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Original Article

Effect of aquatic versus land based exercise programs on physical performance in severely burned patients: a randomized controlled trial

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Abstract. [Purpose] To compare the effect of an aquatic-based versus a land-based exercise regimen on the physical performance of severely burned patients. [Subjects and Methods] Forty patients suffering from severe burn (total body surface area more than 30%) were recruited from several outpatient clinics in Greater Cairo. Their ages ranged between 20 to 40 years and were randomly assigned into two equal groups: group (A), which received an aquatic based exercise program, and group (B), which received a land-based exercise program. The exercise program, which took place in 12 consecutive weeks, consisted of flexibility, endurance, and lower and upper body training. Physical performance was assessed using 30 seconds chair stand test, stair climb test, 30 meter fast paced walk test, time up and go test, 6-minute walk test and a VO2max evaluation. [Results] Significantly increase in the 30 second chair stand, 6-minute walk, 30 meter fast paced walk, stair climb, and VO2 max tests and significantly decrease in the time up and go test in group A (aquatic based exercise) compared with group B (a land-based exercise) at the post treatment. [Conclusion] Twelve-week program of an aquatic program yields improvement in both physical performance and VO2 max in patients with severe burns.
Key words: Physical performance, Aquatic therapy, Burn injuries

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INTRODUCTION

Burn injuries are considered a global problem that affect a wide range of the population. They are among the most devastating of all injuries, and the fourth most common type of trauma worldwide following traffic accidents, falls, and interpersonal violence[1)]. Patients that have lived beyond the acute phase of a burn injury usually have extensive physical functional limitations[2)]. They also suffer from a decrease in pulmonary function, marked prolonged skeletal muscle weakness, and low physical and functional capacity (exercise capacity)[3)]. These factors are considered to be major obstacles preventing the burn victim from returning to work and performing daily living activities.

Furthermore, severe burns (Total Body Surface Area (TBSA) more than ≥30%) can cause critical problems like disfiguring scarring, a decrease in muscle power, and finally debilitating contractures to hyper metabolism, which lasts for 2–3 years post burn. This last problem creates a state of catabolism which leads to an increase in resting energy expenditure, tachycardia, insulin resistance, negative muscle protein balance, decrease in bone mass, decrease physical performance, and lastly growth delay[4)].

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To improve physical performance in burn victims, two approaches can be taken: land and water based exercises. Although land based exercises come with a lot of benefits, and can be performed by almost everyone, they cause a large amount of impact stress on joints and muscles. This may result in stress fractures, injury, and soreness in the muscles, all of which contribute to a reduction in physical activity and fitness in people. On the opposite spectrum, water-based exercises can also be performed by a wide range of the population, and they too are extremely beneficial. In addition to that, water has the capability of supporting 90% of the body's weight, leading to greater flexibility and less impact. This is true because the buoyancy of water eliminates the effects of gravity, thereby decreasing the stress on muscles, weight-bearing joints, tendons, and ligaments[5]. In addition, studies in healthy adults and older subjects have shown that water exercises are effective in increasing muscle strength[6]. For these reasons, water-based exercises are becoming one of the main exercise regimens for a physical therapy treatment program.

Since severe burns affect the physical performance of its victim, so the aim of this study was to compare the effects of water versus land-based exercise training on their physical performance. The authors hypothesized that water-based exercise training in severely burned patients would be more effective in improving physical performance and exercise capacity than land-based exercise training or no exercise training. This is because of water's properties of buoyancy and hydrostatic pressure, which is expected to improve the body's physical performance in several ways, all of which will be discussed later on in the paper.

SUBJECTS AND METHODS

The study was designed as a prospective, randomized, single-blind, pre–post-test, controlled trial. Forty male participants with chronic severe burn (TBSA more than 30%) were recruited from several outpatient clinics in Greater Cairo. They were enrolled and assessed for their eligibility to participate in the study. Their age ranged from 20 to 40 years. They were assessed and treated in labs and outpatient clinics of the Faculty of Physical Therapy, Cairo University. After a brief orientation session about the nature of the study and the tasks to be accomplished, they were randomly assigned into two equal groups (group (A) and group (B)) by a blinded and an independent research assistant who opened sealed envelopes that contained a computer generated randomization card. No subjects dropped out of the study after randomization. Written informed consent was obtained from all participants before the baseline evaluation. Ethical approval was obtained from the institutional review board at Faculty of physical therapy, Cairo University before study commencement [No: P.T.REC/012/001522]. The study followed the Guidelines of Declaration of Helsinki on conduction of human research. The study was conducted between December 2015 and December 2016. The inclusion criteria were participants age ranged from 20 to 40 years old; both gender; diagnosed with post burn of more than 30% of TBSA; had less than 25 kg/m^2 body mass index (BMI); and all participants were able to walk independently without walking devices. Participants were excluded if they had central nervous system lesions or inadequate cardiac functions; diabetic; hypertension; also limited to participants who had no infectious or skin diseases, because aquatic therapy would be inappropriate for them. Participants were randomly assigned into 2 equal groups, group (A), which received an aquatic exercise program, and group (B), which received an on-land exercise program. The exercise regimen lasted for 12 successive weeks. Both types of exercise programs (Table 1) were carried out 3 days per week for 12 weeks. Each session included a 5-minute warm-up, followed by 35 minutes of different types of exercises: flexibility, endurance, and lower and upper body training. Finally, the session ended with a 5-minute cool down[6].

Physical performance was assessed before and after each exercise programs. This was done using 6 difference evaluations: VO2 max evaluation as primary outcome and (30 second chair stand test, stair climb test, 30 meter fast paced walk, time up and go test, and finally a 6-minute walk test) as secondary outcomes. Below is a brief explanation of each of the 6 different tests: These tests were specifically chosen because they give valid and reliable data. The 30 seconds chair test, for instance, provides a reasonably reliable and valid indicator of lower body strength in generally active adults[7]. Additionally, the stair climb test has good inter-rater reliability and is adequate for clinical use to evaluate physical function[8]. The 30 meter fast paced walk test is considered to be a valid tool to assess physical performance in patients that suffer from hip or knee osteoarthritis[9]. Moreover, the time up and go test gave reliable data that was necessary to differentiate the participants from the healthy elderly subjects[10]. The 6-minute walk test has a high test-retest reliability, and can be used to evaluate the physical performance of adults[11]. Finally, the Bruce treadmill test is a reliable tool to measure the maximal oxygen uptake[12, 13]. VO2 max evaluation: VO2 max Cardio-respiratory fitness, which basically assesses the maximum amount of oxygen that a person can utilize in intense exercises, was assessed using a standardized treadmill exercise test (Modified Bruce Protocol)[12, 13]. Patients wore a nose clip and breathed room air through a two-way valve system. After that, breath by-breath, inspired and expired gases, flow, and volume were analyzed. Concomitantly, participants began to walk on a treadmill at a speed of 1.7 miles/hour at a zero grade of elevation. Each stage consisted of 3-minute intervals in which the speed and treadmill incline gradually increased.

Thirty seconds chair stand test: the purpose of this test is to examine lower limb strength. Two equipment's are required for this test: a timer, and a chair with a 44 cm straight back that is preferably armless. To perform this test, the participant must stand up completely from their sitting position, with their hips and knees fully extended then sit back down so that their bottom completely touches the seat. This is repeated for 30 seconds. The number of times the subject comes to a full standing position must be counted[7].

Table 1. Exercise program for both aquatic and on land training

Sections	Duration	Focuses	Types of exercises
1	5 minutes	Warm up	Walk, march and sidestep with variations in moving directions, arm movements, and by alternatively lifting the bent knee or lifting the straight leg like a toy soldier
2	10 minutes	Flexibility training	Twenty-four sets of stretching and flexibility exercises in neck, trunk, shoulders, and pelvic with 10–15 repetitions for each exercise (Water as assistance)
3	10 minutes	Endurance training	Repeat walk moves as it was done in the warm up section for 5 minutes and then move in place for another 5 minutes including Heel Jacks, Rocking Horse, Elbow to Knee, Jump Jack, Cossack Shuffle, Cross-Country Ski and Four Square Waltz Step
4	10 minutes	Lower body training	Exercise by using the wall for support, including 17 sets of exercises in hips, knees, ankles and toes with 10–15 repetitions of each exercise (Water as resistance)
5	5 minutes	Upper body training	Twelve sets of exercises for arms, elbows, wrists, hands and fingers, with 10–15 repetitions of each exercise (Water as resistance)
6	5 minutes	Cool down	Repeat walk moves, squat and stand, as well as hug and pat

The indoor pool works with an air temperature around 27 ± 1 °C and water temperature is controlled at 30.5 ± 0.5 °C with antiseptic solution.
Heel Jacks: alternatively move one heel forward on pool floor/ground and return to start position.
Rocking Horse: stand on one leg and rock forward on to other leg in front, rock to shift weight to back leg.
Elbow to Knee: bend elbow and lift leg, bring an elbow toward the opposite knee.
Jump Jack: side steps with arms up and down in front of the body and bend elbows.
Cossack Shuffle: alternatively moving one leg straight forward and off the pool floor/ground and returning to start position.
Cross-Country Ski: bend elbows slightly and move in a cross-country ski motion front to back.

While, Stair-climb field test: In this test, the subjects were required to climb up 11 floors (22 flights of stairs, ending on the 12th story) at a brisk, but even pace. Steps taken were to be of constant rhythm throughout the whole duration of the test, and a single step must be taken each time. The total vertical distance covered was 27.0 meters. The measurement was based on the number of steps climbed and calculated as follows: Height of a step=15 cm Number of steps per flight: 8 steps (except for first flight with 12 steps) Number of flights=22 (1 flight with 12 steps and 21 flights with 8 steps) Therefore, vertical height of 11 floors=(15 cm ×12 steps) + (15 cm ×8 steps ×21 flights)=180 + 2,520=2,700 cm =27.0 meters. The subjects were informed about the test procedures prior to their climb. They were not allowed to stop at any point during the climb or use the side-railings for support[8]. Additionally, 30 meter fast paced walk: participants were asked to walk as quickly but as safely as possible to a mark 10 m away, return, and repeat for a total distance of 30 meters. Subjects are timed for this test and data is expressed as speed[9]. However, Time up and go test: subjects were asked to stand up from a chair, walk at a comfortable pace to a 3-m marked line, return to the chair, and sit down. Time taken to complete the test was recorded to the nearest 1/100 of a second using a stopwatch[10].

Finally, Six-minute walk test: The 6-min walk test is now commonly used to assess function in patients with cardiovascular or pulmonary disease. The 6-min walk test was carried out in a 50 meters long corridor. Subjects were instructed to walk from end to end of the corridor and to cover as much distance as possible in the allotted period of 6 min. The patients were encouraged every 30 s and were allowed to stop and rest during the test, but were instructed to resume walking as soon as they felt able to do so. At the beginning, at 2-min increments, and at the end of the test, breathlessness was measured using a modified Borg scale. Oxygen saturation was monitored with a pulse oximeter set at the fastest response[11].

Data analysis was performed using (SPSS, Inc. Chicago, IL, USA) program version 22 for Windows. The sample size (40 patients) was calculated to yield an 85% power and α=0.05. Prior to final analysis, data were screened for normality assumption and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculation of the analysis of differences and of relationship measures. 2 × 2 mixed design MANOVA was used to compare the tested variables of interest at different tested groups and training periods.

RESULTS

There were no statistically significant differences (p>0.05) between subjects in both groups concerning age, and BMI (Table 2). Statistical analysis revealed that there was a significant difference regarding subject effect (F=702.79, p=0.0001) and treatment*time effect (F=33.146, p=0.0001) as well as there were significant between subject effect (F=33.837, p=0.0001). Table 3 represents the mean ± SD and multiple pairwise comparisons for all dependent variables in both groups in different measuring periods. Multiple pairwise comparison tests revealed that there was a significant increase (p<0.05) in the 30 seconds chair stand, 30 meter fast paced walk, stair climb, 6 min walking test, and VO2 max tests and significant decrease (p<0.05) in the time up and go test in the post treatment condition compared with the pre-treatment in both groups in the post treatment condition compared with the pre-treatment in both groups. Regarding subject effect, multiple pairwise

Table 2. Physical characteristics of patients in both groups

Items	Group A	Group B
	Mean ± SD	Mean ± SD
Age (years)	32.2 ± 4.8	30.9 ± 6.2
BMI (kg/m^2)	23.4 ± 0.8	23.3 ± 0.7

Table 3. Dependent variables in patients with severe burn in pre and post 12 weeks of exercises for both groups

Dependent variables	Group A (N=20)		Group B (N=20)	
	Pre treatment	Post treatment	Pre treatment	Post treatment
VO2 max (ml/(kg × min))	35.06 ± 1.68	45.91 ± 0.63*	35.11 ± 1.73	36.05 ± 1.73* Ω
30 chair stand up test (Number of times patient stood up)	9.55 ± 1.05	15.95 ± 1.43*	8.95 ± 0.99	14.7 ± 1.21* Ω
30 meter fast paced walk (sec)	9.45 ± 1.04	16.12 ± 0.81*	9.35 ± 1.01	15.35 ± 0.79* Ω
Time up and go test (sec)	14.75 ± 1.69	7.68 ± 0.42*	14.75 ± 1.69	8.58 ± 0.43* Ω
6 min walking test (m)	491.65 ± 9.05	585.65 ± 8.92*	496.95 ± 8.22	510.05 ± 7.59* Ω
Stair climb test (min)	6.61 ± 0.39	10.92 ± 0.35*	6.61 ± 0.39	8.35 ± 1.01* Ω

*Significant ($p<0.05$) difference between pre and post treatment, Ω Significant ($p<0.05$) difference between both groups at post treatment.

comparisons revealed that there was a significant increase ($p<0.05$) in the 30 seconds chair stand, 30 meter fast paced walk, stair climb, 6 min walking test, and VO2 max tests and a significant reduction ($p<0.05$) in time up and go test in in group A compared with group B at the post 12 weeks of treatment.

DISCUSSION

The present study was conducted to compare the efficacy of aquatic versus a land-based exercise program in severely burned patients. The assessment process took place before and after the 12 weeks of exercise program in both groups. This was done by assessing the physical performance using the 30 seconds chair stand test, stair climb test, 30 meter fast paced walk test, time up and go test, 6-minute walk test, and the VO2 max test.

When discussing burn injuries, the main intended outcomes of any form of physical therapy treatment would be to reduce edema, prevent contractures by positioning and splinting, and finally limit the loss of range of movement[14)]. The results of the study concluded that there was an improvement in the overall physical performance in both groups, however, group A showed a larger significant improvement. This is true because resisted exercises, such as the ones completed in the aquatic exercise program, increase muscle power, leading to a higher improvement rate. In addition to that, the hydrostatic pressure of the water may have also played a role, since it helps the participants to exercise in a more vigorous manner while at the same time causing less strain on both the cardiovascular and musculoskeletal systems. This consequently leads to an enhanced venous and lymphatic return, which aids in the reduction of extremities swelling. Furthermore, the high levels of viscosity in water aids the participants in working with the opposite groups of muscles simultaneously, while at the same time using the same amount of resistance. This means that the body is met with resistance in all directions, creating a better resistance program in different muscle groups. Water resistance reduces the speed and aimed point of motion, and thus prevents jerky movements. This consequently decreases the risk of injury and at the same time improves strength and endurance[15)].

Results of this study are supported by Stefanska and Zawadiska[16)]. They found that a swimming program resulted in significantly higher values of maximum muscle movement, performed works, and average force, which were all achieved by knee joint extensors[16)]. The conclusion reached by Wadell[17)] in her paper also supports the conclusion that water based are more effective than land based exercises. Wadell[17)] concluded that people with chronic obstructive pulmonary disease and physical comorbidities gained greater benefits from water based exercises. These benefits are a greater exercise capacity while experiencing less fatigue[17)]. Furthermore, in their paper about the effect of aquatic therapy on stroke survivors regarding the muscle strength and postural balance, Noh et al.[18)] were able to reach the same conclusion. They concluded that aquatic therapy lead to significant improvements in more of their tests: forward and backward weight bearing, knee flexor strength, and Berg Balance Scale scores[18)].

Regarding the VO2 max test, there was an improvement in both groups, however group (A) displayed a more significant improvement than group (B). This is true because during aquatic exercises, the hydrostatic pressure of the water has a positive effect on the chest wall by causing resistance of respiratory muscles in all directions. This forces the individual to inhale a greater volume of air, thereby improving their respiratory muscles. Furthermore, water buoyancy enhances venous return, thereby increasing the cardiac output. This enhances controlled breathing underwater, and leads to better oxygenation and a lower exercise heart rate. Rozek et al., 2005, reached the same conclusion by proving that a 5-month cycle of an aquatic exercise program performed by children diagnosed with scoliosis, lead to a notable increase in the vital capacity and maximum voluntary ventilation[19].

There are some limitations of this study. Firstly, the lack of follow-up for patients in both groups for several months' post rehabilitation program to evaluate the long lasting effect. Secondly, the effect of the aquatic exercise program with the participants' psychological parameters such as quality of life was not examined. In conclusion, this study shows that a 12-week program with a resistive aquatic program can cause improvements in both physical performance and VO2 max in patients with severe burns when compared with an on-land exercise program.

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Conflict of Interest

Authors declare no potential conflicts of interest.

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