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Physiotherapy Approaches in the Treatment of Ataxic Multiple Sclerosis: A Pilot Study

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Objective: This study was planned to investigate the efficacy of neuromuscular rehabilitation and Johnstone Pressure Splints in the patients who had ataxic multiple sclerosis. **Methods:** Twenty-six outpatients with multiple sclerosis were the subjects of the study. The control group ($n = 13$) was given neuromuscular rehabilitation, whereas the study group ($n = 13$) was treated with Johnstone Pressure Splints in addition. **Results:** In pre- and posttreatment data, significant differences were found in sensation, anterior balance, gait parameters, and Expanded Disability Status Scale ($p < 0.05$). An important difference was observed in walking-on-two-lines data within the groups ($p < 0.05$). There also was a statistically significant difference in pendular movements and dysdiadakokinesia ($p < 0.05$). When the posttreatment values were compared, there was no significant difference between sensation, anterior balance, gait parameters, equilibrium and nonequilibrium coordination tests, Expanded Disability Status Scale, cortical onset latency, and central conduction time of somatosensory evoked potentials and motor evoked potentials ($p > 0.05$). Comparison of values revealed an important difference in cortical onset-P37 peak amplitude of somatosensory evoked potentials (right limbs) in favor of the study group ($p < 0.05$). **Conclusions:** According to our study, it was determined that physiotherapy approaches were effective to decrease the ataxia. We conclude that the combination of suitable physiotherapy techniques is effective multiple sclerosis rehabilitation. **Key Words:** Multiple sclerosis—Ataxia—Physical therapy.

Multiple sclerosis (MS) is a multisymptomatic disease (1–3). Of MS patients, 85% develop ataxia, which can be cerebellar, sensory, or mixed type and may be associated with vertigo (4,5). It is rarely seen as a single symptom and usually occurs with muscle weakness and spasticity (5,6).

Truncal and lower extremity ataxia increases disability and produces handicaps by restraining daily living activities. The high incidence of falls leads to fractures in osteoporotic patients (7,8).

Ataxia is a symptom that is resistant to medication. Drugs like isoniazid and carbamezepine must be used in high dosages to be effective. Because these drugs have hepatotoxic effects, achieving the highest dosage is prevented in many patients; therefore the long-term use of these drugs is limited (2,3,5,7–9).

Using weights and heavy walkers may decrease ataxic movements; however, they may increase fatigue (1,3,10–12). The short-term effect of cold has not been found to be an effective method in the treatment of ataxia (13).

The effects of exercise have been studied in ataxia; however, there are no standard treatment programs. This study was therefore planned to develop a standard physiotherapy program for ataxic MS patients.

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Methods

Patients

This study was carried out in the Hacettepe University Neurological Rehabilitation Unit of the School of Physical Therapy and Rehabilitation. Twenty-six outpatients who had been diagnosed as having clinically definite MS (14) in the Neurology Department of Hacettepe University were the subjects of the study.

Patients who met the following criteria were included in the study: the patients' clinical courses were either secondary progressive or primary progressive. Patients who were prominently ataxic with slight muscle weakness (the patients with a muscle strength score of 3 according to Dr. Lovett's muscle test were included in this study) and could walk unassisted (EDSS level, 3–5.5). Corticosteroids were discontinued ≥1 month before starting the study.

Patients were randomly assigned the study or control groups. The control group was given neuromuscular rehabilitation, whereas the study group was treated with Johnstone Pressure Splints in addition to neuromuscular rehabilitation approaches.

Measurements

Before starting this 4-week physiotherapy program, all 26 patients (13 in each group) underwent these tests:

a. Sensory assessment (on a score of 0, severe sensory loss, to 4, no sensory loss) (15).
b. Single-limb stance time.
c. Step width (base of support between successive footprints) (16,17).
d. Walking velocity (assessed through the time required to walk 3 m).
e. Ambulation Index (18).
f. Anterior balance (assessed by measuring the distance between the medial malleolus and body gravity line by means of the Lovet–Reynold Method) (19).
g. Equilibrium coordination tests (using footprints of the number of steps taken outside a support base of 10 cm and during tandem walking).
h. Nonequilibrium coordination (assessed by knee–heel test, alternative-foot movements (dysdiadakokinesia) test on a scale of 0 to 3, number of pendular movements of limb after requested movement).
i. The Expanded Disability Status Scale (EDSS) score (20), somatosensory evoked potentials (SSEPs), and motor evoked potentials (MEPs) measurements carried out by a blinded neurologist and electrophysiologist. SSEPs were recorded using Medelec MS 25, and MEPs were recorded using Medelec MAGSTIM instrumentations.

The patients were assessed by two blinded examining physiotherapists in the morning hours, and the values were averaged.

Treatment Program

The principles during the treatment were as follows: patients received treatment in the morning; the activities were selected from easier to harder ones in accordance with neurodevelopmental physiotherapy principles; and frequent intervals were given to avoid fatigue.

Control Group

Rhythmic stabilization of proprioceptive neuromuscular facilitation (PNF), active repeated contractions of PNF techniques combined with Frenkel Coordination Exercises in the prone and supine positions, and Frenkel Coordination Exercises in the sitting and standing positions were used.

To enhance postural stability and balance reactions, mat activities with PNF techniques combined with balance training (in the crawling, kneeling, half-kneeling positions), approximation of PNF techniques by means of co-contraction in agonist and antagonist muscles were used in all positions, static and dynamic balance training by means of external postural perturbation, weight transfer to both extremities and to posterior parts of the feet while in standing and feet-together positions, training in semitandem and tandem stance, single-limb stance on a balance board and Cawthorne-Cooksey exercises, and walking on uneven terrain were used for limb ataxia.

All activities were first done while eyes were open then progressed to the eyes-closed stage.

Study Group

In addition to the exercises of the control group, Johnstone Pressure Splints were used. The long-leg splint of the Urias/MS splint was applied for 20 min to both lower extremities before exercise sessions. The aim was to stimulate the sensory receptors, especially the proprioceptors in patients with noticeable sensory ataxia by increasing sensory inputs.

The splints also were used during crawling, kneeling, and half-kneeling and single-limb stance to support the extremity.

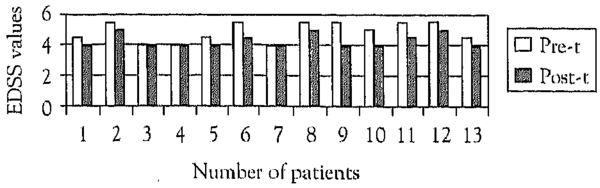

Figure 1. Pre and posttreatment Expanded Disability Status Scale (EDSS) values of the control group.

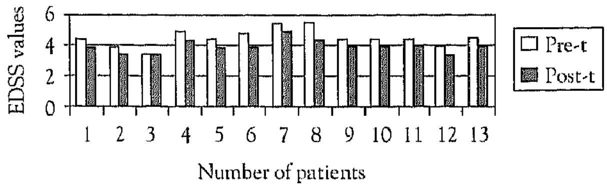

Figure 2. Pre and posttreatment Expanded Disability Status Scale (EDSS) values of the study group.

Frequency of treatment was 3 days a week for 4 weeks. All patients also were given a home exercise program consisting of active exercises. All assessments were repeated after 4 weeks of treatment.

Statistical Analysis

χ^2 and Fisher's Exact tests were used to evaluate equilibrium coordination and nonequilibrium coordination test values between the groups before and after treatment. The Mann–Whitney test was used to evaluate other data. A χ^2 and McNemar χ^2 tests were used to evaluate the pre- and posttreatment equilibrium coordination and nonequilibrium coordination and data within the group. Wilcoxon's Signed Ranks test was used in other data evaluations.

Table 1. *Demographic data*

	Control group (n = 13)	Study group (n = 13)
Gender	7 F, 6 M	9 F, 4 M
Age (yr) (mean and range)	34.61 (26–45)	32.61 (23–44)
Dominant hand	13 Right	13 Right
MS duration (yr) (mean and range)	6 (4–9)	6.15 (5–9)
MS type	5 Primary progressive 8 Secondary progressive	5 Primary progressive 8 Secondary progressive
EDSS levels (mean and range)	4.88 (4–5.5)	4.53 (3.5–5.5)
Symptomatic drug use	1 Myorelaxan (tizanidine HCL) 1 Antiepileptic 2 Amantadine	2 Myorelaxan (tizanidine HCL) 1 Antiepileptic 2 Amantadine

MS, multiple sclerosis; EDSS, Expanded Disability Status Score.

Results

This study was planned to investigate the efficacy of neuromuscular rehabilitation and Johnston Pressure Splints in the patients who had ataxic MS. The study was carried out on two groups consisting of 13 patients each. Demographical data of the groups are given in Table 1.

When the pretreatment data were compared, only left CO-P37 SSEP values were better in the study group than in the control group ($p < 0.05$). There was no difference between the other parameters ($p > 0.05$). The groups also were homogeneous in their pretreatment equilibrium and nonequilibrium coordination test values ($p > 0.05$).

Pre- and posttreatment data of control and study groups are given in Table 2.

Before and after treatment EDSS data are given in Figs. 1 and 2.

In the pre- and posttreatment equilibrium coordination test, which is evaluated by walking on two lines with a distance of 10 cm between them, significant diminution was observed in the right limbs of each group (χ^2_c right, 5.44; χ^2_s right, 7.36; $p < 0.05$). Although there was no decrease between the left-limb values of the control group (χ^2_c left, 0.50; $p > 0.05$), a significant reduction was found between the left-limb values of the study group (χ^2_s left, 3.82; $p < 0.05$).

According to pre- and posttreatment ataxic movement values achieved from tandem gait, there was no important change within either group (χ^2_c right, 1.80; χ^2_c left, 2.00; χ^2_s right, 0.11; χ^2_s left, 0.81; $p > 0.05$).

Pre- and posttreatment pendular limb movement values of the nonequilibrium coordination test showed significant reduction for right limbs of both groups (χ^2_c right, 6.40; χ^2_s right, 3.90; $p < 0.05$), whereas there was no difference in left limbs of both groups (χ^2_c left, 1.60; χ^2_s left, 0.11; $p > 0.05$).

In the pre- and posttreatment knee–heel test results, there was no change in either group (χ^2_c right, 0.09; χ^2_c left, 0.14; χ^2_s right, 1.00; χ^2_s left, 0.33; $p > 0.05$).

There was no significant difference when pre- and posttreatment dysdiadakokinesia test results of the con-

Table 2. *Pre- and posttreatment values*

	Control group (n = 13)			Study group (n = 13)		
Parameters	Pretreatment	Posttreatment		Pretreatment	Posttreatment	
STS (right)	3.75 ± 0.21	3.87 ± 0.15	−2.56	3.61 ± 0.45	3.84 ± 0.20	−2.83
STS (left)	3.68 ± 0.29	3.84 ± 0.17	−2.65	3.55 ± 0.24	3.85 ± 0.14	−3.08
AB	8.03 ± 1.91	5.66 ± 1.30	−3.18	13.5 ± 20.4	5.10 ± 0.97	−3.18
SLST (right)	4.46 ± 3.43	17.7 ± 12.5	−3.06	6.15 ± 8.60	36.1 ± 22.7	−3.06
SLST (left)	6.76 ± 8.16	16.4 ± 15.7	−2.35	7.30 ± 9.11	35.1 ± 18.6	−3.18
SW	16.3 ± 4.53	13.4 ± 3.30	−3.18	16.3 ± 4.40	12.9 ± 2.06	−3.18
WS	4.30 ± 1.46	2.88 ± 0.74	−2.95	5.23 ± 2.53	3.42 ± 1.23	−3.06
AI	2.53 ± 0.51	2.00 ± 0.40	−2.64	2.61 ± 0.50	2.07 ± 0.49	−2.64
EDSS	4.88 ± 0.65	4.30 ± 0.43	−2.87	4.53 ± 0.59	4.00 ± 0.45	−3.27

Values expressed as mean ± SD.

STS, Sensory Test Score (0–4 point); AB, Anterior Balance (cm); SLST, Single-Limb StanceTime (s); SW, Step Width (cm); WS, Walking Speed (s); AI, Ambulation Index; EDSS, Expanded Disability Status Score.

$p < 0.05$ for all parameters.

trol group were evaluated (χ^2_c right, 1.60; χ^2_c left, 1.80; $p > 0.05$). A significant difference was observed in the left limbs (χ^2_s left, 6.40; $p < 0.05$), whereas there was no significant difference in the right limbs in the study group (χ^2_s right, 0.66; $p > 0.05$).

We applied SSEP and MEP procedures to all 26 patients. However, we could not record potentials from all patients. These procedures were applied to 26 patients after the treatment, and the number of patients in which the potentials could be recorded was increased. Pre- and posttreatment SSEP and MEP values that were not statistically analyzed are presented in Tables 3 and 4. Statistical analysis was applied only to the cases whose pre- and posttreatment potentials were to be recorded. According to these findings, SSEP values did not show statistically significant difference in the control group ($p > 0.05$), whereas COL and CCT results of both limbs showed significant differences in the study group ($p < 0.05$). MEP values did not show any important difference in either group ($p > 0.05$).

Table 3. *Pre- and posttreatment SSEP values*

SSEP parameters	n	Pretreatment	n	Posttreatment
Control group				
COL (ms) (right)		43.9 ± 6.41		38.1 ± 7.57
CO-P37 (ms) (right)	4	0.92 ± 0.15	11	0.75 ± 0.29
CCT (ms) (right)		21.4 ± 6.54		16.7 ± 5.57
COL (ms) (left)		39.0 ± 3.88		39.9 ± 5.09
CO-P37 (ms) (left)	5	0.72 ± 0.19	9	0.74 ± 0.29
CCT (ms) (left)		17.1 ± 3.67		17.7 ± 4.76
Study group				
COL (ms) (right)		40.1 ± 6.78		36.1 ± 6.04
CO-P37 (ms) (right)	9	1.21 ± 0.65	11	1.09 ± 0.38
CCT (ms) (right)		18.4 ± 7.68		15.7 ± 5.89
COL (ms) (left)		37.5 ± 3.61		36.7 ± 5.78
CO-P37 (ms) (left)	8	1.31 ± 0.69	12	1.20 ± 0.67
CCT (ms) (left)		15.7 ± 3.46		15.9 ± 5.28

Values express as mean ± SD.

COL, Cortical Onset Latency; CO-P37, Cortical Onset-P37 Peak Amplitude; CCT, Central Conduction Time; SSEP, somatosensory evokes potential.

Table 4. *Pre- and posttreatment MEP values*

MEP parameters	n	Pretreatment	n	Posttreatment
Control group				
MEP (ms) (right)		42.0 ± 4.86		43.4 ± 7.59
CMCT (CML-F) (ms) (right)	6	25.4 ± 6.06	9	23.8 ± 11.1
MEP/M (right)		0.11 ± 0.08		0.11 ± 0.07
MEP (ms) (left)		42.9 ± 9.91		42.2 ± 6.77
CMCT (CML-F) (ms) (left)	6	26.5 ± 10.9	7	25.3 ± 7.54
MEP/M (left)		0.08 ± 0.04		0.10 ± 0.07
Study group				
MEP (ms) (right)		46.6 ± 17.3		43.8 ± 13.5
CMCT (CML-F) (ms) (right)	5	33.8 ± 16.0	9	26.7 ± 11.9
MEP/M (right)		0.21 ± 0.11		0.15 ± 0.17
MEP (ms) (left)		48.9 ± 12.6		44.5 ± 10.6
CMCT (CML-F) (ms) (left)	6	32.5 ± 12.7	7	29.0 ± 10.4
MEP/M (left)		0.05 ± 0.03		0.10 ± 0.05

Values express as mean ± SD.

MEP, Motor Evoked Potential; CMCT (CML-F), Central Motor Conduction Time (Cortical Motor Latency-F); MEP/M, Motor Evoked Potential/M response amplitude.

Posttreatment sensory test, anterior balance, single-limb stance time, step width, walking speed, Ambulation Index, and EDSS values from control and study groups are shown in Table 5. Posttreatment equilibrium and nonequilibrium coordination test values did not show statistically significant differences between the groups ($p > 0.05$).

Posttreatment comparison of SSEP and MEP values showed statistically significant differences in CO-P37 (right) of SSEP in favor of the study group ($p < 0.05$), whereas COL and CCT results did not show any statistical difference ($p > 0.05$; Table 6). There was no statistical difference between the MEP values of the groups ($p > 0.05$; Table 6).

Discussion

Physiotherapy in MS has become an essential approach in the recent years because of functional, psychological, and physical limitations of MS. Numerous studies have investigated disability and quality of life in MS (21–26).

Most of the studies in the literature are interested in the effect of rehabilitation on strength, spasticity, and gait disorders. However, all the problems stated earlier require different specific approaches.

The gait disorders are important problems increasing the disability in early and mild stages of MS. The difficulties leading to gait problems are muscle weakness, sensory disturbances, spasticity, and ataxia. Among them, spasticity is one of the most researched topics (27,28). There are few studies on ataxia.

Frzovic et al. (29) examined the standing balance, which affects walking, in 14 MS patients. Standing balance (feet apart, feet together, stride stance, tandem stance, and single-leg stance), functional reach test, and external postural perturbation test were used in the study. The study of Frzovic et al. is similar to our study with regard to the single-limb stance test and different in assessment approaches for dynamic balance and limb ataxia.

Table 5. *Comparison of posttreatment values*

Parameters	Control group (n = 13)	Study group (n = 13)	
STS (right)	3.87 ± 0.15	3.83 ± 0.19	−2.44
STS (left)	3.83 ± 0.16	3.83 ± 0.13	−2.67
AB	5.66 ± 1.30	5.10 ± 0.97	−1.00
SLST (right)	17.7 ± 12.5	36.1 ± 22.7	−2.08[a]
SLST (left)	16.3 ± 15.7	35.1 ± 18.6	−2.56[a]
SW	13.4 ± 3.30	12.9 ± 2.06	−0.15
WS	2.88 ± 0.74	3.42 ± 1.23	−1.04
AI	2.00 ± 0.40	2.07 ± 0.49	−0.44
EDSS	4.30 ± 0.43	4.00 ± 0.45	−1.74

Values expressed as mean ± SD. See abbreviations in Table 2.
[a]$p < 0.05$.

Table 6. *Comparision of posttreatment SSEP and MEP values*

	n	Control group	n	Study group	
SSEP parameters					
COL (ms) (right)		3.81 ± 7.57		36.1 ± 6.04	−1.28
COP-37A (ms) (right)	11	0.75 ± 0.29	11	1.09 ± 0.38	−1.98[a]
CCT (right)		16.7 ± 5.57		15.7 ± 5.89	−0.65
COL (ms) (left)		39.9 ± 5.09		36.7 ± 5.78	−1.13
COP-37A (ms) (left)	9	0.74 ± 0.29	12	1.20 ± 0.67	−1.75
CCT (left)		17.7 ± 4.76		15.9 ± 5.28	−0.99
MEP parameters					
MEP (ms) (right)		43.4 ± 7.59		43.8 ± 13.5	−0.44
CMCT (CML-F) (ms) (right)	9	23.8 ± 11.1	10	26.7 ± 11.9	−0.58
MEP/M (right)		0.11 ± 0.07		0.15 ± 0.17	−0.12
MEP (ms) (left)		42.2 ± 6.77		44.5 ± 10.6	−0.48
CMCT (CML-F) (ms) (left)	7	25.3 ± 7.54	10	29.0 ± 10.4	−0.12
MEP/M (left)		0.10 ± 0.07		0.10 ± 0.05	−0.14

Values express as mean ± SD. See abbreviations for Table 3.
[a]$p < 0.05$.

Lord et al. (30) examined the effects of two different physiotherapy methods consisting of a facilitation approach and a task-oriented approach in MS patients. After a rehabilitation period of 5–7 weeks, pre- and posttreatment values showed statistically significant differences in each group, although any significant difference could not be found between the two groups.

Although the parameters and treatment methods of our study were different, pre- and posttreatment data on sensation, step width, anterior balance, ataxia evaluated by walking on two lines with a distance of 10 cm between, single-limb stance time, Ambulation Index, and EDSS data were statistically significant within each group ($p < 0.05$). The nonequilibrium coordination test scores, which evaluate limb ataxia, were slightly improved in the right limb in both groups. It was observed that limb ataxia responded later to treatment when compared with truncal ataxia. Equilibrium coordination tests also were improved in both groups in the right limb, and in the study group, also in the left limb. The better advancement achieved in right limbs was thought to originate from the slighter intensity of right-limb ataxia in the pretreatment phase.

Differing from the report of Lord et al. (30), we found single-limb stance and right CO-P37 of the SSEP were statistically different between the two groups ($p < 0.05$). When the balance rehabilitation studies were evaluated, it was observed that widely used exercises are Cawthorne-Cooksey and Zee, which include visual fixation and eye–head movement exercises developed specifically for vertigo treatment (31–33). However, beyond these techniques are many physiotherapy approaches used in balance therapy. Extremity ataxia is one of the factors influencing balance. In this study, although parameters of the Cawthorne-Cooksey Exercise done in standing position were used, our main treatment approach included PNF techniques, Frenkel Coordination Exercises, external postural perturbation training in different positions, exercise on balance board, gait training, and treatment to reduce tremor in the lower extremities in the control group.

Postural responses in normal individuals are 70–180 ms, which is increased in MS patients because of the slow spinal conduction. Therefore, the treatment, which is performed in different positions, is important for external perturbation training to facilitate the postural response (34).

Sensory ataxia is seen because of the proprioceptive sensory loss in MS (35). In our study sensory evaluation was scored from 4 to 0. Based on this scoring, sensory impairment was minimal in both groups. Clinical sensory evaluation is known to be a highly subjective assessment. The minimal sensory-loss results detected clinically were found to be more prominent in the electrophysiologic studies.

Johnstone Pressure Splints were developed by Johnstone in 1982. The potency of the splint is produced by the pressure, which stimulates the cutaneous receptors and proprioceptors. In addition, neutral temperature stimulates the thermal receptors in the inflation of the splint with lung air (36).

In a study investigating the effectiveness of an air-pressure splint in spinal cord–injured patients, the activation of the soleus muscle α motoneuron was evaluated by measuring the H reflex. It was reported that air-pressure splints temporarily decreased the α motoneuron activity (37). A similar study, which was carried out on eight hemiplegic patients, found α motoneuron activity to be temporarily decreased (38). When the posttreatment sensory values were compared in our study, it was seen that splints did not produce any clinical advantage. Although splints provide an additional sensory stimulus, it also can be created by hand contact, approximation, and balance board training during neuromuscular rehabilitation. Although splints possibly provided an effect on right CO-P37 of SSEPs subclinically and single-limb stance time clinically ($p < 0.05$), they did not produce a relevant sensory improvement.

Evoked potentials, especially SSEPs and MEPs, are sensitive electrophysiologic evaluations that can detect subclinical worsening as well as positive clinical outcomes (39–42).

Despite limited number of patients, it is possible that the SSEPs in this study detected the subclinical benefits of Johnstone Pressure Splints. However, the improvements, which were found in only the right extremities and in only one component of SSEP, may be coincidental. These improvements, not reflected by MEPs and other clinical parameters, could be due to a short-term treatment period. This is the most problematic aspect in performing rehabilitative research in steadily progressive diseases such as MS.

Interestingly, the pretreatment data of left CO-P37 SSEP values of the study group were found to be better than those of the control group; posttreatment data of study group showed improvement in right CO-P37. Right-hand dominance was present in all the patients, and the improvement was determined in the right lower limb. As the only significant differences between the groups were seen in right side CO-P37 of SSEPs and the stance time on the right foot, the improvement on the right side might be related to the dominance. The improvement seen in the right side could be related to the effective use of this side.

The EDSS of Kurtzke is used widely in MS patients to evaluate impairment and disability (43–46). In a study done by Petajan et al. (47), the effects of aerobic training on both fitness and quality of life of the patients with MS were investigated. It was then reported that whereas advances were reported in fitness and quality of life, there was no improvement in EDSS. Compatible with this finding is the study of Gehlsen et al. (48), which was performed to investigate the effectiveness of aquatic exercises on walking, and showed that this program had no impact on EDSS. Different from these studies, we found improvement in EDSS (Table 2 and Figs. 1 and 2; $p < 0.05$). The improvement of the level of EDSS by ~0.5 was a surprise to us because, to our knowledge, EDSS could not be affected by such a short-term therapy. When the results were evaluated, pretreatment EDSS points of the control group were between 4 and 5.5, and between 3.5 and 5.5 in the study group. The walking distance also was important as functional status points in EDSS evaluation after grade 3.5. Beyond grade 4, the scale showed disability, and impairment should be taken into consideration between 1 and 3.5 (49).

The patient who received 3.5 points on the EDSS in the pretreatment phase did not show any difference in the posttreatment phase, and this led us to consider the possibility there was a therapeutic effect on the disability rather than on the impairment. The results of tandem gait and knee–heel tests, which are used in the evaluation of the cerebellar system, were not found to be statistically significant when pre- and posttreatment values were compared. This outcome is in accordance with our suggestion that the therapy is not effective on impairment.

Today in MS patients, the benefits of physiotherapy on functional improvement of the early and mild stages have been reported in numerous studies. We believe that it is necessary to discuss not only the effectiveness of physiotherapy but also the effects of different physiotherapy techniques on different symptoms of MS. Our study, which was carried out according to this objective, is a pilot study; however, it is a step in forming a special-standard evaluation and treatment program for ataxia rehabilitation. One of our primary outcomes was that both methods increased single-limb stance, walking velocity, and improved the Ambulation Index level, as well as decreased anterior balance. The improvements of these parameters indicated that truncal ataxia decreased with both these treatment methods. Another primary result was that the study group with Johnstone Pressure Splints, which was the focus of our study, did not have the expected superiority as compared with the control group. Clinically we found that single-limb stance and electrophysiologic CO-P37 SSEP results were in favor of the study group. These results were lower than we expected for the study group. Short treatment duration as well as lower-level sensory component of ataxia of our subjects may be responsible for these results. Although improvements with Johnstone Pressure Splints were lower than our expectations, we suggest that these splints could be used as a treatment modality in patients with mild or severe sensory problems. Another primary outcome was an unexpected improvement in the EDSS level in both groups, even if it was only 0.5 point. The improvements of Ambulation Index and walking welocity also indicated a decrease in the disability of the patients, and this finding paralleled the positive changes in EDSS. This improvement in EDSS also may be due to a mild fluctuation in disability.

As a secondary outcome, nonequilibrium coordination tests did not show a significant improvement. This result can be interprated to imply that limb ataxia is more resistant to physical therapy approaches. These physiotherapy approaches may decrease the ataxia in MS patients. We can conclude that the combination of physiotherapy techniques in MS rehabilitation may be effective. Rehabilitation therapy should be adapted continuously, according to the disease-related deficits, and combined techniques should be tried to overcome the most resistant symptoms.

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