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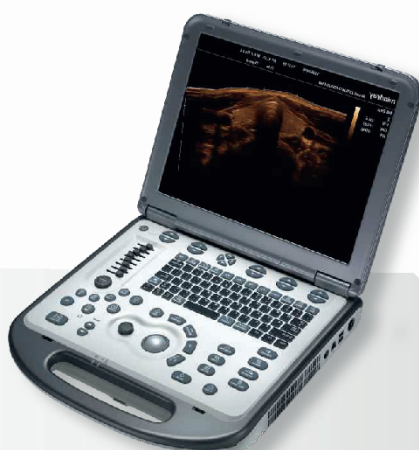
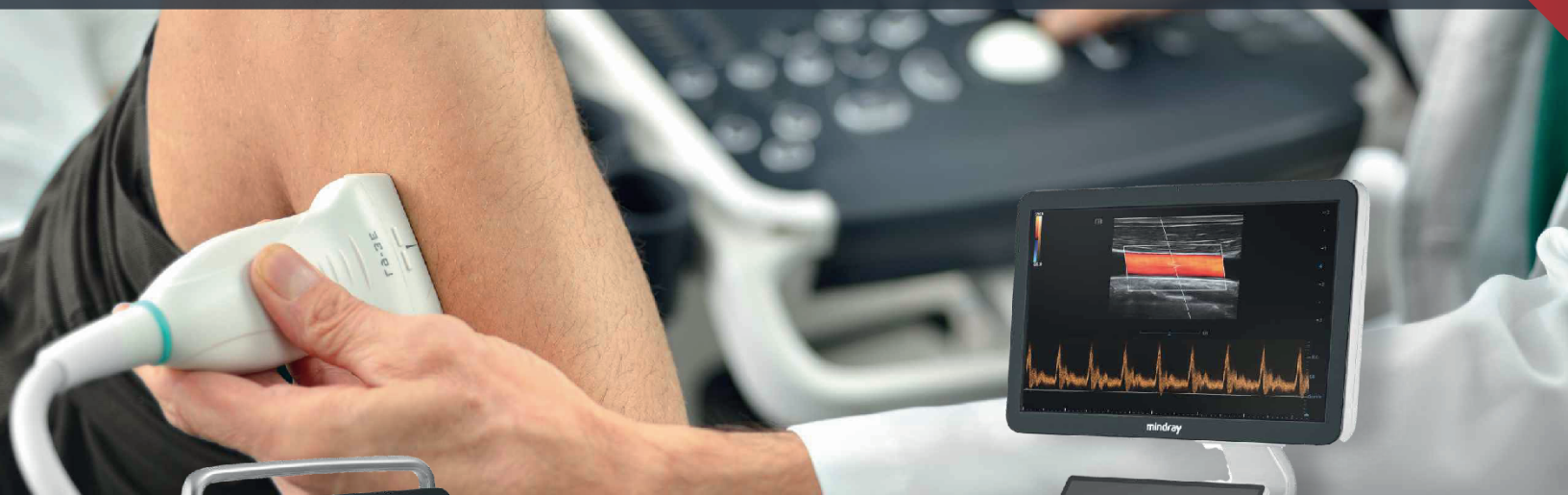


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## Sukces czy porażka? Czyli jak wygląda sytuacja w zakresie szczepień ochronnych w Polsce?



Cztery uczelnie – Centrum Medyczne Kształcenia Podyplomowego, Warszawski Uniwersytet Medyczny, Akademia Leona Koźmińskiego i Uniwersytet SWPS zorganizowały konferencję naukową w ramach Projektu „Budowanie zaufania do szczepień ochronnych z wykorzystaniem najnowszych narzędzi komunikacji i wpływu społecznego”.

Podczas czterech paneli dyskusyjnych eksperci, naukowcy, lekarze, psycholodzy, przedstawiciele instytucji publicznych dyskutowali na temat szans i wyzwań stojących przed systemem szczepień w Polsce.

Nie da się zaprzeczyć faktom – szczepienia ochronne są najefektywniejszą metodą zwalczania chorób zakaźnych. Podnoszenie zaufania do szczepień, które przekłada się na poziom wyszczepienia populacji, jest więc kluczowym wyzwaniem stojącym przed wszystkim odpowiedzialnymi za zdrowie publiczne w Polsce.

Dużym sukcesem i krokiem w dobrym kierunku było wprowadzenie szczepień w aptekach – podkreślił prof. Jarosław Pinkas, Konsultant Krajowy w dziedzinie zdrowia publicznego.

Niemniej, mimo szeroko prowadzonej kampanii medialnej, Polska należy do krajów o najniższym poziomie wyszczepienia przeciw COVID-19 w Europie (niepełna 60% populacji zostało w pełni zaszczepionych). Co roku w naszym kraju przeciw wirusowi grypy szczepi się jedynie 4-6% osób. Według danych PZH-NIPZ liczba uchybień od szczepień obowiązkowych wśród dzieci w okresie od 2016 do 2020 roku wzrosła 2-krotnie z 23 tys. do 50.5 tys.

„Szczepienia przeciwko grypie u pracodawców bardzo zmniejszają absencję w pracy, ta sama prawidłowość dotyczy szczepień rotawirusowych” – mówił prof. Marcin Czech



Z danych uzyskanych przez Warszawski Uniwersytet Medyczny wynika, że postawy mieszkańców Polski wobec szczepień nie są spójne. Może to w przyszłości spowodować dalszy spadek poziomu wyszczepienia populacji, a w dalszej perspektywie wzrost zagrożenia epidemiologicznego.



W ramach panelu prowadzonego przez Uniwersytet SWPS zastanawiano się nad przyczynami postaw wobec szczepień. Pierwszym skojarzeniem, jakie większość Polaków wypowiada po hasło „szczepienia” jest „koronawirus”. I choć rzeczywiście od końca 2020 roku szczepienia przeciwko COVID-19 stały się jednym z bardzo ważnych elementów debaty publicznej, to przecież rosnąca liczba osób uchylających się od szczepień na takie choroby jak odra czy krztusiec była ważną kwestią społeczną już przed marcem 2020 roku.

Jednym z kluczowych wyzwań stojących przed systemem szczepień w Polsce jest walka z fake newsami, podkreślali eksperci Akademii Leona Koźmińskiego. Czy dezinformację naukową można interpretować w kategoriach cyberwojny? Czy jest to zagrożenie porównywalne z katastrofą klimatyczną, bądź rozwojem techniki AI? Jaką rolę odgrywają w tym procesie media społecznościowe? To pytania z którymi musimy się jak najszybciej zmierzyć.

Mimo wszystko wysoka wyszczepialność w Polsce to sukces wszystkich profesjonalistów medycznych i osób działających na rzecz zdrowia publicznego. Wciąż zdecydowana większość Polaków dokonuje właściwych wyborów zdrowotnych. To optymistyczny wniosek płynący z konferencji CMKP, WUM, SWPS i ALK. Jednak nic nie jest dane raz na zawsze – pojawiające się wyzwania powinny mobilizować lekarzy, naukowców, edukatorów, przedstawicieli administracji publicznej do szukania nowych sposobów dotarcia z komunikatem zachęcającym do szczepień i podejmowania zdecydowanych działań na rzecz walki z dezinformacją.







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# Torso based balance weighting versus tailored physical therapy program in postural control in patients with multiple sclerosis

*BBTW oraz indywidualny program fizykoterapii w kontroli postawy u pacjentów ze stwardnieniem rozсіяnym*

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## Abstract

**Purpose.** To compare between the effect of torso based balance weighting and tailored physical therapy program on balance and postural control in ataxic MS patients.

**Methods.** Ninety patients diagnosed as ataxic multiple sclerosis with impaired balance and postural control were selected from outpatient clinic of two hospitals. The patients randomly assigned into two groups, group (A: n = 30) received torso-based balance weighting and selected physical therapy program and group (B; n = 60) received tailored physiotherapy program and the same selected physical therapy program. Treatment lasted eight weeks, three times per week. Pre- and post-treatment assessment using berg balance scale and overall stability index were done for all patients. **Results.** Post-treatment comparisons between the two groups showed a statistically significant improvement in Berg balance ( $p < 0.05$ ) in favor of group (B) and both groups showed clinical improvement. **Conclusion.** The tailored physical therapy program was more statistically effective in improving balance disorders than torso based balance weighting in ataxic MS patients, and there was clinical effect on improving postural control of both groups.

## Keywords

multiple sclerosis, postural control, torso based balance weighting, tailored physical therapy

## Streszczenie

**Cel.** Porównanie efektów BBTW (ang. balance-based torso-weighting) i indywidualnego programu fizykoterapii w poprawie równowagi i kontroli postawy u pacjentów ze stwardnieniem rozсіяnym i ataksją.

**Metody.** Z poradni dwóch szpitali wybrano 90 pacjentów ze stwardnieniem rozсіяnym z zaburzeniami równowagi i kontroli postawy. Pacjenci zostali losowo przydzieleni do dwóch grup, grupa (A: n = 30) została poddana BBTW, a grupa (B; n = 60) indywidualnemu programowi fizykoterapii. Obie grupy zostały poddane konwencjonalnemu programowi fizykoterapii ukierunkowanemu na równowagę i kontrolę postawy. Leczenie trwało osiem tygodni, trzy razy w tygodniu. U wszystkich pacjentów przeprowadzono ocenę przed i po leczeniu za pomocą skali równowagi Berga i ogólnego wskaźnika stabilności. **Wyniki.** Porównanie obu grup po leczeniu wykazało statystycznie istotny wzrost równowagi na skali Berga ( $p < 0,05$ ) na korzyść grupy eksperymentalnej (B). **Wniosek.** Indywidualny program fizykoterapii ma istotny wpływ na poprawę równowagi i kontrolę postawy u pacjentów ze SM i ataksją.

## Słowa kluczowe

stwardnienie rozсіяne, kontrola postawy, BBTW, indywidualny program fizykoterapii



## Introduction

The central nervous system (CNS) disorder known as multiple sclerosis (MS) affects 2.5 million people worldwide [1, 2] which is a chronic autoimmune disease that causes demyelination, gliosis, as well as neuronal death. According to the progression of the disease, it is divided into seven groups, with relapsing-remitting (RR) being the most prevalent [3]. Although the exact cause of MS is unknown, a number of elements such as immunological, environmental, and genetic factors play a role in its development [4–6].

Multiple sclerosis leads to many visual, vestibular, and sensory manifestations all contributing to the highly prevalent (75%) balance and postural control impairments and hence limiting daily activities in these patients [7–9].

Postural control consists of neural control of the postural equilibrium that maintains the balance and prevents fall and postural orientation that maintain body alignment [10]. It occurs as a result of the integration of sensory data from convergent sensory systems, such as the somatosensory, vestibular, and visual systems, which estimate the body's position and motion in relation to the environment [11].

Balance based torso weighting (BBTW) evaluates the directional instability of a standing subject if a perturbation and resisted rotations at the shoulders and pelvis are manually applied while a light weight placed on the trunk to counter instability. It is proposed to benefit MS patients by providing strong sensory input compensating for impaired sensory integration by improving motion and position perception [12, 13].

Customized interventions may be essential for improving the effectiveness of balance rehabilitation therapies. Patients having prevalent proprioception deficit got (PROP) rehabilitation therapy for balance dysfunction in the open- and closed-eyes situations with balance as well as gait-training exercises, whereas the patients having prevalent vestibular deficit got (VEST) rehabilitation therapy for balance dysfunction with visual feedback. Patients having prevalent visual deficit got visual rehabilitation therapy for balance dysfunction in the open-eyes situation [14].

Impairment to the spinocerebellum, in particular, reduces the ability to optimize postural strategies based on previous experience and causes bigger than usual automatic as well as anticipatory postural alterations. In contrast, injury to the vestibulocerebellum makes it difficult for a person to orient their body in relation to gravity or other reference points [15].

Due to the complex nature of ataxic MS, it frequently results in heterogeneous impairments that impair balance as well as postural control, involving visual (VIS), proprioceptive (PROP), as well as vestibular (VEST) impairments, which are particularly prevalent in MS patients. As a result, task-specific rehabilitation of VIS, PROP, as well as VEST deficits, assessed clinically and using biodex, could play an important role in improving the effectiveness of balance rehabilitation interventions and stimulating patients' attention, thereby reducing the risk of injuries and falling in MS patients [16].

The literature review on MS balance physical therapy does not provide a clear consensus of the balance treatment using a substantial decline in falls, regardless of the fact that physiotherapy (PT) is an essential part of a comprehensive treatment for patients having MS [17, 18]. So, the present study aimed to compare between the effects of balance-based torso weighting and tailored physical therapy program in improving balance and postural control in ataxic MS patients.

## Materials and methods

### Study Design

This randomized control comparative study was conducted to compare between the effect of torso-based balance weighting and tailored physical therapy program on balance and postural control in patients with relapsing-remitting ataxic multiple sclerosis with impaired balance and postural control. Data were collected from September 2020 and ended January 2022, and all patients signed informed consent form.

### Ethical considerations

Consent number: P.T.REC/012/002785 was reviewed for ethical consideration and authorized for the current investigation. A single blind randomization was carried out by assigning the odd numbers to group (A) and the even numbers were assigned to group (B). The privacy and anonymity of every patient were ensured.

### Participants

Ninety patients from both genders aged from 20 to 40 years, were medically stable receiving the same medical treatment interferon beta medication, were in the stable stage of the disease, with no relapses or deterioration over the previous 3 months, had a moderate level of balance impairments according to berg balance scale (21–40), body mass index ranged from (18.5 – 30), all patients were ambulant with a score of Expanded Disability status scale (EDSS) ranged from 2.0 to 4.0, muscle power of the upper and lower limb muscles ranged from grade 3+ to 4+ according to Manual Muscle Testing. Normal muscle tone to mild spasticity (grade 0, 1, 1+ according to Modified Ashworth Scale) They were selected from outpatient clinic from Shebin Elcom Teaching Hospital and Menoufia University hospital, Menoufia, Egypt. Patients were excluded who had complications that make it difficult for them to undergo testing and tolerate therapy, osteoporosis with high risk of fractures, full blindness and blurred vision and had severe current back pain. psychiatric disorders and cognitive impairment, severe motor impairments, with motor power less than three, pregnant females, cardiovascular and pulmonary diseases, patients who were in acute relapse stage, patients who had uncontrolled diabetes mellitus were excluded.

### Randomization

The recruited patients were randomly assigned, after signing consent form, into two groups. A single blind randomization was carried out by assigning the odd numbers to group (A) and the even numbers were assigned to group (B). Following randomization, there was dropping out of patients from the study as showed in Figure (1).

### Outcome measures

#### Berg Balance Scale

By evaluating performance patients executing functional tasks, it examines balance in patients who had impaired balance function. It is a valid tool used in clinical practice and academic research to assess the efficacy of therapies and provide quantitative descriptions of function. It requires a ruler, 2 standard chairs (one including arm rests, one without), a stool or step, a stopwatch or wristwatch, as well as a 15-foot pathway. The scale has 14 items. It takes about 15 to 20 minutes to finish.



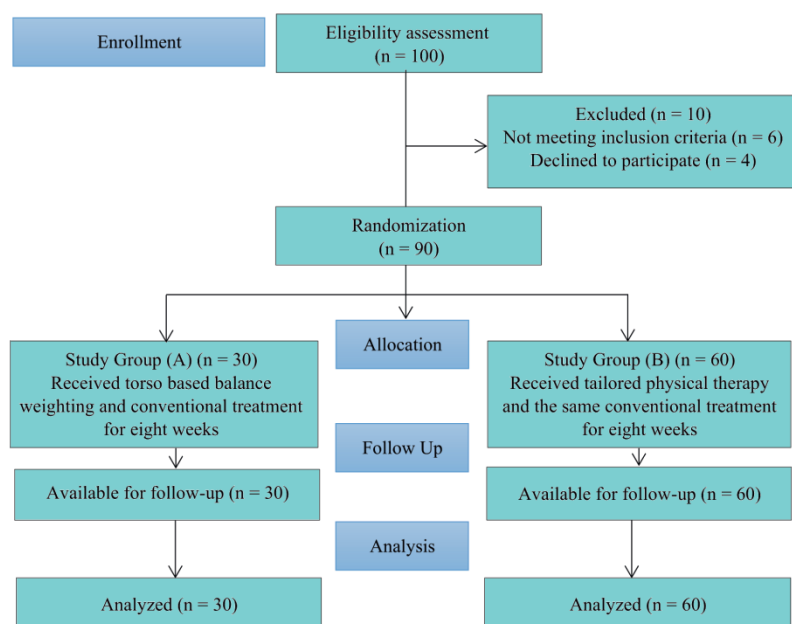


Figure 1. Flow chart of the study

It is graded from 0 to 4 on a five-point scale. The numbers "0" and "4" represent the lowest and highest levels of function, respectively. Scores 41–56 indicate low fall risk; 21–40 indicate medium fall risk, while 0–20 indicates high fall risk [19].

### Overall stability index

Biodex balance system (BBS): that evaluates a patient's closed-chain neuromuscular performance. The patient's capacity to preserve dynamic unilateral or bilateral postural stability whether in a static or dynamic state is measured using a multi-plane test. It makes use of a circular platform which may move freely in both the medial-lateral as well as anterior-posterior axes at the same time. Additionally, it can be applied to balance training. The BBS provides for a foot platform inclination of up to 20°, allowing for the maximum stimulation of the ankle joint mechanoreceptors. The BBS determines the medial-lateral stability index (MLSI), anterior-posterior stability index (APSI), plus the overall stability index from the tilt about every axis measured in degrees under dynamic conditions (OSI). Once the platform is stable, these indexes depict variations near a zero-point that was defined before testing [20].

Poor balance is indicated by a high OSI score. The OSI score is thought to be the most accurate predictor of the patient's total capacity to balance the platform. By altering the amount of resistance provided by the springs underneath the platform, the stability of the platform may be changed. Platform stability is scaled from 1 to 8, with 1 denoting the most unsteady condition. The platform becomes less stable as the resistance level decreases. The device has a screen that can be adjusted in height to fit the needs of each patient. The patient's posture and behavior as they attempt to stand and maintain balance are represented on the screen by a cursor.

### Interventions

Patients randomized assigned into two groups, group (A) got torso-based balance weighting and selected physiotherapy program for balance and postural control. Group (B) got tailored physiotherapy program and the same selected physiotherapy program for balance and postural control. Assessment done by (Clinical evaluation she-

ne for both groups before and after treatment. Treatment time were for eight weeks, three times per week, one hour per session and in between this hour, there were time for rest for the two groups, as the following (25 min for exercises- 10 min rest- 25 min for exercise).

### Group (A)

Got a torso-based balancing weighted using weight placement to alter the center of gravity and, consequently, the moment of inertia for a body part, affecting the biomechanics of a movement, the weight was 1.5% of body weight and started gradually to increase it and was placed according to direction of center of mass, weights were placed in the anterior, posterior or medio-lateral portion of a vest at the level of the umbilicus according to direction of the impairment which determined by biodex balance system. There were various steps used to determine where the weight should be placed for the balance-based torso-weighting situation.

- The patient was asked to stand with his or her feet together, with his or her eyes open and then closed, without wearing the vest.
- The second phase was providing the patient nudges to the upper chest in four different directions to see how they affected him or her. An anterior displacement was delivered to the back at roughly mid thoracic level, a posterior displacement was softly applied at the sternum during a posterior displacement, a force from every side was applied at the shoulder during a lateral displacement.
- Similar displacements were carried out at the hips if the chest area was stable.
- The following phase involved watching the trunk rotation that was prompted by applying manual shoulder resisting force in a diagonal motion (right anterior, left posterior as well as left anterior, right posterior).
- The first weight placement was chosen by the direction of the wobble and instability seen throughout these steps (described below).
- The vest was put on the patient's torso after the direction of the balance dysfunction was determined. To counterbalance the detected direction(s) of instability, tiny weights in 0.11 kg (0.25 lb) to 0.23 kg (0.5 lb) intervals, reaching a maximum of 1.13 kg (2.5 lb) for every patient, were put strategically on the chest in the vest.
- Weights may be inserted into the vest's compartments from the



shoulders to the waist, and from medial to lateral. Weight was added in the opposite direction from the loss of equilibrium.

- The therapist clarified the last weighting by asking patients to walk, turn, and also get up and down from a chair whereas the therapist watched for qualitative alterations in their movements.
- When a patient displayed improvement in function, greater stability with displacements, and the capacity to resist rotation, the therapist recorded the weight amount and location to make sure that the balance-based torso-weighting for that patient remained constant for all tasks.

### Group (B)

Got a tailored physiotherapy program as a peripheral compensatory mechanism for a central balance problem that was made to accommodate patients having a persistent visual deficiency who needed treatment for balance issues. Exercises were done with open eyes also with visual feedback. Exercises for body stability in a variety of positions, including bridging, sitting, quadruped, half-kneeling, kneeling, standing, as well as monopodalic, are accomplished with visual biofeedback as component of the intervention. Transfers training are also included, as ambulation training using courses drawn on the ground in a linear fashion and with greater complex tracks with visual control.

- Balance and gait-training exercises were given to patients having prevalent proprioception impairment as part of (PROP) rehabilitation treatment for balance problems in open-eyes as well as closed-eyes circumstances. Exercises for dynamic balance throughout transfers as well as ambulation utilizing unstable surfaces and stimuli accomplished without visual control and walking with closed eyes are also included. Other exercises involve stimulation of deep sensitivity utilizing air splints, kinesiotaping, vibration, as well as progressive limitation of support base and the utilization of unstable surfaces like wobble boards, balance pads, and otherwise stability balls in various positions (bridge, sitting, quadruped, half-kneeling, standing, or single leg standing).
- Patients with a predominate vestibular deficit underwent (VEST) rehabilitation therapy for balance problems with targeted interventions to improve vertigo, gaze stability, as well as postu-

ral stability. Exercises for slow and fast ocular motility in various head positions sitting & standing on both stable and unstable surfaces; gaze activities with head motion in sitting posture; standing and transferring in stable and unstable surfaces; plus, ambulation with head in various positions are among the balance training exercises that use variable or moving surfaces, head motion (whenever the body is static or moving), and reducing visual inputs.

### Statistical analysis

Statistical SPSS Package program version 25 for Windows was used to conduct the analysis (SPSS, Inc., Chicago, IL). Data were checked for homogeneity of variance and the normality assumption testing. Shapiro-Wilk test for data normality is used to determine whether the study's variables have a normal distribution. This test revealed that the Berg balance scale, overall stability index, as well as demographic data were normally distributed ( $p > 0.05$ ). All of these conclusions were subject to parametric analysis. Quantitative descriptive statistics, such as the Berg balance scale, Overall Stability Index, as well as the mean and standard deviation for demographic data. The investigated variables of interest were compared across testing groups (group A got torso-based balance weighting while group B got a tailored physiotherapy program) and measurement periods using a 22 mixed design MANOVA (Pre-treatment and post treatment). The significance level for each statistical analysis was less than or equal to 0.05 ( $p \leq 0.05$ ).

### Power analysis

Statistical power for the current study was calculated as a post-hoc using G\*Power (version 3.1) calculating the average effect size  $d$  ( $d = 1$ ) from mean and standard deviation of the change by each treatment on Berg and Biodex balance, with alpha 0.05 and sample size 90, the statistical power was  $> 90\%$  as showed in figure (2).

### Results

At baseline, both groups were similar regarding age, BMI and all outcome measures ( $p > 0.05$ ) (Tables 1–2).

There were no significant impacts of the tested group on the all tested dependent variables; Berg balance scale and Overall stability index ( $F = 0.78$ ,  $p = 0.464$ , Partial Eta Square = 0.033). However, there were significant effects of the measuring periods on the tested dependent variables ( $F = 99.528$ ,  $p = 0.0001^*$ , Partial Eta Square = 0.812). but, there was a substantial ( $F = 4.129$ ,  $p = 0.0001^*$ , partial eta square = 0.022) interaction among the 2 independent variables.

The Berg Balance Scale showed statistically substantial increase ( $p < 0.05$ ) within the two groups (A & B). The post-treatment comparison of both groups showed a statistically substantial rise ( $p < 0.05$ ) in favor of experimental group (B). Also, there was a greater improvement percentage regarding Berg Balance Scale in experimental group (B) (58.8%) than in control group (A) (36.94%) (Table 2).

The Overall stability index showed statistically substantial reductions ( $p < 0.05$ ) within the two groups (A & B). The post-treatment comparison of both groups showed a statistically no substantial difference ( $p > 0.05$ ). However, there was a greater improvement percentage regarding Overall stability index in experimental group (B) (6.31%) than in control group (A) (4.213%) (Table 2).

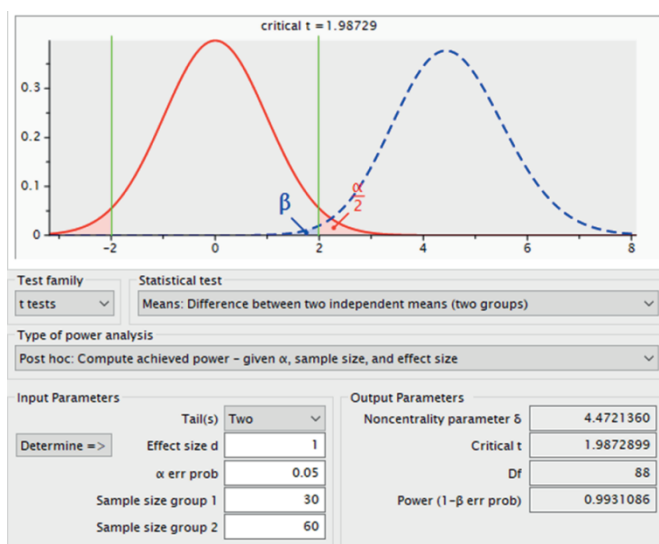


Figure 2. Power analysis



**Table 1. Demographic data of participants in both groups**

	Group A, n = 30 Mean ± SD	Group B, n = 60 Mean ± SD	p-value
Age [years]	31 ± 5.83	29.83 ± 5.96	0.381 <sup>NS</sup>
BMI [kg/m <sup>2</sup> ]	22.85 ± 5.65	23.41 ± 3.71	0.570 <sup>NS</sup>

*NS*  $p > 0.05$  = non-significant;  $p$  = probability

**Table 2. Berg balance scale and Overall stability index for both groups**

		Group (A), n = 30 Mean ± SD	Group (B), n = 60 Mean ± SD	p value*
Berg Balance Scale	Pre-treatment	32.10 ± 4.36	30.1 ± 3.64	0.09 <sup>NS</sup>
	Post-treatment	43.96 ± 4.68	47.8 ± 4.82	0.008 <sup>S</sup>
	Improvement%	36.94%	58.8%	
	p value**	0.0001 <sup>S</sup>	0.0001 <sup>S</sup>	
Overall stability index	Pre-treatment	0.95 ± 0.01	0.96 ± 0.02	0.854 <sup>NS</sup>
	Post-treatment	0.91 ± 0.04	0.89 ± 0.03	0.238 <sup>NS</sup>
	Improvement%	4.213%	6.31%	
	p value**	0.0001 <sup>S</sup>	0.0001 <sup>S</sup>	

\* Inter-group comparison; \*\* intra-group comparison of the results pre- and post-treatment;

*NS*  $p > 0.05$  = non-significant; *S*  $p < 0.05$  = significant;  $p$  = probability

## Discussion

In the present study, we aimed to compare between the impact of torso balance based weighting and tailored physical therapy program on balance and postural control in ataxic MS patients. Results revealed significant improvement in Berg and Biodex balance post-treatment in both groups and significant improvement in favor of group B (tailored group) only in Berg balance.

Impairment in postural control strategies as well as resultant loss of balance are extremely common due to impairment of frequently affected neural pathways linked to sensory experience, vision, vestibular information, sensory integration, motor control, as well as muscular activation, which raises the risk of falling and restricts daily activities and social interaction [21–24].

In the present study the recruited patients were diagnosed with Relapsing-Remitting Multiple Sclerosis (RRMS) and fulfilled the Revised McDonald's criteria for diagnosis of multiple sclerosis 2017 [33]. Because RRMS is the most common subtype approximately 87% of all MS patients [34].

In the current study the patient's age ranged from 20 to 40 years because MS usually detected in this age, but less than 1% can occur in childhood and approximately 2–10% after 50 years of age [34]. Greater number of female patients compared to male patients who participated in this study as MS affects women more than men (sex ratio 2.5:1) [34].

In this study the berg balance scale and biodex balance system were used to assess and describe severity and progression of patients with MS. It is the most suitable to detect the effectiveness of clinical interventions and to monitor balance disorders progression. It is considered the most widely used tool to measure disease outcomes in clinical trials [35] before starting the current study, the results of the BBS and biodex revealed non-significant difference between both groups.

Berg balance scale ranged from 21 to 40, mild impairment of muscle power (grade 3+ to 4+ according to Manual Muscle Testing), normal muscle tone to mild spasticity (grade 0, 1, 1+ according to Modi-

fied Ashworth Scale) and all the patients were able to understand and follow instructions were an important parts of the patients' selection criteria to ensure that all patients had the physical and cognitive prerequisites to perform isokinetic dynamometer testing procedures.

All the study procedures were performed in air-conditioned rooms to avoid the negative effects of overheating on MS patients. [36] Reported that an estimated 60–80% of MS patients experience temporary worsening of clinical signs and neurologic symptoms with heat exposure. This heat intolerance in MS is related to the detrimental effects of increased temperature on action potential propagation in demyelinated axons, resulting in conduction slowing and/or block.

In the present study assessment and treatment procedures were performed at morning in different days with multiple rests during treatment sessions to avoid fatigue. Fatigue is one of the most prevalent and debilitating symptoms in PwMS. Its prevalence can increase up to 85% in the first year of the disease and reach up to 95% as the disease progresses. Both immune-related processes (acute inflammation, chronic inflammation, immune-mediated neurodegeneration, immune-mediated alterations of endocrine functions related to fatigue) and non-immune-mediated disturbances and factors (sleep disturbances, depression, cognitive alterations, chronic infections, adverse effects of medications) contribute to its multifactorial nature [37].

The finding of the present study agrees with several studies confirmed the positive effects of balance-based torso-weighting (BBTW) for example it was found to improve postural control, cadence, gait velocity and stand time in patients with MS [13, 24–26]. Furthermore, Gait and performance were improved in participants who were instructed to wear Balance Wear while doing functional tasks [27] and mobility [28]. Spinal reflexes, supraspinal orders, and also the integration of afferent and/or efferent inputs travelling through the visual, vestibular, as well as somatosensory systems, sequentially by the CNS all work together to control the difficult process of balance control [29]. Impairment any of these systems leads to impaired balance, so tailoring the rehabilitation to each group of patients with specific system impairment

can improve balance more than traditional approach of giving all patients with different impairments the same rehabilitation. The present study's results are consistent with the belief that MS produces a variety of deficiencies in the visual (VIS), proprioceptive (PROP), as well as vestibular (VEST) systems, and also that task-specific training of VIS, PROP, and VEST deficits may play a significant role in enhancing the effectiveness of balance treatment strategies and focusing patients' attention, which may assist in avoiding injuries and falls [30]. Additionally, the current study found an improvement in tailored program that is higher than that was found in previous literature that used the traditional approach [31].

Finally, despite of group assignment, there were some challenges with putting on and taking off the Balance-Based Torso-Weighting in this sample of older patients. Due to restricted shoulder movement, some of the patients needed help putting on the vest. Despite patients had their balance-based torso weights evaluated before to the study, their larger abdomens also made it difficult for the vest to fit properly in their chests, and they periodically complained that the vest would travel up while they were seated. To enhance fit, particular adjustments were performed. Since the idea behind BBTW is to give sensory information to a particular area of the trunk, an improperly fitted orthotic may cause the weight of the vest to rest on a different area of the trunk muscles when the garment shifts, which could alter postural control.

Comparatively, the method used to assess postural control may have contributed to the lack of statistically significant differences in the postural control data we had collected. We examined postural sway area with the biodex laboratory system; sway variability could not be quantified. Studies may find it useful to examine postural sway using a force plate in addition to alterations in sway variability across older patients following BBTW because increased postural sway is connected to a higher risk of falling [32]. Furthermore, the present study found an improvement higher (BBS improved 22 points or very large effect) than that was reported in previous literature that used the tailored balance exercises (Berg balance scale improved 6 points) [14]. Differences in the effects between the present study and that of Brichetto may be

explained by the methodological differences between both studies. The latter used smaller sample and shorter duration of treatment.

Tailored physical therapy program induced improvement in postural control which matches with a study which showed that clinical recovery in PwMS was facilitated by adaptive functional reorganization which enhanced by task-specific rehabilitation training. With this knowledge, it can be argued that tailored balance rehabilitation training could provide the necessary task-specific trigger for reorganization of neural networks, promoting central sensory integration and, as consequence, improving balance and upright postural control (38).

The present study had some strengths; it is the only known one that tailored the rehabilitation of balance to each specific deficit in the sensory inputs, it used a highly objective tool to assess balance disorders, it included somewhat large number of patients with different sensory deficits, and it included age range in which MS commonly occurs.

## Conclusion

The tailored physical therapy program was more effective in improving balance disorders in patients with multiple sclerosis than torso based balance weighting, but both were effective. Treatment of balance deficits in MS patients should be a comprehensive and multimodal process and physical therapy is an important integral part of it. Our results provide evidence that a multimodal approach training sensory impairments is more effective than static and dynamic training in improving balance and upright postural control in PwMS. The concept presented in this study, assessing sensory system impairment that impact balance control in PwMS and providing tailored interventions, could serve as the basis for further investigations on the designing of customized balance disorders rehabilitation treatment for those patients.

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