https://doi.org/10.5817/StS2024-2-8

The Effect of Individual Telerehabilitation on Postural Stability in People With Multiple Sclerosis, A Pilot Study

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ABSTRACT

Background: The aim of our pilot study was to assess the feasibility and effectiveness of individual balance telerehabilitation for people with multiple sclerosis.
Methods: In this pilot study 20 individuals with multiple sclerosis (MS) with balance impairment were included (10 in experimental, 10 in control group). The experimental group underwent 12 weeks of individual telerehabilitation consisting of balance and strength exercises (2 times per week for 45 minutes). The control group also received therapy for 12 weeks in the form of conventional outpatient physiotherapy consisting of strenght and sensimotor exercises (4–6 individual sessions of 60 minutes). The standardized tests of balance and functional mobility were assessed at baseline and after intervention.
Results: Comparing the two groups, the experimental group achieved statistically significant improvement in balance: the BBS test (p=0.002), TUG (p=0.048), functional test standing on one limb (p=0.01), and subjectively perceived balance with the ABC Scale questionnaire (p=0.041). The substantive significance (Cohen's d) when comparing the two groups reached a large effect size in the BBS (d=0.83) and standing on one limb (d=1.06) and in the MSWS-12 (d=0.78) and ABC Scale questionnaire (d=0.78).
Conclusion: Telerehabilitation interventions represent an increasing trend and our data suggest that individually delivered online telerehabilitation can be effective in the treatment of balance and functional mobility disorders in MS.

Keywords: Multiple sclerosis, balance, postural stability, rehabilitation, telerehabilitation

INTRODUCTION

Telerehabilitation (as part of telemedicine) represents a new approach to the provision of rehabilitation (in patients' home or community). Telerehabilitation uses a variety of modern telecommunication technologies such as smartphones, computers and tablets with built-in internet applications for communication between patients and their therapists. Interest in the potential of telemedicine including telerehabilitation has increased significantly in recent years, mainly due to the ongoing Covid-19 pandemic, but also due to advances in technology (Amorim et al., 2020). A number of systematic reviews and meta-analyses have investigated the potential use of telerehabilitation in patients with postoperative conditions (Agostini et al., 2015), in patients with type II diabetes (Duruturk, 2020), with cardiovascular disease (Cavalheiro et al., 2021), in patients with myoskeletal pain (Turolla et al., 2020) or also in patients with neurologic conditions (such as stroke, Parkinson disease or multiple sclerosis) (Gandolfi et al., 2017; Laver et al., 2020; Sarfo et al., 2018; Di Tella et al., 2020; Tallner et al., 2016; Yeroushalmi et al., 2020).

Multiple sclerosis (MS) can manifest in different symptoms of central nervous system involvement (weakness, spasticity, sensory impairment, fatigue, sphincter impairment etc.) Gait and balance disorders in particular, as one of the most common symptoms of MS, are present in up to 50–80 % of people with MS and it is reported that more than 50 % of patients fall at least once a year (Cameron & Nilsagard, 2018). Studies have found that balance and gait disturbances can occur early in the disease in persons with MS with minimal neurological deficits (Prosperini & Castelli, 2018; van Asch, 2011).

Balance is in clinical practise defined as the ability to control the body's centre of gravity in relation to the support base. The demands on balance vary with the environment and the activity performed. Maintaining postural control requires a complex interaction between the nervous and musculoskeletal systems (including intact afferent inputs to the central nervous system). This complex interaction between nervous and musculosceletal system is impaired in people with MS resulting in disturbed ability to maintain static, dynamic (proactive) and reactive balance (Prosperini & Castelli, 2018; van Asch, 2011).

A systematic review of studies and a meta-analysis by Di Tella et al. (2020) showed that integrated telerehabilitation (online connection between therapist and patient) can improve motor function (mobility, balance) and especially reduce physical disability in MS patients. When compared with conventional rehabilitation, telerehabilitation seems to be comparably effective (Fjeldstad-Pardo et al., 2018). However, even during the Covid-19 pandemic, telerehabilitation was not commonly used and widespread among people with MS (according to the international RIMS study) (Moumdjian et al., 2022). In the Czech Republic, there is also still insufficient experience with telerehabilitation of people with MS. Therefore, the aim of our pilot study was to compare the feasibility and effectiveness of individual telerehabilitation for people with MS with balance disorders.

METHODS

Sample

In this pilot study were included individuals with MS with balance impairment. Thus, a total of 20 persons were randomly divided into experimental and control groups. Patients were randomly divided into experimental and control groups, but no method of strict randomization was used. All participants signed an informed consent form before the start of the intervention. The research was approved by the Ethics Committee of the General University Hospital in Prague under reference number 63/22 Grant GAUK.

Inclusion criteria were as follows 1) a diagnosis of definite MS, 2) subjectively perceived balance impairment, 3) clinically stable MS (at least 30 days since the last attack of the disease), 4) no presence of other disease adversely affecting balance impairment, 5) ability to independently operate a PC or tablet, and 7) absence of severe cognitive deficits that would interfere with understanding exercise instructions.

Assessment

The most commonly used standardized tests of balance and functional mobility were chosen to objectively measure balance: the Berg Balance Scale (BBS), Timed Up and Go (TUG), Timed Up and Go with an added cognitive task (TUG Cognitive), and the standing on one lower limb test. Standardised questionnaires were also used, focusing on balance (Activity Balance Scale-ABC Scale, Falls Efficacy Scale-I-FES-I), walking (Multiple Sclerosis Walking Scale-12-MSWS-12 and fatigue (Modified Fatigue Impact Scale-MFIS. We also asked participants if they fall and how often they fall fall.

Therapeutic intervention

The experimental group underwent 12 weeks of individual telerehabilitation. For direct synchronous contact between the physiotherapist and the patient, an audiovisual link via the freely available ZOOM app was used. The training (2 times per week for 45 minutes) was conducted in the form of interval training (2 minutes of exercise, 50 seconds of rest). At the beginning and the end of the interventions sessions there were 5–10 minutes of stretching of the main muscle groups. The therapeutic intervention consisted of a combination of strength exercises (using body weight exercises such as squat, lunge or exercise with resistance band) combined with balance exercise (functional task or using the Homebalance® system). This system consists of a stabilometric platform that senses changes in the patient's centre of gravity and a tablet with built-in balance training software providing audio-visual biofeedback. Homebalance® offers balance training in the form of a game, where we can choose from two games (Universe, Chessboard). In the game Universe, cognitive functions are also trained by memorising the sequence of the task.

The control group received conventional outpatient physiotherapy (4–6 individual sessions of 60 minutes in total over 12 weeks). The therapy included elements of leg joint mobilisation, lower limb muscle relaxation using soft tissue techniques, followed by active exercises for muscle strength and standing balance training using elements of sensorimotor exercise. Subjects were instructed on appropriate short daily home exercises (minimum 15 minutes) without the use of specific equipment, but their performance was not monitored in the home environment.

Statistical analysis

The Shapiro-Wilk test was chosen to analyze the normal distribution of the data. For data with normal distribution (MSWS-12, MFIS, FES-I) Student‘s two-sample t-test was used. For the other data the Mann-Whitney test was used. The substantive significance of the difference between groups was calculated using Cohen d.

RESULTS

In 20 participants the mean neurological deficit (EDSS score) was 5.35±1.0 in both groups. Detailed demographic characteristics of the participants are shown in Table 1.

Table 1. Demographic characteristic

	Experimental group N=10 Mean (SD)	**Control group** N=10 Mean (SD)
Age (years)	50.7 (11.1)	45 (7.2)
Gender (woman:man)	9:1	9:1
MS type	SP:PP:RR (2:3:5)	PP:RR (2:8)
Disease duration (years)	16.8 (9.1)	16.4 (9.3)
EDSS	5.35 (1.0)	5.35 (1.0)

SP – secondary-progressive, PP – primary-progressive,
RR – relapsing-remitting, EDSS – Expanded Disability Status Scale

All participants in experimental and in control group completed exercise program. When comparing the two groups, the (experimental group) achieved statistically significant improvement in balance: the BBS test (p=0.002), TUG (p=0.048), functional test standing on one limb (p=0.01), and subjectively perceived balance with the ABC Scale questionnaire (p=0.041).

The substantive significance (Cohen‘s d) when comparing the two groups reached a large effect size in the BBS (d=0.83) and standing on one limb (d=1.06) and in the MSWS-12 (d=0.78) and ABC Scale questionnaire (d=0.78). The results comparing the difference in scores between the two groups are shown in more detail in Table 2.

Table 2. Results of assessed parameters

Assessment	**Group**	**Baseline** Mean (SD)	**After intervention** Mean (SD)	**Difference**	**p-level**	**Cohen´s d**
TUG (seconds)	Experimental	20.6 (17.1)	15.6 (11.3)	5	**0.048**	0.32
	Control	16.8 (15.2)	14.3 (10.2)	2.4		
TUG + cognitive dual task (seconds)	Experimental	21.2 (16.4)	17.4 (14.8)	3.8	0.203	0.23
	Control	17.8 (16.1)	15.3 (11.5)	2.5		
One leg stance RLL (seconds)	Experimental	6.6 (7.2)	9 (7.7)	2.4	**0.01**	**0.80**
	Control	7.7 (8.9)	6.7 (7.3)	-1		
One leg stance LLL (seconds)	Experimental	4.8 (8.1)	8.4 (7.1)	3.7	**0.004**	**1.06**
	Control	7.5 (8.6)	5.6 (7.3)	-1.9		
BBS (points, min 0-max 56)	Experimental	43.6 (14.2)	49.3 (9.5)	5.7	**0.002**	**0.83**
	Control	46 (6.7)	46 (7.4)	0		
MSWS-12 (points, min 12-max 60)	Experimental	58.8 (20.7)	51.1 (20.9)	7.7	0.053	**0.78**
	Control	58.1 (10.6)	56 (10.7)	2.2		
MFIS (points, min 0-max 84)	Experimental	41.3 (11.1)	38 (8.9)	3.3	0.231	0.33
	Control	42.6 (9.7)	41.6 (10.2)	1		
FES-I (points, min 16-max 64)	Experimental	37.3 (11.7)	36.5 (10.3)	0.8	0.283	0.26
	Control	37 (9.2)	37.3 (10.5)	-0.3		
ABC Scale (%, min 0-max 100)	Experimental	52.4 (20.8)	53.8 (18.9)	1.4	**0.041**	**0.78**
	Control	54.2 (19.0)	46.3 (22.1)	-7.9		

TUG – Timed Up and Go test, BBS – Berg Balance Scale, RLL – right lower limb, LLL – left lower limb, MSWS-12 – Multiple Sclerosis Walking Scale-12, MFIS – Modifing Fatigue Impact Scale, FES-I – Falls Efficacy Scale International, ABC Scale – Activities-specific Balance Scale

Table 3. Frequency of falls (converted to a month frequency)

Experimental group	Baseline	After intervention	**Control group**	Baseline	After intervention
Participant 1	4×	4×	Participant 1	4×	4×
Participant 2	4×	2×	Participant 2	occasionally	occasionally
Participant 3	8×	2×	Participant 3	2×/year (0.166×)	1x
Participant 4	-	-	Participant 4	1× so far	1× so far
Participant 5	1×	1×/3 month (0.33×)	Participant 5	occasionally	sometimes
Participant 6	4×/year (0.33×)	3×/year (0.25×)	Participant 6	2×	12×
Participant 7	4×	1×/3 month (0.33×)	Participant 7	1×/3 months (0.33×)	1×/3 months (0.33×)
Participant 8	-	-	Participant 8	1×/ 6 months (0.16×)	1×/6 months (0.16×)
Participant 9	2×	1×	Participant 9	4×	4×
Participant 10	1×/year (0.083×)	1×/year (0.083×)	Participant 10	1x	1x

In the experimental group, the six from ten participants experienced a reduction in the frequency of falls (from an average of 3.22 falls per month there was a reduction to 0.98 falls) and the other four participants remained unchanged. A detailed description of the frequency of falls per month for both groups is given in the Table 3. There were no adverse events or complications during the intervention in either the experimental or control group.

DISCUSSION

Our pilot study demonstrated the feasibility of individual telerehabilitation of balance disorders in people with MS using the Homebalance® system. This system has been used in the past for balance therapy in the elderly (Janatová et al., 2016) and in persons after stroke (Janatová et al., 2018) (under the guidance of a therapist at a rehabilitation facility or after patient instruction independently in the home environment). However, our study is the first to describe the feasibility of the possibility of individual telerehabilitation under direct online guidance of a therapist (synchronous telerehabilitation). There were no major technical complications or difficulties on the part of the patients in the provision of telerehabilitation.

Patient cooperation and adherence was very good. Patients' answers in the final questionnaire also indicate good cooperation. When asked whether they would like to continue with the exercise, 10 out of 10 patients answered „yes". The course of telerehabilitation was without major complications. In the first two weeks, most patients became accustomed to the online environment (connecting through the online platform ZOOM) and learned to fully operate the platform. Initially, pairing the platform via Bluetooth with the tablet was problematic for some patients, however, the problem was usually only due to an insufficiently charged tablet, the long distance of the platform from the tablet or low batteries in the platform.

The results of our study are in line with the results of an italian study, in which patients who received specific balance training focused on motor and sensory strategies showed a significant improvement in balance and a reduction in the frequency of falls than patients who received conventional training (motor only). The findings of the study by Brichetto et al. (2013), which compared the effect of physiotherapist-led therapy using a similar platform (namely the Nintendo Wii Balance Board®) and conventional balance training, also correspond with our results. It showed that there was a significant improvement in balance (BBS) in the Nintendo Wii® training group.

The incidence of falls was 18 out of 20 patients in our study group, of which two patients did not report a fall at all. According to the outcome examination, it was evident that the incidence of falls subjectively decreased in six patients from the experimental group and increased in two patients from the control group. Thus, there was a significant reduction in the frequency of falls in the patients of the experimental group. This may have been due to the improvement in objective balance parameters evident in the experimental group results (BBS, One leg stance). The audiovisual feedback may also have played an important role, which helped to improve the centre of gravity work observed by the patients on the tablet monitor. The results of our study are in line with the results of the study by Cattaneo et al. (2007), in which patients who received specific balance training focused on motor and sensory strategies showed more significant improvements in balance (BBS) and a reduction in the frequency of falls than patients who underwent conventional training.

In our study, there was an improvement in the TUG test, but not in the TUG test with the cognitive task. We also did not observe improvements in the subjective assessment of gait (MSWS-12), fatigue (MFIS) and in one of the balance questionnaires (FES-I). Similar results were obtained in a study by Novotná et al. (2019), where there was an improvement in balance (Mini-BESTestest, BBS) but no improvement in gait (TUG, GAITRite instrument) or subjectively measured parameters (MSWS-12, ABC Scale, FES-I). This may result from the different length of the intervention (4 weeks). Furthermore, the results could have been influenced by the synchronous communication model of telerehabilitation, where the physiotherapist was constantly present during the exercise and checked and motivated the patient during the exercise. The addition of strengthening and balancing exercises that took place off the balance platform may also have played an important role and may have positively influenced the dynamic component of balance and gait parameters.

There was no improvement in fatigue (MFIS), which may have been due to the absence of aerobic exercises that could have had a greater effect on reducing fatigue, as shown in a study using high-intensity aerobic exercise (Langeskov-Christensen et al., 2021). A more significant improvement in both gait and fatigue parameters could also occur if motor imagery is involved, which was used by Kahraman et al. (2019).

It seems that the presence of a physiotherapist during exercise is essential, especially in terms of patient motivation and possible correction of the patient´s posture during exercise. A study investigating the level of physical activity and technology use among MS patients during the

Covid-19 pandemic also described that most individuals preferred face-to-face contact with a therapist to independent individual exercise (Moumdjian et al., 2022).

Also in our pilot study, participants in an experimental telerehabilitation intervention highly valued personal guidance and contact with a physiotherapist during exercise.

Limitation of this study is that the therapeutic intervention was provided mostly in standing position, so these were patients with EDSS up to 6.5. Thus, the findings cannot be applied to patients with higher levels of disability (EDSS>6.5). However, for people with higher levels of disability and severely impaired balance, unassisted telerehabilitation in the home environment may not always be a suitable alternative (due to the risk of falling and the lack of manual correction and guidance). The use of telerehabilitation for people with more severe cognitive deficits is also limited (Gopal et al., 2022). Another limitation is small sample of patients in this pilot study.

To ensure the effectiveness and safety of therapy for balance disorders in neurological patients, regular monitoring by a physician and physiotherapist is essential during the therapeutic process. However, it seems that telerehabilitation will occupy an increasingly important place in therapy for MS patients (and for some other neurological diagnoses) in the future.

CONCLUSION

Telerehabilitation interventions represent an increasing trend in international studies in different groups of neurological patients. The results of a pilot study in a Czech setting demonstrate that individually delivered online telerehabilitation can be effective for people with MS patients to improve their postural control and functional mobility. However, these results need to be validated in a larger group of patients to demonstrate the effect of the therapy.

ACKNOWLEDGEMENTS:

This study was supported by the Czech Ministry of Health project RVO-VFN64165 and the Czech Health Research Council (AZV) grant NU22-04-00193. The project has also received funding from the Czech Ministry of Education – project Cooperatio LF1, research area Neuroscience, and the project National Institute for Neurological Research (Programme EXCELES, ID project No LX22NPO5107), funded by the European Union-Next Generation EU.

The authors declare that the study on human subjects described in the manuscript was conducted in accordance with the ethical standards of the relevant committee (institutional and national) responsible for conducting clinical trials and the Helsinki Declaration of 1975, revised in 2000.

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