sclerosis: epidemiology, etiology, pathophysiology, and treatment. *Medicine*. 2024;103(8):e37297. [CrossRef]
3. McGinley MP, Goldschmidt CH, Rae-Grant AD. Diagnosis and treatment of multiple sclerosis: a Review. *JAMA*. 2021;325(8):765-779. [CrossRef]
4. Hauser SL, Cree BAC. Treatment of multiple sclerosis: a review. *Am J Med*. 2020;133(12):1380-1390.e2. [CrossRef]
5. Patti F. Optimizing the benefit of multiple sclerosis therapy: the importance of treatment adherence. *Patient Prefer Adherence*. 2010;4:1-9. Published online January 2010. [CrossRef]
6. Bruce JM, Hancock LM, Arnett P, Lynch S. Treatment adherence in multiple sclerosis: association with emotional status, personality, and cognition. *J Behav Med*. 2010;33(3):219-227. [CrossRef]
7. Craft BB, Carroll HA, Lustyk MKB. Gender differences in exercise habits and quality of life reports: assessing the moderating effects of reasons for exercise. *Int J Lib Arts Soc Sci*. 2014;2(5):65-76.
8. Sánchez Martínez I, Cerdán Sánchez M, López Román J, et al. Possible influence of the route of treatment administration on treatment adherence in patients with multiple sclerosis. *Clin Ther*. 2020;42(5):e87-e99. [CrossRef]
9. Ben-Zacharia A, Adamson M, Boyd A, et al. Impact of shared decision making on disease-modifying drug adherence in multiple sclerosis. *Int J MS Care*. 2018;20(6):287-297. [CrossRef]
10. Schootemeijer S, van der Kolk NM, Ellis T, et al. Barriers and motivators to engage in exercise for persons with Parkinson's disease. *J Parkinsons Dis*. 2020;10(4):1293-1299. [CrossRef]
11. Di Lorito C, Bosco A, Booth V, Goldberg S, Harwood RH, Van der Wardt V. Adherence to exercise interventions in older people with mild cognitive impairment and dementia: a systematic review and meta-analysis. *Prev Med Rep*. 2020;19:101139. [CrossRef]
12. Lun V, Pullan N, Labelle N, Adams C, Suchowersky O. Comparison of the effects of a self-supervised home exercise program with a physiotherapist-supervised exercise program on the motor symptoms of Parkinson's disease. *Mov Disord*. 2005;20(8):971-975. [CrossRef]
13. Dennett R, Madsen LT, Connolly L, Hosking J, Dalgas U, Freeman J. Adherence and drop-out in randomized controlled trials of exercise interventions in people with multiple sclerosis: a systematic review and meta-analyses. *Mult Scler Relat Disord*. 2020;43:102169. [CrossRef]
14. Chen S, Lv C, Wu J, Zhou C, Shui X, Wang Y. Effectiveness of a home-based exercise program among patients with lower limb spasticity post-stroke: a randomized controlled trial. *Asian Nurs Res (Korean Soc Nurs Sci)*. 2021;15(1):1-7. [CrossRef]
15. Dalmazane M, Gallou-Guyot M, Compagnat M, et al. Effects on gait and balance of home-based active video game interventions in persons with multiple sclerosis: a systematic review. *Mult Scler Relat Disord*. 2021;51:102928. [CrossRef]
16. Cezar NO de C, Ansai JH, de Andrade LP. Home-based multimodal exercise program in older people with Alzheimer disease: randomized controlled trial protocol. *Physiother Res Int*. 2021;26(2):e1899. [CrossRef]
17. Argent R, Daly A, Caulfield B. Patient involvement with home-based exercise programs: can connected health interventions influence adherence? *JMIR MHealth UHealth*. 2018;6(3):e47. [CrossRef]
18. Mahmood A, Nayak P, English C, et al. Adherence to home exercises and rehabilitation (ADHERE) after stroke in low-to-middle-income countries:

5

a randomized controlled trial. *Top Stroke Rehabil*. 2022;29(6):438-448. [CrossRef]

19. Ghahfarrokhi MM, Banitalebi E, Negaresh R, Motl RW. Home-based exercise training in multiple sclerosis: a systematic review with implications for future research. *Mult Scler Relat Disord*. 2021;55:103177. [CrossRef]
20. Duan H, Jing Y, Li Y, Lian Y, Li J, Li Z. Rehabilitation treatment of multiple sclerosis. *Front Immunol*. 2023;14:1168821. [CrossRef]
21. Warutkar V, Gulrandhe P, Morghade S, Krishna Kovela R, Qureshi MI. Physiotherapy for multiple sclerosis patients from early to transition phase: a scoping review. *Cureus*. 2022;14(10):e30779. Published online October 27, 2022. [CrossRef]
22. Kim Y, Lai B, Mehta T, et al. Exercise training guidelines for multiple sclerosis, stroke, and Parkinson disease: Rapid Review and Synthesis. *Am J Phys Med Rehabil*. 2019;98(7):613-621. [CrossRef]
23. Mahalakshmi B, Maurya N, Lee SD, Bharath Kumar V. Possible neuroprotective mechanisms of physical exercise in neurodegeneration. *Int J Mol Sci*. 2020;21(16):5895. [CrossRef]
24. Aykın Yığman Z, Karaahmet ÖZ, Umay E, Avşar Ertürk F, Güven B. Can home exercise programs be a low-cost alternative to multiple sclerosis treatment? *J Contemp Med*. 2021;11(6):827-832. [CrossRef]
25. Learmonth YC, Motl RW. Exercise training for multiple sclerosis: a narrative review of history, benefits, safety, Guidelines, and Promotion. *Int J Environ Res Public Health*. 2021;18(24):13245. [CrossRef]
26. Elhusein AM, Fadlalmola HA, Awadalkareem EM, et al. Exercise-based gaming in patients with multiple sclerosis: a systematic review and meta-analysis. *Belitung Nurs J*. 2024;10(1):1-14. [CrossRef]
27. Tallner A, Pfeifer K, Mäurer M. Web-based interventions in multiple sclerosis: the potential of tele-rehabilitation. *Ther Adv Neurol Disord*. 2016;9(4):327-335. [CrossRef]

28. Çetin B, Tekeoğlu Tosun A, Onay T. The effect of technology on improving the quality of people with multiple sclerosis. *Ergoterapi ve Rehabilitasyon Dergisi*. 2021;8(3):221-228. [CrossRef]
29. Truijen S, Abdullahi A, Bijsterbosch D, et al. Effect of home-based virtual reality training and telerehabilitation on balance in individuals with Parkinson disease, multiple sclerosis, and stroke: a systematic review and meta-analysis. *Neurol Sci*. 2022;43(5):2995-3006. [CrossRef]
30. Donkers SJ, Nickel D, Paul L, Wiegers SR, Knox KB. Adherence to physiotherapy-guided web-based exercise for persons with moderate-to-severe multiple sclerosis: a Randomized Controlled Pilot Study. *Int J MS Care*. 2020;22(5):208-214. [CrossRef]
31. Hao Z, Zhang X, Chen P. Effects of different exercise therapies on balance function and functional walking ability in multiple sclerosis disease patients—A network meta-analysis of randomized controlled trials. *Int J Environ Res Public Health*. 2022;19(12):7175. [CrossRef]
32. Morrison JD, Mayer L. Physical activity and cognitive function in adults with multiple sclerosis: an integrative review. *Disabil Rehabil*. 2017;39(19):1909-1920. [CrossRef]
33. Li C, Lin J, Yang T, Xiao Y, Jiang Q, Shang H. Physical activity and risk of multiple sclerosis: a Mendelian randomization study. *Front Immunol*. 2022;13:872126. [CrossRef]
34. Thompson AJ, Baranzini SE, Geurts J, Hemmer B, Ciccarelli O. Multiple sclerosis. *Lancet*. 2018;391(10130):1622-1636. [CrossRef]
35. Ryan L, Mills KHG. Sex differences regulate immune responses in experimental autoimmune encephalomyelitis and multiple sclerosis. *Eur J Immunol*. 2022;52(1):24-33. [CrossRef]