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ARAŞTIRMA / RESEARCH

Effects of combined Pilates and aquaplyometric exercises on postural control and physical functions in patients with multiple sclerosis

Multipl sklerozlu hastalarda kombine Pilates ve akuapliyometrik egzersizlerin postural kontrol ve fiziksel fonksiyonlara etkisi

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Abstract

Purpose: Postural control deficits in people with multiple sclerosis (MS) are common and aggravate in dual tasking. Spinal stabilization approaches like Pilates and aquaplyometric exercises may have a positive effect on postural control. We aimed to determine the effects of combined Pilates and aquaplyometric exercises on postural control with and without dual task and physical functions in people with MS with this study.

Materials and Methods: Twelve people with MS were recruited to 8-week combined exercise programme applied twice in a week and evaluated before and after the exercise training. Timed up and go test was performed for functional mobility and Biodex Balance System was used to evaluate the limits of stability (LoS) with and without a cognitive task. Upper limb functions were evaluated with nine-hole peg test (NHPT) and grip **strength** where 5-Repetition Sit-To-Stand (STS) and timed 25-Foot walk test were used for lower limb functions.

Results: Eight-week combined exercise programme improved postural control, upper limb functions and lower limb functions. Additionally, there was no significant difference between LoS tests scores with and without dual task.

Conclusion: Eight-week combined aquatic plyometrics and Pilates exercises were effective in improvement of postural control, upper and lower limb functions in people with MS.

Keywords:. Postural control, exercise, multiple sclerosis

Öz

Amaç: Multipl sklerozlu hastalarda (MSH) postüral kontrol defisitleri yaygındır ve ikili görevle artmaktadır. Pilates ve akuapliyometrik egzersizler gibi spinal stabilizasyon yaklaşımlarının postüral kontrole olumlu etkileri olabilir. Biz bu çalışmada MSH'de kombine Pilates ve akuapliyometrik egzersizlerin ikili görev verilerek ve verilmeden postüral kontrole ve fiziksel fonksiyonlara etkisini belirlemeyi amaçladık.

Gereç ve Yöntem: On iki MSH haftada 2 gün uygulanan 8 haftalık kombine egzersiz programına alındı ve egzersiz eğitimi öncesi ve sonrasında değerlendirildi. Zamanlı kalk yürü testi fonksiyonel mobilite için uygulandı ve kognitif görevle ve görev verilmeden kararlılık sınırlarını (LoS) değerlendirmek için Biodex denge sistemi kullanıldı. Üst ekstremite fonksiyonlarını değerlendirmek için dokuz delikli test (NHPT) ve handgrip kullanılırken, alt ekstremite fonksiyonları için 5 tekrarlı otur kalk testi (STS) ve zamanlı 25 adım testi kullanıldı.

Bulgular: Sekiz haftalık kombine egzersiz programı postüral kontrolü, üst ve alt ekstremite fonksiyonlarını geliştirdi. Ayrıca, ikili görev verilerek ve verilmeden bakılan LoS skorları arasında anlamlı fark yoktu.

Sonuç: Sekiz haftalık kombine akuatik pliyometrikler ve Pilates egzersizleri MSH'de postüral konrolü, üst ve alt ekstremite fonksiyonlarını geliştirmede etkilidir.

Anahtar kelimeler: postüral kontrol, egzersiz, multipl skleroz

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INTRODUCTION

Multiple sclerosis is a progressive neurological disease and decreased postural control is one of the initial symptom in disease progression[1]. Postural control deficits in people with MS (MS) are mainly caused by decreased interaction between neuromuscular, musculoskeletal and cognitive components[2]. Performing activities of daily living at the same time requires dual or multi-tasking which involves a high level of cooperation of these components[3]. Dual tasking is frequently altered in MS and in addition to this the simultaneous performance of a cognitive task during standing increases postural sway[4,5]. Improving postural control in people with neurological impairment is one of the goal of physiotherapy[1]. Generally, there are many ways of improving postural control in people with MS. Land-based or water-based exercises, robot-assisted training, strengthening and aerobic training or neuromuscular facilitation may be helpful to cope postural impairement and studies have reported the benefits of these approaches[6-8].

A popular alternative rehabilitation method is Pilates for improving postural control in people with MS[9-11]. Pilates involves precise, controlled exercises that target to stabilize and strengthen both core and peripheral muscles of the body. During daily activities such as walking and standing; proximal part of the body needs to be stabilized to generate contraction at the distal part, in other words the stabilization of the proximal joints is necessary for maintaining distal movements in a coordinated way. While there are limited studies examined this exercise approach for improving postural control in people with MS [9-12], there is only one study that showed Pilates improved balance and cognitive functions compared with traditional exercise in people with MS[13]. On the other hand, aquatherapy has been using for people with MS safely and few papers showed that it had a positive effect on balance and muscle strength. Balance problem is one of the most studied subject in aquatherapy as buoyancy and viscosity of the water help and support the body as increase the reaction time for regaining balance. Besides, plyometric exercises (PE) are often used to augment performance in sports as they are resistive strengthening exercises which involve an eccentric contraction followed by a rapid concentric contraction of the same muscle[14,15]. Although PE has potentials for developing motor control yet the literature on neurological problems is scarce. One possible reason for not performing PE in neurologic problems could be the high injury risk, especially at the landing time of the exercise[16]. Hydrodynamic properties of water provide a safer environment by lowering the impact forces as well as improving the dynamic stability. Despite studies showed that aquatic plyometric exercises (APE) have the similar effect of land-based plyometric exercises[17-19] to our knowledge there is no study determined the effects of combine APE and Pilates exercises on postural control in people with neurological problems.

Pilates and aquatic exercises provide benefit to postural control treatment in people with MS yet limited numbers of researchers studied this topic. We hypothesized that combined Pilates and aquaplyometric exercise training would improve the postural control and functionality. Our primary aim was to determine the effects of combined Pilates and aquaplyometric exercises on postural control with and without dual task and physical functions in people with MS.

MATERIALS AND METHODS

We conducted this prospective study between the dates May 2018 and July 2018. The participants completed an informed consent approved by the local ethical committee before enrollment; then, the patients were given combined Pilates exercises with aquatic plyometric exercises (APE). All subjects gave their written informed consent before involving the study in accordance with the Declaration of Helsinki. The study protocol was approved by the local ethical committee (Approval No. 2018/06-32). This study is registered with Clinical Trials.gov, number NCT03718819.

The power analysis calculated with GPower Software (version 3.0.10) revealed that the study must recruit 10 participants to have 80% power with 5% probability level to detect a minimum clinically significant difference in balance 20 and 80% statistical power level.

Participants

Twenty-one participants were screenedfor eligibility and 15 of them met the criteria. Three subjects withdraw from the program within the first four weeks of the study period due to difficulties in arriving to the center. Twelve relapsing-remitting MS patients (7 women, 5 men) were enrolled to the study. Inclusion criteria were being over 18 years old, having

Expanded Disability Status Scale (EDSS) score between 1 and 6, having no clinical relapse within the last three-months. Exclusion criteria were being unstable phase in MS, diagnosed dementia, any systemic disease including cardiovascular, respiratory, vestibular and endocrine systems, orthopedic disabilities, and usage of any medication or substance, which may affect cognition or balance and not being suitable for aquatic therapy for reasons like incontinence and dermatological problems etc.

Exercise Protocol

The combined program consisted of Pilates and aquatic plyometric exercises were applied twice a week, in separate days for eight weeks. All participants participated in at least 15 (out of the planned 16) exercise sessions. The supervised programs started with 10 min. warming up, followed with 45 min main program and 10 min cool down. The detailed programme is given below.

Pilates Exercises

Patients in the study group underwent 8-week modified clinical Pilates training designed to improve their ability to integrate multisensory inputs and challenge postural control. Pilates was applied by a certified physiotherapist (MST). Activation of transversus abdominis in neutral spinal alignment and basic principles of Pilates was informed in the first session. Exercises were performed in front of the mirror and different positions (supine, prone, side lying, sitting and upright position). The difficulty of exercises was gradually increased and focused on keeping neutral positions of the spine in different gravity orientations. Pilates instructor provided verbal and tactile cueing during the exercise routine and participants were given feedback to help them correct wrong movements while emphasizing core stability. Modified clinical Pilates exercises applied 45 minutes a day, once a week and every exercise were done with 10 repetitions.

Aquatic Plyometric Exercises

Aquatic plyometric exercises were performed in a private pool once a week for 8 weeks. Pool depth was 120 cm and water and room temperature were held between at 30-31°C and 26-28°C respectively. Patients were taken in a group of threes to a 45 minutes session of aquatic exercises by a certificated physiotherapist (BG). Patients were asked to walk in various direction and speed, as well as they change direction rapidly and keep their balance for 3-5 seconds for warming up exercises. Arm movements combined with breathing also included warm-up exercises. The APE programme was progressed by increasing the speed and the range of motion of the movements. Patients were carefully informed not to deform the exercise just to emulate the speed. The three phases of each exercise; the eccentric (or loading) phase, the amortization phase, and the concentric (or unloading) phase explained thoroughly at the beginning of every exercise. At the end of each session, patients were cooled down by walking in their preference speed and laid on the supine position on two noodles for three minutes.

Measurements

Same physiotherapist performed all the measurements in the same examination room before the exercise program and at the eighth week when exercise program was finished. All evaluations were conducted in the afternoon, 1 and a half hour after lunch. Participants had a rest for at least 10 min before starting the tests. The assessments for each patient lasted approximately 40 minutes. The temperature of the examination room was kept constant between 22°C and 24°C.

Biodex Balance System

Postural control was evaluated with Biodex Balance System (BBS; SD 12.1"Display 115 VAC). Limits of stability (LoS, test time and overall score) were evaluated in firm surface when eyes open. Participants stood barefoot and were not permitted to touch the handrails during the tests. The foot positions were recorded using the platform rail. The platform locked and the patients were asked to control themselves keeping the indicator in the center of the target on the screen. Limits of stability test challenges patients to move and control their center of gravity within their base of support. During each trial, patients were asked to shift their weight to move the cursor from the center target to a blinking target and back as quickly and with as little deviation as possible. Targets on the screen blinked in random order. The same process was repeated for each of the nine targets. The tests repeated three times with 10 second resting time between trials. Postural tasks were explained to each participant before starting the measurements. Participants were fully briefed on testing procedure. Limits of stability assessment were repeated with a dual task (motor plus cognitive task: Patients were instructed to maintain balance while three-by-three counting down a randomly selected

two-digit number during performing the tests) in same assessment session. Patients' performance was evaluated from a total score of 100 where the higher score represents better trunk control [21].

Nine Hole Peg Test (NHPT)

Nine Hole Peg Test (NHPT) was used to measure upper extremity functionality and is considered a golden standard for measuring manual dexterity. The patient was seated at a table with a plastic NHPT placed at the patient's middle and asked to place pegs in a random order as quick as possible by using dominant hand first. Total time was recorded in seconds. Three consecutive trials with the dominant hand were immediately followed by three consecutive trials with the non-dominant hand. The lower score represents better hand dexterity in this test [22].

Grip strength test

Grip strength was evaluated with JAMAR handgrip. The patient was seated at a table and the subject held the dynamometer in the dominant hand with the arm at right angles (90° flexion) and the elbow by the side of the body. The handle of the dynamometer was adjusted as the base should rest on the first metacarpal, while the handle should rest on the middle of four fingers. When ready, the patient asked to squeeze the dynamometer with maximum isometric effort, which was maintained for about 5 seconds. Three consecutive trials were done and the higher score was recorded. A higher score represents better grip strength [23].

The timed up and go (TUG) test

The timed up and go (TUG) test was used to assess mobility, static and dynamic balance. The starting point was determined after the patient had been seated in a standard height chair with their back against the chair and their arms resting on the armrests. The patients asked to stand up, walk three meters, turn around, walk back to the chair and sit down again. During the test, the patient was expected to wear their regular footwear and use any mobility aids that they would normally require. Timing began when the patient started to rise and ended when returned to the chair and sit down. Lower time score represents better mobility and balance [24].

The 5- Repetition Sit-To-Stand (STS) test

The 5- Repetition Sit-To-Stand (STS) test measures time taken to complete five repetitions of the STS movement which represents lower extremity function. The patients were told to start the test in a seated position with full weight on the chair and arms folded across the chest. The feet were placed parallel to each other. The patients asked to move to a standing position with full knee extension and then back to a seated position as quickly as possible. After completion of five repetitions the test ended when the patient touched the seat. Lower time score represents better lower extremity muscle strength [25].

25-Foot walk test

To evaluate the mobility and leg function performance, timed 25-Foot walk test were applied. The patients were directed to one end of a clearly marked 25-foot course and instructed to walk 25 feet as quickly as possible but safely. The time was calculated from the initiation of the instruction to start and ended when the patient had reached the 25-foot mark. Lower time score represents better walking or mobility performance [26].

Statistical analysis

The statistical package SPSS 20.0.0 for Windows (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Level of significance was set at $p<0.05$. Data were presented in medians in combination with quartiles and percentiles. The treatment effect was tested with the Wilcoxon signed-rank test.

RESULTS

Median age, body mass index (BMI) and EDSS score of the patients were 57.00 years, 25.05 kg/m^2 and 4.05, respectively (Table 1). Significant improvements occurred in LoS test time ($p=0.002$) and LoS overall score ($p=0.002$) compared to baseline when postural control evaluated without a dual-task. There was also a significant difference in LoS test time and overall score when postural control evaluated with dual-task after 8-week combined exercise therapy ($p<0.05$). NHPT, TUG, STS, grip strength and 25 foot walk test time were significantly decreased after exercise program and hand grip score was significantly increased in both hands ($p<0.05$, Table 2). After 8 weeks of combined exercise training, there was no significant difference neither LoS test time nor LoS overall scores that evaluated with or without dual task (Table 3).

Table 1. Demographics of MS patients.

		Median (IQR)
Age (year)		57.00 (52.25-64.00)
EDSS (0-10)		3.5 (3.0-5.5)
BMI (kg/m²)		25.09 (22.34-29.43)
Disease Duration (year)		18.5 (9.25-24.25)
		n (%)
Gender	Female Male	7 (58.3) 5 (41.7)
Working Status	Working Not working	4 (33.3) 8 (66.7)
Falls in last 3 months	None More than 2	4 (33.3) 8 (66.7)
Assistive device (cane or walker)	Using Not using	7 (58.3) 5 (41.7)

Descriptive statistics, IQR: the Interquartile Range, EDSS: Expanded Disability Status Scale, n: number

Table 2. Changes in postural control and physical functions after training.

	Before exercises	**After exercises**	**p**
LoS Time	54.00 (36.50-57.75)	41.00 (34.25- 53.00)	0.002*
LoS Overall score	44.50 (35.00- 44.50)	54.50 (50.50-63.50)	0.002*
LoS Time with dual task	52.00 (39.75- 101.00)	42.00 (34.50-50.25)	0.002*
LoS Overall score with dual task	37.00 (20.00-47.75)	53.00 (48.00-61-50)	0.002*
NHPT	21.36 (20.38-23.68)	21.16 (17.78-23.09)	0.008*
Grip Strength	27.00 (17.75-34.13)	29.50 (24.63-35-38)	0.011*
TUG	10.23 (7.67-16.05)	9.71 (6.68-10.84)	0.019*
25 Foot Walk Test	25.83 (24.19-32-29)	23.70 (21.71-27.76)	0.012*
5 RSTS	10.82 (8.50-14.44)	9.76 (7.52-10.84)	0.015*

Wilcoxon Test, *p<0.05; LoS: Limits of Stability; NHPT: Nine Hole Peg Test; TUG: Timed Up and Go Test; 5RSTS: 5 Repeated Sit to Stand Test.

Table 3. Comparison of LoS results with single and dual-task after training.

	Before Exercises			**After Exercises**		
	Single task	Dual task	p	Single task	Dual task	p
LoS Time	54.00 (36.50-57.75)	52.00 (39.75-101.00)	0.025*	41.00 (34.25-53.00)	42.00 (34.50-50.25)	0.146
LoS Overall	44.50 (35.00-44.50)	37.00 (20.00-47.75)	0.009*	54.50 (50.50-63.50)	53.00 (48.00-61.50)	0.223

Wilcoxon Test, *p<0.05; LoS: Limits of Stability

DISCUSSION

The aim of our study was to determine the effects of combined Pilates and aquaplyometric exercises on postural control with and without dual task and physical functions in people with MS. Our findings showed combined exercise program was effective to improve postural control performed with and without dual task, upper extremity function (hand dexterity and grip strength), walking capacity and

lower extremity muscle strength.

There are only a small number of studies that have investigated postural control in people with MS. Mohan et al.[27] evaluated postural control with dynamic posturography in people with MS and compared them age and gender matched healthy controls. Their findings showed individuals with MS had direction-specific right side and backward limits of stability impairment. Parallel to their study, a recent systematic review showed people with MS display considerable deficits in postural control compared to healthy controls regardless of task condition or complexity[28].

In the literature, the effects of exercise on postural control were studied with numerous articles. Many different types of exercise program either specially designed programes like CoDuSe and hippotherapy [29-31] or methods already exits such as Tai Chi Chuan and virtual reality-based games conducted with people with MS in order to improve balance and postural control[30-32]. In a systematic review by Gunn et al., a range of exercise interventions were shown to improve balance outcomes for people with MS. Programs incorporating gait, balance, and functional training showed the greatest effect in comparison to other intervention types[33]. Clinical Pilates is an exercise program basically affecting the trunk muscles and primarily affects core stabilization, running posture, and muscles. In a study of Bulguroğlu et al., they compared the effects of Mat and Reformer Pilates methods in people with MS found improvements in balance, functional mobility, core stability, fatigue severity and quality of life after Pilates in Mat and Reformer Pilates training. As a result, they declared patients with MS had similar benefits in Reformer Pilates and Mat Pilates methods[34]. In our previous study we examined the effect of modified clinical Pilates exercises on sensory interaction and balance, postural control and fatigue in people with MS, findings showed that significant improvements occurred in sensory interaction of balance (eyes open, foam surface) and total, physical and cognitive scores of fatigue after 10-week modified clinical Pilates training[20]. We decided to analyze the effect of combined exercises involved core stabilization namely Pilates and agility such as plyometrics. The results of our study showed that combined exercises improved postural control by increasing not only the accuracy of directionally targeting but also shorting the test time in limits of stability test. Additionally, the improvement in the computerized test system also transferred to the functional outcomes as TUG test scores of the participants improved statistically.

Studies showed that white and grey matter volumes, specially in cerebellum decreases in people with MS and cerebellar volume, is associated with cognitive performance [35]. Balance disturbance and falls are highly related to cognitive impairment in people with MS[36]. The relation between falls and cognitive performance might be related to decrease in executive functions and lower processing speed due to cerebellar atrophy. On the other hand, cognitive impairment may result in falls just because it might be too complicated and difficult to control all risk factors while multi-tasking[35]. In our study, patients experienced balance disturbance while performing the cognitive task during LoS test as their test completion time and accuracy rate was lower than single task test scores before the combined training. However, after eight weeks of combined exercises adding the second task to LoS test did not change the scores this might be the result of increased balance and multitasking capacity.

Upper limb functions and handgrip strengths are indicators of falls, independence of ADL, disability, morbidity, and mortality[23,37]. Even though the exercise programme in our study did not target specifically, upper limb functions and grip strength were improved after eight weeks of combined training. The reason of the improvement may be related to exercises during training, such as rapid arm movement in water to challenge core stabilization, movements of hands to help to regain balance in the water, rapid arm movements during Pilates "hundreds" exercises and standing on arms during 4-point kneeling. Another explanation for the upper limb the improvement could be improvement of postural control. Better postural control may allow better stabilization of the shoulder which results in generating superior strength and function[38].

Walking ability and lower limb functions are essential in people with MS as they are closely related to disability severity (EDSS) and quality of life. Gait deficits are most common and one of the earliest signs of MS. Combet et al reported that even lower EDSS scores are highly related to decreased stride length and velocity where the double support duration increased. These impairments are likely predisposed postural control mechanism deficits which lead to compensation during gait and ADL[28] therefore specifically targeting gait activities may

increase those compensations which may lead unintentional postural instability[39]. The results of our study are consistant to the related literature, interventions involving postural stability improved gait features of the patients. Following eight-week combined exercise program, patients walked faster and had a better lower extremity or muscle strength.

This paper presents the results of a combined land-based and aquatic exercise programme; there are limited numbers of studies designed similar to our study. Numbers of studies proved that exercise is essential for people with MS regardless of the environment. Marandi et al. compared the effects of Pilates and water exercises in different groups and their findings showed that both interventions had similar effects[11]. On the other hand, Bansi et al. suggested that aquatic interventions might have additional benefits then land-based treatments[40]. Properties of water, decrease the fall and injury risk during the plyometric exercises.

There are few strengths of this study; to our knowledge, it is the first study analyzed the effect of combined exercises on postural control as well as the aquaplyometrics in people with MS. Also, postural control was tested with and without dual task. The number of studies which examined dual task is limited in literature. The absence of a control group limited to compare and contrast our findings, besides we did not include the cognitive assessment as an outcome yet our findings showed improvement in postural control with dual task which may result of a decreased cognitive workload.

This paper shows that plyometric exercises could be performed in water without any unintended adverse effects. Additionally, combined water and land exercises are effective in the improvement of postural control correspondingly upper and lower limb function in people with MS.

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