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* **Corresponding author**.

physio.kric@krupanidhi.edu.in

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Effect of Anchor System on Postural Control, Balance, and Lower Extremity Function in Patients with Multiple Sclerosis

Aishwarya Deshmukh[1], Kalidasan Varathan[1]*

1 Krupanidhi College of Physiotherapy, Bengaluru, Karnataka, India

Abstract

Objective: To ascertain how anchor system training affects the participants with multiple sclerosis's balance, postural control, and lower extremity functions. **Method:** Thirty multiple sclerosis subjects based on inclusion criteria. After obtaining informed consent, the study subjects received anchor system training sessions lasting 40 minutes per session, two days/week for six weeks. MS subjects were assessed before and after six weeks for balance, postural control, and lower extremity function using TUGT, FRT, LRT, AND LEFS. Data were analyzed using descriptive statistics, paired t-tests, and reliability test statistics. **Findings:** The time up and go test for the subjects before and after the intervention protocol were 26.53$\pm$1.52 and 21.66$\pm$2.46, respectively. The score was statistically significant with p=0.001 ($p<0.05$), indicating a significant improvement in the balance component of motor symptoms in MS after six weeks of intervention protocol. This study measured postural control using the forward and lateral reach tests. The pre- and post-FRT mean for the right upper extremity of the study participants was 13.87$\pm$1.08, 19.05$\pm$1.39 respectively, and the mean left upper extremity of the study participants was 14.05$\pm$1.14 and 19.2$\pm$1.51. Pre- and post-LRT mean for the right upper extremity of the study participants was 11.27$\pm$0.96 and 16.78$\pm$1.20 respectively, and the mean left upper extremity of the study participants was 11.32$\pm$0.95 and 16.93$\pm$1.18. The score was statistically significant with p=0.001 ($p<0.05$) for both the FRT and LR. For lower extremity function LEFS (scores:33.70$\pm$2.92 and 39.90$\pm$3.58) ($p< 0.05$), which infers a significant improvement in the lower extremity function of motor symptoms in MS after 6 weeks of intervention protocol. **Conclusion**: The study concludes that the anchor system significantly improves balance, regulates alignment, and improves lower limb functioning with multiple sclerosis. **Novelty:** The study's innovation lies in incorporating a suitable and focused assessment tool, namely a rehabilitation of equilibrium, maintaining alignment, and limb work.

Keywords: Balance; Postural control; Nonrigid tool; Lower limb function; Neurological symptoms

1 Introduction

Multiple sclerosis (MS) is a demyelinating, autoimmune, persistent neurological disease [(1)].The symptoms depend on the area and severity of the lesion. Sensory, ocular, and Genito-sphincteric function decline is the present clinical signs of MS. Balance, and postural control depend on these processes [(2)]. Balance detriment and postural control deficiency are the leading symptoms of Multiple sclerosis individuals, and they affect the function system [(3)].

The balance is the maintenance of the center of mass over the base of support and appeals to both movements (static and dynamic) [(4)]. The control of posture (PC) desired significant recipience, succession, and incorporation of visual, vestibular, and proprioceptive knowledge and communication of the motor inputs to the lower extremity muscles and trunk [(5)]. Decreased postural control and muscle weakness, seen explicitly in the lower extremities, deteriorate gait function and physical performance [(6)]. Balance disruption and falls accentuate the importance of balance rehabilitation, frame of intervention, disability, and various treatments to subside impairment [(7)].

Lower extremity muscle power and postural balance affect performance, and the kinetic chain plays a vital part in this vicious cycle [(8)]. Multiple sclerosis patients show impairment in lower extremity function [(9)]. Furthermore, walking is the most crucial physiological activity for individuals with multiple sclerosis. A finding like this highlights the significance of functional ability in the lower extremities in MS patients [(10)].The time up and go test (TUGT) is widely used and simple to perform this test to check the balance mobility of a person [(11)]. A seat and a walking area for the individual to walk 3 meters are required. The duration of the test is a presentation by an individual. The normal value is less than 1 minute [(12)]. The forward reach test (FRT) and lateral reach test (LRT) are easy tests, not time-consuming, and forward reach and lateral reach of individuals while reaching forward and lateral in a standing position measure [(13)].

The anchor system comprises two ropes with a modest load (125g) tied to each cable's end [(14)]. The anchor system uses a stretchable cord-attached weight touch to a floor to prevent positional oscillation to promote postural control by continuously haptically perceiving the upper limbs during balancing exercises [(15)]. Body sway was reduced by 68% compared to no-touch on the floor when the person touched something significantly less than 1 N of applied force [(16)]. Oats et al. showed that the practice of a two-arm anchor system effectively decreased the trunk sway, and it is integrated to improve walking balance control in individuals with injury [(17)]. Brito et al. revealed that the anchor weight arm could decline postural sway while walking tasks in older adults in a shorter period of intervention protocol. It showed positive effects during the deferred intervention phase after the withdrawal of anchors only in patients who used a declined anchor frequency [(18)]. Batistela et al. concluded that implementing the anchor tool and auditory and visual cognitive tasks increased postural control in young individuals in a demanding balancing task [(19)]. Rangon et al. concluded that Multiple sensory training with the anchor system tool is agreeable for postural balance control and self-assuredness for falls, regardless of age and upper extremity volume, for breast cancer survivors [(20)].

The novelty of the study: Previously Various studies used the Anchor System device as a rehabilitation protocol to upgrade Balance, trunk control, gait, and PC in neurological conditions like Parkinson's disease, vestibular deficit, stroke, old age, etc. There are multiple studies conducted on multiple sclerosis patients to improve postural control and balance by using other interventions, but the Anchor System is a new device that provides haptic cues to the body. To know about how it will affect postural control and balance in the multiple sclerosis population this device was selected. The study gap was found in the Multiple sclerosis neurological condition using an Anchor system for rehabilitation protocol for balance and postural control outcome measures. This tool was not used in MS conditions for intervention.

The study's novelty is that, for the first time, our analysis endorsed that an Anchor system device is used for rehabilitation protocol for the increment of Balance, Postural Control, and Lower Extremity Function.

2 Methodology

The pre-test and post-test experimental investigations were conducted on a single group using a purposive sampling method. Their informed permission was acquired after outlining the study to all 30 patients. Following securing ethical clearance from the Ethical Committee (MPT/2022/PHY/001), 30 patients with multiple sclerosis were assigned. The study was conducted at Neurorehabilitation institutions, House facilities, and the Outpatient Department (OPD). After being inducted regarding the study procedure, each one of the subjects agreed to participate and signed a consent form. The study duration was six months; subjects underwent exercise training using the Anchor system for 40 minutes per session, two days/per week for six weeks.

Inclusion Criteria:

- The patient was diagnosed with multiple sclerosis.
- Age- 20-40 years [(11)].

- Disability status score on expanded disability status scale (EDSS -3 0-5 0 [12].
- Medically stable during 6 months before the baseline [13].

Exclusion Criteria:

- If a relapse occurs in the month before the baseline or during the intervention process. [13]
- Diagnosed with a psychiatric disorder, malignant disease, and orthopedic condition (falls, infection).

Outcome measures:

Balance: time up and go test [11]

The TUG test is a simple and widely used test of balance. The subjects were instructed to sit on an armchair before standing up, walk 3 meters, turn around, walk back to the chair, and sit down on the chair again. The timing of the TUG started when the participants were getting up from the chair and stopped when their buttocks retouched the seat of the chair. We asked a patient to walk at normal speed and gait aids will be provided when appropriate. The TUG test was performed three times with a pause between repetitions and the shortest time was selected. [14]

Postural control:

Forward reach test : [15,17] The participant was instructed to stand, without support for the upper limbs, positioned lateral to the wall without touching it and keeping his shoulder flexed 90° at 10 cm from the wall. The therapist records the starting position at the 3rd metacarpal head. The subject was then instructed to bend forward as much as possible without losing balance. The location of the 3rd metacarpal was recorded. The scores were assessed by measuring the difference between the start and end positions, usually measured in centimeters. The types of reach were measured in 3 attempts and the mean of the 3 attempts was calculated. [15]

Lateral reach test: [15] The participant keeps his arm by the side of the body, the distance between the hand and the floor was measured at rest (measure 1). Next, he was asked to perform lateral bending of the trunk as much as possible and the maximum distance of his hand from the floor was measured (measure 2). Lateral reach was defined as the difference between these two measures.

(Lateral reach) = (measure 1- measure 2)

Lower extremity function : [16,18] The LEFS consists of 20 equally weighted questions of functional activity. The items evaluate the degree of difficulty in performing different functional activities due to a problem in the lower extremity. Each item was scored on a 5-point scale ranging from 0 to 4 points; 0: extreme difficulty or unable to perform the activity; 1: quite a bit of difficulty; 2: moderate difficulty; 3: a little bit of difficulty; and 4: no difficulty. Accordingly, total scores of the LEFS range from 0 to 80, with higher scores representing higher levels of lower extremity functional status.

Procedure:

Institutional Ethical clearance was obtained for the conduct of the study from the Ethical committee. The subjects were informed regarding the purpose and procedure of the study. Written consent for participation was obtained from each subject individually, and they were selected based on selection criteria. Pre-treatment outcome measure data was taken for balance, postural control, and lower extremity function. The balance was measured by TUGT (Time up and go test). The postural control was measured by using a FORWARD REACH TEST (FRT) LATERAL REACH TEST (LRT), and lower limb function was measured by using LEFT SCALE. Patients were asked to wear goggles/cloth before starting the exercise protocol to prohibit vision and ask the patient to hold the anchor system in bilateral hands while performing the exercise. In the sitting position, the patient was instructed to perform middle lateral body sway, weight transfer from left to right lower extremity, sit to stand, and decreasing BOS must perform three repetitions each for 20 seconds. The protocol was changed in repetitions with duration. In standing single-leg stance, distributed the body weight back and front, anteroposterior trunk sway must perform 1-15 reptation in 1st –2nd weeks. Patients were instructed to perform middle-lateral body sway, weight transfer from one extremity to another, stand-to-sit transfer, and single-leg stance by holding an anchor device. All patients were instructed to perform all these exercises followed by gait training exercises like forward walking, backward walking, diagonal walking, and walking over obstacles. The treatment sessions lasted for 40 mins per session, 2 days/week for 6 weeks. Post-treatment outcome measures were taken for balance, postural control, and lower extremity function.

Position of exercise	1st-2nd weeks	3rd – 4th weeks	5th-6th weeks
1) Sitting position	Middle-lateral body sway, weight transfer from left to right LL, sit-to-stand transfer, decreasing BOS. (3-20sec)	3-40 sec	3-60 sec

Continued on next page

Table 1 continued

2) Standing position	Single Leg stance. Repeat the same activity on the other side. (3-10sec)	3-20 sec	3-30 sec
	Distribute the body weight back and front.	Disseminate the body mass to diagonal sides	Adding movement to make a circle with the body.
	Antero-posterior trunk sway. (1-15reps)	2-12 reps	3-10 reps
3) Gait training	Forward walking (1-15 reps)	Backward walking, diagonal walking (2-12 reps)	Walking over obstacle (3-10 reps)

2.1. Outcome Measures

- Time up and go scale (balance) [11].
- Forward reach test (postural control) [17].
- Lateral reach test. [17]
- Lower extremity function. [13]
- **Statistical Analysis:**

To analyze the data, Windows SPSS (version 29.0) was used. illustrative statistics were used to calculate the mean and standard deviation for the demographic and outcome variables. The significant differences between the variables were determined via a paired t-test.

3 Results

A paired t-test was used for the pre-test and post-test within the group analysis to analyze the effect of 6 weeks of anchor system training in Multiple Sclerosis subjects as shown in Table 3.

From Table 3 it is inferred that the mean difference between the Time up and Go test pre-test and the post-test was 4.866±0.776 after 6 weeks of intervention within the group. The obtained t-value for the study subjects was 34.34 and the p-value was found using a table from students' distribution. The calculated p-value is below the threshold chosen for statistical significance of 0.001 (<0.05), therefore the alternate hypothesis is accepted, and the null hypothesis is rejected for the Time up and Go test for anchor system training on balance. It is inferred that the mean difference between the and the Forward reach test right side pre-value-forward reach test right side post value was -5.173±1.048 after 6 weeks of intervention. The obtained t-value for the study subjects was -27.017 and the p-value was found using a table from students' distribution. The calculated p-value is below the threshold chosen for statistical significance of 0.001 (<0.05), therefore the alternate hypothesis is accepted, and the null hypothesis is rejected for the Forward reach test for anchor system training on postural control. It is inferred that the mean difference between the and the forward reach test left side pre-value-forward reach test left side post value was -5.203±1.134 after 6 weeks of intervention. The obtained t-value for the study subjects was -25.12 and the p-value was found using a table from students' distribution. The calculated p-value is below the threshold chosen for statistical significance of 0.001 (<0.05), therefore the alternate hypothesis is accepted, and the null hypothesis is rejected for the Forward reach test for anchor system training on postural control. It is inferred that the mean difference between the and the lateral reach test right side pre-value-lateral reach test right side post value was -5.506±0.961 after 6 weeks of intervention. The obtained t-value for the study subject was -31.364 and the p-value was found using a table from students' distribution. The calculated p-value is below the threshold chosen for statistical significance of 0.001 (<0.05), therefore the alternate hypothesis is accepted, and the null hypothesis is rejected for the lateral reach test for anchor system training on postural control. It is inferred that the mean difference between the lateral reach test left side pre-value-lateral reach test post-value mean was -5.61±1.009 after 6 weeks of intervention. Obtained t-value obtained for the study subjects was -30.44 and the p-value was found using a table from the students' distribution. The calculated p-value is below the threshold chosen for statistical significance= of 0.001 (<0.05), therefore the alternate hypothesis is accepted, and the null hypothesis is rejected for the lateral reach test for anchor system training using the postural control. It is inferred that the mean difference between the and the lower extremity function scale pre-value- and the post-value mean was -6.20±1.93 after 6 weeks of intervention. The t-value for the study subjects was -17.53 and the p-value was found using a table from students' distribution. The calculated p-value is below the threshold chosen for statistical significance= of 0.001 (<0.05), therefore the alternate hypothesis is accepted, and the null hypothesis is rejected for the lower extremity function scale for the anchor system training on the lower extremity function. Overall, there is a significant difference between all the outcome measures.

Table 2. Age of the study participants- descriptive statistics

VARIABLE	MEAN	SD
Age (years)	31.33	5.90
BMI	22.12	1.52

From Table 2 above, 30 Multiple sclerosis subjects were considered based on inclusion criteria of age group between 20-40 years. The mean age group of study participants is 31.33±5.90. The BMI was calculated based on the height and weight of the subjects who participated. The study subjects' mean BMI (kg/m^2) was 22.12±1.52.

Table 3. Mean difference of outcome measurer variable

TEST	MEAN	SD	DIFFERENCE		t	p	SIGNIFICANT/NON SIGNIFICANT
			MEAN	SD			
Time up and test pre-value	26.53	2.59	4.866	0.776	34.34	0.001	HIGHLY SIGNIFICANT
Time up and test post-value	21.66	2.46					
Forward reach test rt side pre-value	13.87	1.08	-5.173	1.048	-27.01	0.001	HIGHLY SIGNIFICANT
Forward reach test rt side post value	19.05	1.39					
Forward reach test left side pre-value	14.05	1.14	-5.203	1.134	-25.12	0.001	HIGHLY SIGNIFICANT
Forward reach test left side post value	19.2	1.51					
Lateral reach test right side pre-value	11.27	0.96	-5.506	0.961	-31.36	0.001	HIGHLY SIGNIFICANT
Lateral reach test correct side post value	16.78	1.22					
Lateral reach test left side pre-value	11.32	0.95	-5.61	1.009	-30.44	0.001	HIGHLY SIGNIFICANT
lateral reach test left side post value	16.93	1.18					
Lower extremity function scale pre-value	33.70	2.92	-6.20	1.936	-17.53	0.001	HIGHLY SIGNIFICANT
Lower extremity function scale- post-value	39.90	3.58					

From the above Table 3, The study shows a significant difference ($p<0.05$) within the group among all the outcome measures.

4 Discussion

This study focuses on determining the effect of the "Anchor system" on balance, postural control, and lower extremity function in patients with MS. The most common finding seen in multiple sclerosis patients was abnormal balance control, postural control, and other risk factors, which increase the risk of falls. After diagnosis, 80 % of people with multiple sclerosis experienced various mobility issues due to a deprivation of lower limb muscle strength (due to which the lower extremity shows function loss). Therefore, the study's main aim is to know the response of the "Anchor system" on balance, postural control, and lower extremity function in individuals with multiple sclerosis. This study rejected the null hypothesis for balance, PC, and lower extremity function, and an alternate hypothesis was accepted.

The present study focuses on the "Anchor system" combined with exercise training protocol among thirty multiple sclerosis subjects at a 6-week intervention protocol to check the balance using the time up-and-go valid and reliable method. The time up and go test for the subjects before and after the intervention protocol were 26.53±1.52 and 21.66±2.46, respectively. The score was statistically significant with p=0.0000 ($p<0.05$), indicating a significant improvement in the balance component of motor symptoms in MS after six weeks of intervention protocol. This study measured postural control using the forward and lateral reach tests. The pre- and post-FRT mean for the right upper extremity of the study participants was 13.87±1.08, 19.05±1.39 respectively, and the mean left upper extremity of the study participants was 14.05±1.14 and 19.2±1.51. Pre- and post-LRT mean for the right upper extremity of the study participants was 11.27±0.96 and 16.78±1.20 respectively, and the mean left upper extremity of the study participants was 11.32±0.95 and 16.93±1.18. The score was statistically significant with p=0.0000 ($p<0.05$) for both the FRT and LRT, which infers a significant improvement in the postural control component of motor symptoms in MS after 6 weeks of intervention protocol.

This study's result is correlated with the study of Cohelo et al. on the peripheral vestibular chronic dizziness population using an Anchor System where they analyzed gait and dynamic balance. The obtained result for the mini-BESTest test for subjects before and after the intervention protocol was for G1 was 22.12±3.78 and 26.98±1.65 and for G 2 was 23.68±2.68 and 25.98±1.78which showed significance with this study [21]. This research shows similar findings that support this study of the lower limb function using the LEFS by Almuklass et al. on the Multiple Sclerosis populations evaluated lower extremity muscle power and functional capacity as P =0.11 (p<0.05), which shows significance. The study by Bowser et al. evaluated lower-limb muscle power and functional capacity as P = 0.09 (p<0.05), which interpreted the significance [9]. The study that supports this article was supplemented by Soke and Eldemire et al. in Multiple Sclerosis individuals for the FRT and analyzed the difference between the mean FRT distances of MS patients and healthy controls (29.91 7.38 vs. 36.53 6.07) (p .001) which indicates significance [13].

This article's findings can be explained by the previous articles showing that sensory feedback plays a vital role in auspicious body displacement in space, derived from the accumulation of sensory systems, which are vestibular, somatosensory, and visual information that moderate the network during body displacement in individuals. This CNS and the locomotor networks are efficiently graded so that supraspinal locomotor centers control spinal inputs.

A previous study shows a similar result by Dascal et al. that an anchor system is a primary tool for developing PCs, as it allocates useful haptic information, and its use is associated with more excellent stability. The obstruction of visual information increased body sway. In the older individual, changes in sensory information are used to control balance, which may be associated with the acquisition or refinement of sensory information and muscle activation. Maintaining a stable posture requires flexibility on the part of the PC system. Vision is essential in postural control, providing information on the individual and his environment. In addition to the importance of vision, the haptic system's contribution to balance regulation is essential. Body sway can be abbreviated by light touch due to the benefaction of haptic cues for achieving PC and Balance [22]. In the anchor system, due to the massive weight attached to the rope, the force threshold level for compensation via touch is unknown [23]. Similarly, in this study, an Anchor System device supplements light touch to avoid postural imbalance and works another system majorly in compensation for vision to maintain PC and Balance.

This research shows similar findings that support this study by Mergner and Rosemeire et al., which suggested that the anchor system plays an important role in improving walking patterns and dynamic equilibrium in chronic peripheral vestibulopathy patients. This study suggested modes of body illustration: top-bottom and vice versa. Body orientation in the environment is increased by haptic inputs from bottom to top. Similarly, in this article, the subjects showed improved balance, which may have transpired due to the companion of haptic guidance. As individuals with multiple sclerosis have a crisis with vision, anchors slightly offset for this deficiency of vision and enrich to soma direction concerning the vertical since they implement instruction on the body position relative to the floor. Therefore, the enhancements that were identified with anchors are probably due to haptic information augmentation serving as other input to the central nervous system in the sensory integration of mainly the vestibular and proprioceptive systems [21].

Similarly, an article by Castro et al. shows the haptic cues knowledge informed by an Anchor System for the inclination of Postural Control and Lower extremity function in Intellectually disabled individuals. They suggested that the investment of knowledge during the representation of the motor function identifies the role of haptics in the action-perception system. So, in this study, the contribution of haptic perception cues has been playing an essential functional role in maintaining postural control through an anchor system. When an individual touches a hard surface lightly with the index finger, the haptics from the finger help to maintain steady posture and can help to decline body sway up to 50%. In PC conservation, information collected from the haptic system is integrated with the vestibular and somatosensory systems. Decreased postural control and muscle weakness, notably in the lower extremities, disintegrated gait function and physical performance. The quality of life of MS individuals was affected or deteriorated due to impairment in lower extremity function [24].

According to the above description of mechanisms, an Anchor System device can play a significant role in rehabilitating patients with Multiple Sclerosis for improving Balance, Postural Control, and lower extremity function.

5 Conclusion

Finally, we have manifested that an Anchor System significantly improves Balance, PC, and lower limb function in patients with Multiple Sclerosis. The anchor system plays an additional role by providing the haptic information during exercise rehabilitation protocol for improving balance and postural control in Multiple Sclerosis. To the best of our information, for the first time, our analysis endorsed that an Anchor system device is used for rehabilitation protocol for the increment of Balance, Postural Control, and Lower Extremity Function. The result of this study indicates that an Anchor System device shows significant improvement in the mean post scores of Balance by using the time up and go test, Postural Control by using FRT and LRT, and Lower Extremity Function, which was evaluated by using LEFS with a p-value is less than 0.05 after 6 weeks of intervention protocol.

Limitations of study

The sample size study was less (30). The intervention protocol was short (6 weeks). The study lacks follow-up, so we do not know the long-term effect of the interventions. The study was experimental in one group.

Future work of study

The studies can be performed on a larger population. The intervention protocol can exceed 1 year for MS patients to achieve better recovery. For better results, further studies can be done in three groups. The study shows a better impact with follow-up intervention.

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