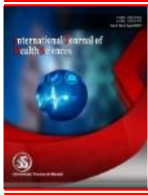

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Effect of Underwater Treadmill Program on Gait Speed, Balance and Lower Extremity Function in Stroke Patients

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Keywords

balance;
gait;
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underwater treadmill;

Abstract

Objective: The purpose of this study was to determine whether using an underwater treadmill program could enhance gait speed, balance and lower extremity function. Study design: Randomized control trial. Methods: Forty post-stroke male patients with abnormalities in gait and balance were divided randomly into two equal groups: Study group (A): was given a program for an underwater treadmill. A treadmill program on the ground was given to the control group (B). The ten-meter walk test was used to assess the gait speed of patients in both groups. Assessment of functional capacity utilizing the lower extremity functional scale and the Posturomed device for balance. For all groups, assessments were performed before and after the four-week therapy period. Results: Post-treatment results revealed a significant increase in gait speed in both groups but no significant difference between them. More significant increase in balance and lower extremity function in the study group (A) than in the control group (B) Conclusion: Underwater treadmill training program is an effective program in improving, balance, gait speed and lower extremity function in stroke patients.

Contents

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1 Introduction

Stroke is a leading cause of mortality and morbidity worldwide, and it is becoming more common in developing nations. The two types of stroke that can be roughly categorized as ischemic and hemorrhagic are intracerebral haemorrhage and subarachnoid haemorrhage. In the world, ischaemic stroke accounts for roughly 71% of all strokes (Campbell et al., 2019). The impact on the brain tissue and the source of the obstruction or injury will determine the cerebrovascular stroke signs and symptoms. Sudden intense headaches, hemiplegia, difficulty speaking and understanding, confusion, loss of balance, and loss of consciousness are among the signs and symptoms (Kraft, 2017).

Stroke survivors have an unbalanced and uncoordinated body because of the uneven weight distribution on both sides of the body. Fear of falling may result from decreased sensation, postural muscle tone, instinctive movement, balancing response, and spasticity (Anna et al., 2020).

Aquatic therapy is a promising and growingly well-liked form of stroke rehabilitation that provides a special and advantageous environment that may help with motor recovery (Mooventhan & Nivethitha, 2014). More info Long-term performance maintenance, balance improvement, and fall prevention in older persons have all been shown to be benefits of aquatic therapy. Due to the physical characteristics of water, it has some benefits over non-aquatic exercise (Graça et al., 2020).

2 Materials and Methods

Forty male stroke survivors were randomly assigned and divided into two groups of twenty patients: study group (A) performed an underwater treadmill training program. Control group (B) performed an over-ground treadmill training program. Patients from both groups had their walking speed evaluated using the ten-meter speed test, their balance evaluated using the Posturomed device, and their ability to move their lower extremities evaluated using the lower extremity functional scale. Both before and four weeks after therapy, the two groups were assessed.

Study design

This was a pre-test/post-test, randomized controlled study. It received approval from the Faculty of Physical Therapy's ethics committee at Cairo University in Egypt (P.T.REC/012/002182).

Sample size estimation

Before the study, the sample size was calculated using G-power statistical software (Version 3.1.9.2, Franz Faul, Universitate Keil, Germany), and it was discovered that 20 patients per group with an effect size of 1.62, a critical value of 2.08, and a power of 0.95 were needed for the current study.

Randomization

The SPSS application was utilized to implement the randomization through the creation of a computer-produced randomized table (version 26 for Windows). There was an identification number for each participant. Two groups of equal size were formed using these numbers. Index cards with sequential numbers were contained in covert envelopes. The sealed envelope was opened by a blinded researcher, who divided the patients into groups (figure 1).

Groups

Forty male patients with post-stroke gait and balance abnormalities participated in the current investigation. The following patients were required for inclusion: stroke patients had to be between the ages of 45 and 60, be able to walk at least ten meters unassisted, and have a body mass index (BMI) between 22 and 30 kg/m^2. Acute or recurrent stroke, lower limb shortening or contracture, moderate or severe spasticity (defined as a modified Ashworth scale equal or greater than grade three), any cognitive or psychiatric disorders, other neurological diseases that could affect the results of this study, and chronic neglected patients were all causes for exclusion from the study.

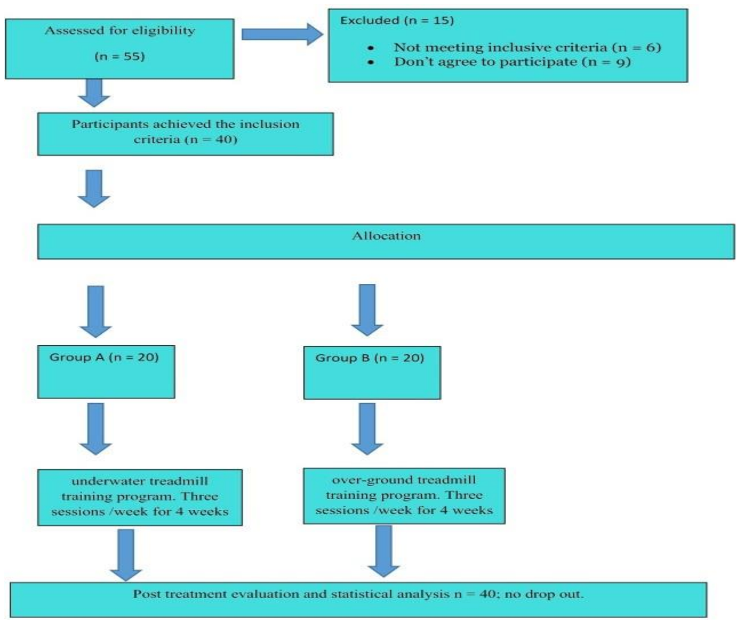

Figure 1. Flow chart showing the method of the study

Instrumentations

For evaluation
Two evaluation procedures were done before and after the treatment program:

1-Gait speed assessment by using a ten-meters walk test:
Patients perform the test with bare feet. Patients passed the initial entry test. In the comfortable speed test, the instruction was "walk as every day, don't run." At the fast speed test, the instruction was often: "Go fast, but don't run". The test should be repeated and recorded three times (de Baptista et al., 2020).

2-Balance assessment by using Posturomed
The balance reaction can be tested by Posturomed in which the platform sways within the transverse plane. To reduce the effect of learning, participants got two minutes standing on the platform and trying to maintain balance and participate in the test position many times. Patients stand for thirty seconds whereas the platform swaying is measured. The additive of the three trials was calculated within the computer of the device providing the mean score on the screen (Taube et al., 2020).

3-Arabic version of the lower extremity functional scale
For patients with musculoskeletal disorders, the LEFS is a 20-item printed questionnaire that the patient can use to assess and determine the functional level of the lower extremity. The questionnaire asks about the

ability to perform various necessary activities that require using the lower extremity on a five-point Likert scale; the total score is 80 points, which represents a healthy person (Korakakis et al., 2019).

For treatment

1-Underwater treadmill

The American-made Aqua Gaiter, by HUDSON aquatic systems, is an underwater treadmill system that combines traditional treadmill training with the natural properties of water (buoyancy, resistance and hydrostatic pressure). The model used in the current study, 5 HP heavy duty, features variable speed adjustments from half mph to five mph, a large 22" x 58" running surface, pneumatic speed control, safety side steps and handrails, and large digital wall display (showing speed, time and distance) and suction sup levelling pads.

2-Overground treadmill

Germany-made h/p/cosmos mercury® med treadmill system comes with a running surface of the length of 150 cm x width of 50 cm which meets the standards for many applications. The h/p/cosmos system for rehabilitation has a low entry height and long handrails that extend to the end of the walking surface. Patients with an impaired ability to walk can mount the treadmill more safely. An additional stop button is incorporated into the hand grip for patient safety.

Procedures

Evaluation procedure:

The assessment procedure was done for both groups before and after treatment. The assessment environment was constant for all the patients throughout the study.

1- Gait speed assessment by using a ten-meters walk test.

Patients walk with no help for ten meters, with the time measured for the intermediate six meters to permit acceleration and deceleration. Then begin time recording once the toes pass the two Meters mark. Finish time recording when the toes pass the eight Meters mark. Repeat the test three times then calculate the mean of three trials.

2-Posturomed for balance assessment

Before beginning the test, the patient is to be familiarized with the device. The characteristics and range of motion of the initial position should be explained. During the tests, the patient should first stand still on both feet, with legs spread, securing his stand by holding the rail (Masumoto et al., 2007; Raghu et al., 2021). If the patient feels steady, he can try to take up the initial position which is standing still on one leg in the middle of the platform, arms hanging loose, looking straight ahead, the main supporting leg in a neutral – stance, swing leg: The hip joint was in 90^0 flexion, zero-degree abduction or Adduction, zero degrees internal or external rotation. The knee joint was in 90^0 of flexion. The ankle joint was in maximum dorsiflexion and external rotation, with zero degrees of pronation/supination. Three measurements of ten seconds each best and worse attempt to be deleted.

-Always without holding.

- The assessment procedure started with the unaffected leg and then the affected leg.

3- Lower extremity functional assessment by using the Arabic version of the lower extremity functional scale:

The Lower Extremity Function Scale (LEFS) is a questionnaire used for self-assessment. Patients use about 20 different daily activities to answer the question "Do you have or have difficulties today". The maximum possible number of points is 80 points, which indicates that the performance is very high. The lowest possible score is zero, which indicates very low functionality.

Treatment plans

The patients of both groups received twelve sessions at a frequency of three sessions per week for four successive weeks. This program was done in approximately 45 minutes. Study group (A) The patients performed an underwater treadmill training program in a therapy pool with a water depth adjusted to the chest level (Xiphoid process) by using a movable floor pool, (Jung et al., 2019). The temperature of the water was adjusted to 34 °C– 36 °C with an air temperature of 24 °C, the program consisted of five minutes warm up-period followed by 30 minutes of strengthening, balance exercises and 15-minute aquatic treadmill training, started at the patient's comfortable speed on level ground, finally ten minutes cool-down period (Mukherjee & Patil, 2011; Gray et al., 2009).

Control group (B) The patients performed an over-ground training program consisting of five minutes warm up-period followed by 30 minutes of strengthening, and trunk mobility exercises (Sitting on a Swiss ball then standing up or moving the pelvis from side to side, standing on balance board and changing the upper limb position.) then 15-minutes over-ground treadmill training, started at patient's comfortable speed on level ground, finally ten minutes cooling-down period (Zhu et al., 2016).

Analysis of the data

Comparisons between patient characteristics in the two groups are made using the t-test and descriptive statistical analysis. To compare the effects of the treatment (before and after), a mixed multivariate analysis of variance was performed (between the two groups), and P 0.05 was used as the significant level for all tests (Asharani & Umarani, 2015). The statistical analysis was conducted using the Statistical Package for Social Studies (SPSS) version 22 for Windows.

3 Results and Discussions

I-General characteristics of the patients

The General characteristics of patients in both groups are presented in table (1). Patients of both groups were matched in regard to mean age, weight, height, BMI and duration of illness ($p > 0.05$).

Table 1
Comparison of General characteristics of patients in both groups

	Study group	Control group	MD	T- value	p-value	Sign
	$\bar{x}$ ± SD	$\bar{x}$ ± SD				
Age (year)	54.2 ± 6.29	52.45 ± 6.19	1.75	0.88	0.38	NS
Weight (kg)	81.35 ± 9.83	80.4 ± 8.27	0.95	0.33	0.74	NS
Height (cm)	168.6 ± 5.27	170.3 ± 5.12	-1.7	-1.03	0.3	NS
BMI (kg/m^2)	28.58 ± 2.84	27.75 ± 3	0.83	0.89	0.37	NS
Duration of illness (months)	8.33 ± 2.35	8.66 ± 1.95	-0.33	-0.48	0.63	NS

SD: standers deviation; P-value: probability value; MD: mean difference; NS: non-significant

II-Effect of treatments in both groups on gait speed, balance and lower extremity function was seen in the table (2).

1-Gait speed:

- *At comfortable speed*

The pre-therapy mean SD of the study group's ten-meter speed test at a comfortable speed was 0.77 ± 0.24 m/sec, and the post-therapy mean SD was 0.95 ± 0.22 m/sec. The ten-meter speed test at a comfortable speed significantly increased after therapy as compared to before; the control group's mean and standard deviation for this test at a comfortable speed before therapy was 0.78 ±0.21 m/sec, while it increased to 0.85 ± 0.25 m/sec after therapy. In comparison to pre-therapy, the findings revealed a considerable improvement in the ten-meter speed test at a comfortable speed. The findings of the ten-meter speed test at a comfortable speed between the groups pre- and post-therapy did not reveal any significant differences.

- *At fast speed*

The study group's mean and standard deviation for a quick ten-meter speed test was (1.05 ±0.22 m/sec) before therapy and (1.27 ± 0.14 m/sec) after therapy. When compared to pre-therapy, the findings revealed a considerable improvement in the ten-meter speed test at a fast speed. The control group's mean speed pre-therapy was 1.04 ± 0.2 m/sec, and the mean speed post-therapy was 1.02 ±0.15 m/sec. When compared to pre-therapy, the findings revealed a considerable improvement in the ten-meter speed test at a high speed. The results of the ten-meter speed test at a fast speed between the groups before and after therapy did not significantly differ.

2-Postrumed scores

Postrumed scores mean ± SD of the study group pre-therapy was (720 ± 24.53 mm), and post-therapy was (441.55 ± 27.6 mm). The results showed a significant decrease in postrumed scores post-therapy in comparison with pre-therapy. Postrumed scores mean ± SD of the control group pre-therapy was (726.6 ± 27.3 mm), and post-therapy was (636.45 ± 23.92 mm). The results showed a significant decrease in postrumed scores post-therapy in comparison with pre-therapy. The results didn't show a significant difference in the postrumed scores between both groups pre-therapy. while the results showed a significant decrease in postrumed scores for the study group in comparison with the control group post-therapy.

3- LEFS

Pre-therapy LEFS scores for the study group were (28.5 ± 8.25), while post-therapy was (49.5 ± 10.2). The results showed a significant increase in LEFS score post-therapy in comparison with pre-therapy. Pre-therapy LEFS scores for the control group were (27.55± 7.68), while post-therapy was (28.5± 7.7). The results didn't show a significant increase in LEFS scores between pre and post-therapy. The results didn't show a significant difference in the LEFS scores between both groups' pre-therapy. while the results showed a significant increase in LEFS scores for the study group in comparison with a control group.

Discussion

The main finding of the current study showed that compared to over-ground treadmill training, an underwater treadmill training program significantly increased balance and lower extremity function. Although there was no significant difference between the two groups, there was a considerable increase in ten-meter speed at both fast and comfortable speeds in both groups (Suryasa et al., 2021).

The findings are in line with those of Iliescu et al. (2020), who demonstrated the superiority of underwater exercises to conventional land exercises in the improvement of balance. Additionally, Moritz et al. (2020), demonstrated how aquatic therapy could enhance walking ability, balance, and mobility, encouraging greater engagement in everyday activities. The findings of the present investigation concur with those of Sagrario, (2020); Ramos et al., (2020); Veldema & Jansen, (2021) and Zhu et al., (2016). Additionally, the findings of the present study support Marinho-Buzelli et al. (2015) who showed that water exercises can improve dynamic balance and walking speed in people with neuromuscular dysfunction, particularly in those with multiple sclerosis, Parkinson's disease, and stroke. Mehrholz et al. (2011), also discovered a significant improvement in muscle strength and activities of daily life following water-based exercises for stroke patients.

The physical characteristics of water can be used to explain the causes of the improvement in equilibrium. Immersion and flotation in water boost the input of deep receptors, which enhances the body's ability to stabilize and modify itself and maintain balance (Eggermont et al., 2010; Moreland et al., 1998). Since water is more resistive than air due to its higher viscosity, sensory feedback rises in water, raising bodily awareness of its senses (Resende & Rassi 2008). Another factor that contributes to exercise's influence on the water is a synergistic effect between the stimulation of the vestibular system and the facilitation of vestibular inputs. Water exposure can increase inputs for skin stimulation and hence increase the activation of afferent nerves (Sadeghi & Alirezaee, 2008).

The results of the current study are consistent with the results of Temperoni et al. (2020), who confirm that aquatic training in stroke patients significantly improves motor functions. These improvements can be attributed to the water environment, which partially supports the body, thus facilitating whole-body movements. The findings of the present study supported those of Lee et al., (2017) and Nayak et al., (2020). Furthermore, Kim & Lee (2017), demonstrated that exercising on an underwater treadmill for 20 minutes, five times per week for four weeks, significantly improved step length, velocity, and cadence.

Table 2.
Comparison of median values of gait speed, balance and lower limb extremity function pre- and post-treatment between both groups.

	Study group	Control group	MD	P-value	Sig
	$\bar{x}$ ±SD	$\bar{x}$ ±SD			
1-Gait speed					
a- At comfortable speed (m/sec)					
Pre treatment	0.77 ± 0.24	0.78 ± 0.21	-0.01	0. 92	NS
Post treatment	0.95 ± 0.22	0.85 ± 0.25	0.1	0. 18	NS
MD	-0.18	-0.07			
% of changes	23.38	8.97			
P- value	0.0001*	0.0001*			
b- At fast speed (m/sec)					
Pre treatment	1.05 ± 0.22	1.04 ± 0.2	0.01	0. 9	NS
Post treatment	1.27 ± 0.14	1.2 ± 0.15	0.07	0. 12	NS
MD	-0.22	-0.16			
% of changes	20.95	15.38			
P- value	0.0001*	0.0001*			
2-Postrumed (mm)					
Pre treatment	720 ± 24.53	726.6 ± 27.3	-6.6	0. 42	NS
Post treatment	441.55 ± 27.6	636.45 ± 23.92	-194.9	0. 0001*	S
MD	278.45	90.15			
% of changes	38.67	12.41			
P- value	0.0001*	0.0001*			
3-LEFS					
Pre treatment	28.5 ± 8.25	27.55 ± 7.68	0.95	0. 7	NS
Post treatment	49.5 ± 10.2	28.55 ± 7.7	20.95	0. 0001*	S
MD	-21	-1			
% of changes	73.7	3.63			
P- value	0.001*	0.38			

SD: standard deviation; P-value: probability value; MD: mean difference; NS: non-significant

The outcomes are in line with aquatic treatment has been shown by Nayak et al. (2020), to help enhance balance and gait speed when given alone in eleven investigations including 455 individuals. When combined with land-based therapy, aquatic therapy proved successful in enhancing cadence. The study's findings conflict with those of Morer et al. (2020), who reported that there was no significant improvement in gait speed over a short distance, the ten-meter walk test, but that there was a significant improvement for a longer running time, the six-minute walk test, following two weeks of aquatic therapy. Each session included two components: thalassotherapy (ten minutes in the water bath and an hour of outdoor activity for exposure to the environment), and aquatic therapy (Sayfullaevich, et al., 2021).

In line with Chu et al. (2004), the current study's findings demonstrated that an eight-week aquatic program was more successful in improving post-stroke patients' cardiovascular fitness, lower limb muscular strength, and gait speed. In addition to Nascimento et al. (2020), claim, moderate quality evidence also suggests that water-based activities have significant advantages over land-based exercises in terms of increasing walking speed.

Limitations

- The psychological status and cooperation of the patients may affect the results of this study.
- Individual differences between patients in consideration of their effort during assessment and treatment outcomes.
- The study was limited to men as a result of cultural constrain preventing women from uncovering an area of the marker in public places.

4 Conclusion

The current study's findings support the notion that an underwater treadmill training program can help chronic stroke patients with their balance and lower extremity function.

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