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Multi-function Swing Suspension Training in Multiple Sclerosis: Assessing the Influence on Upper and Lower Extremities Function and Quality of Life with Respect to Expanded Disability Status Scale

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Abstract

Background: Upper extremities' function impairments (UEFI) and gait impairment are frequently reported even in the early stages of Multiple Sclerosis (MS) disease. These motor deficits can negatively affect the quality of life (QOL) in MS patient. Exercise has been repeatedly introduced as a beneficial adjuvant therapy for MS, attenuating a wide range of physical and psychological symptoms without any side effects or increased risks of relapse or exacerbation in disease symptoms.

Aim: This paper investigates the effect of multi-function swing suspension training (MFSST) program on upper and lower extremities' function (ULEF), and QOL in MS women according to expanded disability status scale (EDSS) score.

Design: Experimental method with a pre-test and post-test design with control group.

Setting: The department of Sports Injuries and Corrective Exercise at the Shahid Bahonar University of Kerman.

Population: Forty-seven MS women.

Methods: Eligible subjects who matched the selection criteria were randomly assigned into three groups as follow: i. Intervention group A (EDSS of 2 – 4), ii. Intervention group B (EDSS of 4.5 – 6.5), and iii. Control group (EDSS of 2 – 6.5). The intervention groups have been trained by the SET program for a duration of 8 weeks. At baseline and after the intervention, the upper extremities' function (UEF) and the lower extremities' function (LEF) were assessed by 9-hole peg test (9HPT) and the timed 25-foot walk (T25FW) test, respectively. Moreover, participants' QOL was measured using the Short Form questionnaire (SF-36).

Results: A significant difference was found between the pre-test and post-test variables of walking speed and upper extremity endurance in intervention groups, and between the intervention groups and control group ($P < 0.05$). Compared to control group, both intervention groups showed improvements in all subscales of QOL, except emotional role limitation score.

Conclusions: In summary, these results show that the present protocol of MFSST could be effective in improving ULEF and QOL in MS patients, showing the improvements after 4th week. Moreover, this protocol was more useful for patients with an EDSS score of more than 4.5. Therefore, it seems that exercise therapy should be considered as a beneficial clinical intervention approach to improve ULEF and QOL in MS patients.

Key words: Multi-function swing suspension training; Upper extremity function; Lower extremity function; Quality of life; Multiple sclerosis

Introduction

Multiple sclerosis (MS) is defined as a complex neurodegenerative disease of the central nervous system (CNS) causing impairment in nerve signal conduction that can result in a complete blockage of action potentials [1]. The clinical symptoms, which are related to the location of the demyelinating lesions [2], are often variable among individuals and can affect motor, sensory, and cognitive functions [3]. Although the symptoms vary individually, two of the motor deficits as upper extremities' function impairments (UEFI) and lower extremities' function impairments (LEFI) have been reported among the most prevalent and disabling symptoms in MS patients [4]. These hallmark symptoms are caused by a variety of impairments including muscular weakness, ataxia, and spasticity [5]. Christogianni et al. showed that 75% of the patients have LEFI and 50% have reported accidental injuries due to frequent falls [6]. Therefore, such patients may require walking aids and wheelchairs more often [6]. On the other hand, the UEFI and the inability to quickly generate sufficient muscle force in addition to daily life activities could influence the use of an externally fixed object (e.g., cane or a handrail) to avoid a fall [7]. Consequently, these disabling deficits can negatively affect the QOL and functional independence [8]. Although the majority of the motor impairments arise as a direct consequence of the disease, could be also side effects of medications used in the treatment [6]. Therefore, it is important that researchers and physicians pay attention to ULEFI in MS patients and consider optimal management strategies, which require the combination of pharmacologic and nonpharmacological treatments [9, 10].

The exercise therapy (ET) is one of the promising and best non-pharmacological interventions for patients with MS [4, 11]. ET slows down the course of the disease by function maintenance and symptoms improvement [4]. Overall, there seems to be some evidence to indicate that ET is potential immunomodulatory therapy that, modulates the development and progression of MS symptoms by targeting innate signaling mechanisms [12]. Despite the importance, safety, and efficacy of ET, up to 78% of MS patients do not partake in any meaningful exercise activity and some patients report a lack of information concerning ET [11, 13]. Following such a lack of voluntary exercise activities, atrophic changes have been observed in the muscles and Lead to muscle weakness, reduction of functional capacity, and QOL in MS patients. In fact, ET with strengthening of special muscle could help to minimize patients' disability and earlier return to activities of daily life [14].

Up to now, a series of exercise programs have been designed to improve the symptoms in MS patients, while the most effective treatment options is still challenging. Suspension Training (ST) can strengthen the core and extremities muscles through promotes coordination of the neuromuscular system due to stimulating more proprioceptors, recruiting more motor units, and improving the interplay between nerve and muscle [15]. A number of researchers have reported that the electromyographic activity of the core muscles, which is the base and prerequisite for the movement and the coordination of the upper and lower limbs, obviously enhances during the ST program [15, 16]. Although the application of ST program in rehabilitation have been investigated, but based on our observations, no previous study has evaluated the effect of MFSST on ULEF and QOL in MS patients. Since the MFSST program is a multi-purpose exercise program, our hypothesis is that MFSST would lead to a better outcome in comparison with single-purpose exercise programs. Here, we could provide a basis for promoting the use of the MFSST in rehabilitation programs of MS patients. In this paper, we propose a total body program training is included workouts of core stability, neuromuscular re-education, balance, sensorimotor, and range of motion, by a single device. This program has been done by the Multi-Function Swing Apparatus. MFSA is among the most promising approach due to various advantages such as low equipment cost, safety, efficiency, and easiness of application [16]. On the other hand, we showed previously [17] that the exercise prescriptions should be personalized for the MS patients which is due to the wide variation in the physical capacity between MS patients. The EDSS is a ranking system, which determines quantitatively the rate of clinical and functional disability in MS patients [18]. Thus, the EDSS needs to be taken into account when a personalized exercise prescription is designed for MS patients. In this study, we set out to assess the effect of MFSST program on ULEF and QOL in the MS women according to EDSS score.

Method

Study design and Subjects

A single-blind randomized control trial was performed on 47 women MS patients. Patients with the diagnosis of relapsing–remitting MS with EDSS Score of 2 – 6.5 which confirmed by MS committee of Kerman University of Medical Sciences, included in this study. Moreover, participants evaluated their own current disability level using the self-Expanded Disability Status Scale (self-EDSS).

Patients were selected using simple random sampling method. The sample size (n) was determined using the G* Power 3.1.9.2 (G* Power 3 for Mac) software15,16 using a repeated-measures ANOVA between factors, 90% test power, probabilistic error: 0.05 and f = 0.5. Being F = 3.35413, the sample calculation was estimated for 45 subjects. However, 57 participants were recruited for each group to prevent probable attrition from affecting the findings.

The researcher explained the study's purpose, and the participants gave signed written informed consent according to the Helsinki Declaration (2004). This study was registered with the International Standard Randomized Controlled Trial Number Register (IR.UK.VETMED.REC.1399.002) after approval by the University Research Ethics Committee.

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The exclusion criteria were as follows. (I) Relapse during the study period or two months before that. (II) History of orthopedic or rheumatic disorders within the last six months. (III) History of musculoskeletal injury within the last six weeks. (IV) Pregnancy. (V) Changes to medication during the study or two months before that [17]. The selected participants were randomly divided into three groups; two intervention groups (intervention groups A (n = 16 and 2 ≤ EDSS ≤ 4), intervention group B (n = 18 and 4.5 ≤ EDSS ≤ 6.5)) and one control group (n = 13 and 2 ≤ EDSS ≤ 6.5).

Familiarization and Measurement Procedure

All assessments at pre-test, fourth week and sixth week follow-up, and post-test were performed at the same time of day, in the same order and by the same test leader. The study was done at the Department of Sports Injuries and Corrective exercise at the Shahid Bahonar University of Kerman. All participants took part in two phases of the experiment: the first to familiarization and the second to data collection.

The familiarization session was performed about 1 to 2 hours before data collection, during which, the participants were given an overview of the standard testing procedure, and exercise techniques, and how to correctly perform the exercises. In the second phase, participants completed a baseline questionnaire including demographic characteristics before starting the exercise protocol. Body weight was recorded in kilograms using a calibrated digital scale and body height in meters was obtained from a single stadiometer (SECA 769; SECA, Chino, CA, USA).

The 9-HPT is the gold standard for upper extremity function assessment (hand and arm) in MS patients, which is an evidence-based, relatively fast, and simple test [19, 20]. The test standardized device is a peg-board with 9 holes and 9 pegs that placed input the holes. This test was performed in the sitting position in patients, during the 9-HPT was asked to center the pegboard directly in front of them and then, respectively put 9 pegs into the holes and remove that one at a time, as quickly as possible [21]. Patients performed two consecutive trials with the dominant hand and immediately followed by two consecutive trials with the non-dominant hand. The score was measured in seconds calculation by the chronometer, from the moment the dominant hand touched the first peg until the last peg hit the board. The average time of the two trials for each hand recorded as the final scores of the test. Faster speed indicates the better function of the upper extremity.

The T25FW test is a short-distance, 25 feet (~8 meters), measurement of walking speed [20]. This test is considered the best objective measure for the description of gait impairment in MS patients [22]. The gait speed value in this test equaled travel the distance of 25 feet walked, divided by the total time of the test. The test time was measured in seconds, greater time indicating slower the gait speed value [23].

Finally, the health-related QoL was assessed by the Short-Form Questionnaire (SF-36). This self-administered questionnaire assesses health concepts relevant to MS patients across eight domains including physical function, bodily pain, role-physical, general health, vitality, social function, role-emotional, and mental health [24]. Scores derived from these eight domains combined to calculate two summary scales, the physical component summary (PCS) score and the mental

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component summary (MCS) score, which to have a mean of 50 and a standard deviation of 10. The higher scores reflecting better QoL [25, 26].

Intervention program

The intervention program comprised twenty-four 1-h exercise sessions held at the university gym thrice per week for 2 months (from April to June 2020). Each session includes a 10 to 15 min warm-up (static stretching and dynamic warm-up), 40 min MFSST program, and 5 minutes cool-down (breathing and the muscles loosening exercises). This ST program was included workouts of core stability, neuromuscular re-education, balance/sensorimotor, and range of motion, with 4 levels of difficulty for every exercise. These exercises were performed under the supervision of the ST trainer. The study protocol was designed and modified based on the previous studies protocols [27, 28] The control group received no such training and continued to receive usual routine care (e.g., individualized drug treatment) and daily activities.

Statistical analysis

The study data analyses were conducted using IBM SPSS statistical software version 26.0. Statistical analysis was performed using the Kolmogorov-Smirnov test for the normal distribution of the findings. The homogeneity of variances was determined using the Levene's test. The Repeated Measures mixed ANOVA was used to determine the difference between pre-test, follow-up (fourth week and sixth week), and post-test and also, compare the obtained results between the study groups.

Results

Subjects

The following diagram shows a comprehensive view of the current study (Figure 1). In this study, the MS patients were evaluated for eligibility. After screening according to inclusion and exclusion criteria, 102 patients remained. To investigate the effect of exercise therapy, 57 patients were randomly selected from the remaining 102 patients. The selected participants were randomly assigned into three groups as the intervention group A (N.= 20), the intervention group B (N.= 20), and the control group (N.= 17). Ten of the patients excluded from the study according to the criteria which is explained in methods section. They did not attend allocated intervention mostly due to COVID-19 situation, lack of participation in post-test sessions, and relapse of MS symptom. Finally, 16 patients in the intervention group A, EDSS 2 – 4, 18 patients in the intervention group B, EDSS 4.5 – 6.5, and 13 patients in the control group, EDSS 2 – 6.5, have been analyzed for the following training effects. Participant demographics including age, height, and weight of the three groups have been represented in Table 1. The obtained results show that characteristics variables were matched and there was no statistically significant difference between three study groups with regard to the age, height, weight, and EDSS ($P \geq 0.05$). All patients had relapsing-remitting MS.

9-HPT

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The results obtained from the mixed ANOVA of the 9-HPT can be seen in Table 2. There is a significant difference between the times (P = 0.001, F = 52.48) with large effect size (Es = 0.78) and also significant interaction between time and group (P = 0.001, F = 9.01) with large effect size (Es = 0.39).

The Bonferroni post-hoc test of the 9-HPT score revealed a significant difference between all measurement's times in group A and in group B (P = 0.001), while this difference in the control group was not significant as demonstrated in Table 3. Table 3 shows an improvement in 9HPT in the intervention groups A and B, which was observed from the fourth week onwards.

T25FW

In connection with the T25FW the results of the mixed ANOVA show that there is a significant difference between the times (F= 85.63، P = 0.001), and the effect size was observed as large (Es = 0.85). As such, there is a significant difference between the time and group (P = 0.001، F = 13.81), and the effect size was observed as large (Es = 0.49). The results are reported in Table 4.

The Bonferroni test indicates a statistically significant difference between the times of measurement (pre-test, follow-up (fourth week and sixth week), and post-test). Table 5 shows that there is a significant change between the groups in the T25FW test score; for example, in group A, there are significant differences between pre-test and fourth week, pre-test and sixth week, pre-test and post-test (P = 0.001) and there is no significant difference between the sixth week and post-test (P = 0.003). In group B, there are significant differences between all the times of measurements (P = 0.001). But in the control group, there was no significant difference between groups and times. It was found that the T25FW test results significantly improved after the intervention.

QOL

The effectiveness of the SET protocol on eight subscales of self-assessed QOL (SF-36) is shown in Table 6. In connection with the QOL test (SF-36), repeated-measure of analysis of variance was used to figure out the difference of outcome measures in different time intervals. There is a significant difference between the time (pre-test, follow-up (fourth week and sixth week) and post-test), and also there is a significant difference between the three groups in all of the subscales of QOL (P < 0.05), except emotional role limitation score, in comparison with the control group.

Discussion

The effect of the MFSST program on upper and lower extremities function and QOL in the MS women was evaluated according to the EDSS score. With respect to the measured parameters by the 9HPT, T25FW, and SF-36, the intervention groups showed a significant improvement in the upper and lower extremities functions and also QOL in comparison with the control group. These results indicate a positive effect of the MFSST program on performing activities of daily living in the MS patients which is in correlated with the EDSS scores. Noted that the exercise training was

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followed 8- weeks, while this improvement in functions was observed from the fourth week onwards.

The explanations of the present study findings were supported by several hypotheses, because this cross-sectional study cannot identify the cause-effect relationship. One of the possible causes can be decreased muscle strength in MS patients, which may have both muscular and neural origin [29]. Cardenas et al. demonstrated that the Multi-Function Swing apparatus due to the multiple handles and postures and movements are applied as an ideal physical therapy device for neuromuscular re-education, re-patterning, exercises, and rehabilitation [30]. Generally, unstable devices such as Swiss balls, BOSU balls, and rocker boards provide an unstable base, while suspension training can provide alternative instability to upper and lower limbs and the core at the same time [16]. To determine the effect of using a ST system, Byrne et al. (2014) [31] investigated muscle activation during the performance of variations of the plank exercise and showed suspension-based plank exercise enhances the electromyographic activity of the abdominal muscles. They also showed that suspension-based plank exercise improves greater than the ground-based plank exercises the activation of the abdominal muscles, which could be attributed to the stabilization effect. On the other hand, since the body weight is loaded through the bungees in this multi-point suspension, this system can stimulate the target muscles with minimum pain. For example, this system could effectively drive muscle strength for the upper and lower extremities regardless of the instability and restore the range of motion with less pain.

The ST could obviously reactivate and enhance the electromyographic activity of the core muscles [16, 31-33], therefore another possible explanation for the positive impact of the designed exercise on MS might be attributed to an increase in core stability. Core stability is defined as the ability to control the position of the trunk and pelvis for optimum production which could transfer the force from the center of the body to the upper and lower extremities [34, 35]. The previous studies shown a correlation between trunk control and walking. Klemetti et al. [36] demonstrated the trunk muscles performance has been implicated throughout the walking cycle and should be considered in the design of rehabilitation programs for the physical management of the core and prevention of the fall. In another study, Miyake et al. (2013) [37] demonstrated that core training is likely to elevate trunk stabilization to improve UEF, also they emphasized that trunk stability ensures shoulder movement, and shoulder stability supports the elbow, wrist, and fingers movement. Previous studies have reported that MS patients would present impaired trunk control that is directly influencing disability in ULEF, and it has been showing that exercise programs that comprehensively focus on the aspects of the core stability could influence ULEF [38-41]. Chung et al. (2008) [42] demonstrated that in clinical practice, trunk postural control is purported to be an important contributor to voluntary ULF in MS patients, including motor control and upper limb dexterity. Freund et al. (2016) [43] demonstrated the isometric trunk endurance of MS patients is worse compared to healthy controls. They showed that trunk flexion endurance positively correlated to walking speed and step activity in MS patients. Forsberg et al. (2016) [44] have indicated the CoDuSe program with a focus on core stability can improve balance through addressing walking limitations. Norman et al. (2020) [45] have suggested that dynamic trunk control should be considered addressed in rehabilitation programs in order to optimize balance and walking in MS patients with minor to moderate disability. This evidence proves the trunk control's importance as an obvious prerequisite for elevate ULEF in MS patients.

The ULEF and the trunk control are important cornerstones for daily activities performance and finally QOL in MS patients [39]. The results of the present study show that similar to the accepted routine rehabilitation in MS patients, the MFSST programs could improve QOL following the improvement of these factors. In addition, the ST programs are suitable for training a group of patients simultaneously, which is favored socially, to prevent a strange environment that may be created if patients are treated separately.

The results of this study regarding the EDSS score show that MS patients with poor EDSS experienced a better recovery, which is in agreement with our earlier observations [17]. It seems possible that these results are due to the severity of muscle weakness that could be led to various improvements. Since the strength development of the muscles depends on the type, the loading intensity, and the strength training volume, in the recent MFSST program, the activity of muscle groups, the muscle contraction type, and the volume of strength training was similar in the intervention groups, so, these differences result in the strength improvement may be due to the differences in the effect of exercise intensity [17]. Although, the similar exercise intensity was presented for both intervention groups, perhaps the exercise intensity has not been enough to influence on the A group. Given that, perhaps the A group patients were greater physical fitness compared to the B group patients and need to higher intensity exercises for the effectiveness of the MFSST program.

Limitation of the Study

The findings in this report are subject to at least four limitations including

1. Absence of a long-term follow up in order to evaluate the maintenance of the beneficial effect of the MFSST protocol;
2. The small patient numbers;
3. Patients with the diagnosis of relapsing-remitting MS with EDSS score between 2 to 6.5;
4. The lack of measurement of the muscle’s strength directly;

Conclusions

Understanding the correlation between the rating scales such as the expanded disability status scale (EDSS) in multiple sclerosis (MS) patients and the type of exercise is critical for designing a personalized exercise for improvement of symptoms in MS patients. This work provides new insights into such a correlation for exercise therapy by multi-function swing suspension training in MS women and their EDSS score. Interestingly, the exercise therapy usually focused on either one type of exercise or a combination of two different exercise types, in this study, we opted for a protocol including workouts of core stability, neuromuscular re-education, balance, sensorimotor, and range of motion, within a single device. Therefore, multi-function swing suspension training is capable of influencing upper and lower extremities function in the patients. We show that the MFSST program could be effective in improving upper and lower extremities' function (the ULEF), and the quality of life (QOL) in the MS patients, which this improvement in functions was observed from the fourth week onwards. The second major finding was that this protocol was more useful for patients with an EDSS score of more than 4.5. We can conclude that the suspension training program not only could improve neuromuscular activation but also are able to provide higher activation, followed by eliciting clinically meaningful benefits in the ultimate improvement of symptoms in MS patients.

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