

Therapeutic Effect of an Underwater Exercise Program for Patients with Peripheral Arterial Disease

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Abstract. [Purpose] This study investigated the effect of a simple underwater training program on ambulatory functions of patients with peripheral vascular disease. [Subjects and Methods] Seven male patients participated in supervised underwater exercise training for twelve weeks to determine the effect of the program on their ambulatory capacity through comparison of their pre- and post-training values of their ambulatory indices, including toe pressure, maximum ambulatory distance, and ankle brachial index. [Results] We show that twelve weeks of underwater training improved the ambulatory functions and quality of life of patients with peripheral vascular disease. [Conclusion] This program should be considered as an effective conservative treatment for low risk patients with intermittent claudication.

Key words: Underwater exercise, Peripheral arterial disease, Intermittent claudication

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INTRODUCTION

Peripheral arterial disease (PAD) is a chronic atherosclerotic disease affecting the lower limbs. It may present as intermittent claudication (IC), pain or weakness that is aggravated by walking or exercise, but disappears during rest. This pain is commonly localized to the calf due to atherosclerosis of the superficial femoral and the popliteal arteries and reversible ischemia of the calf muscles¹⁾. The development of IC impairs the functional abilities of PAD patients and gradually impairs their quality of life. In the adult population, 12% are affected by PAD, and up to 20% of elderly subjects, but many of them are asymptomatic²⁾. A recent study showed that the prevalence of PAD in the Saudi community is 11.7%, which is higher than in other developing countries; and 92.7% of Saudi patients are asymptomatic³⁾.

The functional abilities of PAD-patients are decreased due to development of IC, which is exercise-induced pain or discomfort mainly in the calf.

Treatment of IC aims to improve walking ability and the functional conditions of patients, and to maintain the viability of the affected limbs. In addition, treatment aims to reduce the cardiovascular risks caused by treatment of the underlying systemic atherosclerosis⁴⁾. Improvement of the

symptoms can be achieved by exercise training, pharmacotherapy, and re-vascularization. Several studies have indicated that PAD-patients can benefit from supervised exercise training that assists in reducing pain, increasing walking distance, and improving functional mobility and quality of life⁵⁻⁷⁾. Supervised exercise training was recently recommended as the first choice treatment as it can additionally reduce the associated cardiovascular risks⁸⁾. Most exercise training programs designed for PAD-patients are based on supervised treadmill walking that requires close supervision by a qualified therapist in order to adjust the dose and the intensity of the exercise. In addition, it requires travel to the treatment facilities that is often not reimbursed by medical insurance. Alternative types of exercise therapy are therefore needed.

Aquatic exercise training has recently been widely used in rehabilitation programs especially when exercising under normal gravity conditions is difficult or painful. Water buoyancy relieves pressure on joints, bones, and muscles^{9, 10)}. The warmth and pressure of the water can also assist in reducing swelling and improving blood flow that allowing early active mobilization and dynamic strengthening¹¹⁾. Nowadays, swimming pools are available at most recreational and sports centers, and sometimes at even home, and the patients can follow a pre prescribed program

under the supervision of a member of his family member. To the best of our knowledge, no study has been yet done that investigated the efficacy of underwater training on claudication indices of PAD-patients.

This study aimed to investigate the effect of underwater training in improving the quality of life of PAD-patients suffering IC. An additional aim was to improve the ambulatory function of PAD-patients without putting stress on the cardiovascular system as it is known that PAD-patients suffering IC are subjected to coronary and cerebrovascular ischemic events¹².

SUBJECTS AND METHODS

Seven male PAD patients participated in this study which investigated the effect of 12 weeks of underwater exercise training on their claudication indices at the Rehabilitation Department of King Khalid University Hospital, Riyadh. Their ages ranged between 55 and 68 years (mean 61.3 ± 4.5 years). Their weights ranged between 55 and 82 kg (mean 68 ± 9.4 kg) and while their heights ranged between 160 and 180 cm (mean 167.3 ± 7.0 cm).

The study protocol was approved by the ethical committee of the Rehabilitation Department of King Khalid University Hospital, Riyadh. All subjects were diagnosed as Fontaine stage II PAD-patients, defined by IC elicited during a screening treadmill test and an ankle/brachial index (ABI) of less than 0.97 at rest¹³. All subjects with asymptomatic PAD (Fontaine stage I), rest pain PAD (Fontaine stage III), ischemic ulcers or gangrene (Fontaine stage IV), severe coronary artery disease, dyspnea, uncontrolled hypertension or myocardial infarction within the last 6 months were excluded.

For each subject Ankle Brachial Pressure index (ABI), and toe pressure were measured using (Nicolet Vaso Guard Ver 8.04) was noted. In addition, Maximum walking distance (absolute walking distance) was measured on an electronic treadmill (Marquette Series 2000 Treadmill) and maximum heart rate was also recorded for each subject in the Symptoms Limited Graded Exercise Test.

All the patients were initially seen in the vascular surgery clinic after receiving their informed consent to select the participants according to the inclusion and exclusion criteria. All participants received written and oral instructions about the risks and benefits of the study, and gave their written informed consent before participation. Each subject provided demographic information at the initial visit by completing questions pertaining to age, gender, height, weight, history of diabetes mellitus, smoking status, and family history of PAD and presentation of claudication symptoms.

The ABI for each subject was measured by a specialist nurse at the vascular laboratory of King Khalid University Hospital, before and after the twelve weeks of underwater training, by using a handheld Doppler probe (Nicolet Vaso guard ver 8.04; Nicolet vascular Inc) to obtain the systolic pressures in the brachial, dorsalis pedis (DP), and posterior tibial (PT) arteries of the affected limb. The ABI values were determined by dividing the values of DP or PT systolic pressure in the affected leg by the brachial artery systolic

pressure which normally ranges between 0.9 and 1.3. PAD is diagnosed by an ABI of less than 0.9¹⁴. Patients with mild PAD usually have an ABI ranging from 0.7 to less than 0.9, while those with severe PAD have an ABI of less than 0.4¹⁵.

The maximum walking distance (MWD) for each subject was measured before and after the training program in a progressive treadmill exercise test at a constant walking speed of 2.0 mph and zero-grade inclination angle with a 2% increases every two minutes until the maximum claudication pain forced the patient to stop¹⁶. The treadmill was calibrated before the test. The walking test was done according to international treadmill protocols^{17, 18}.

All patients received supervised underwater exercise training for twelve weeks. This was composed of three exercise sessions per week, each lasting one hour, supervised by a senior physiotherapist. The exercise was conducted in waist to chest deep warm water ($28-30^{\circ}\text{C}$)¹⁹, and the subjects wore hydro-tone exercise boots. Each exercise session started with 10 minutes of warming up in the form of underwater stretching exercises for the lower limb muscles (hamstrings, calf, hip adductors, and flexors) and underwater gait training (forward and backward walking). Formal exercises were then performed for 30 minutes in the form of hip flexion-extension, hip abduction-adduction and knee flexion-extension exercises using the hydro-tone exercise boots. This was in addition to water cycling by using floatation devices for 10 minutes. During the first 8 weeks, the subjects were exercised within the intensity range of 50 to 70% of their maximum heart rate attained during the symptoms-limited exercise test that corresponded to (10–12) on the scale of rate of perceived exertion (RPE) and then progressed to an intensity range of 70 to 85% of their maximum heart rate (RPE 10–12) during the last 4 weeks¹⁹. The exercise session was ended with 10 minutes of cooling down exercises (stretching and simple walking) for relaxation.

RESULTS

Data are expressed as mean and standard deviation, and were analyzed by using the SPSS program, version 10.0 (SPSS Inc., Chicago, IL, USA). The one-tail paired t-test was used to compare the pre- and the post-training mean values of ABI, Toe pressure, and the claudication distance of the affected limb in PAD-patients. A p value of 0.05 was used to determine the significant differences. The results showed that the 12 weeks of underwater exercise training produced a significant improvement in the ABI, as its mean value increased from 0.6 ± 0.1 before training to 0.7 ± 0.1 after training (p value = 0.002) (Table 1).

Also 12 weeks of underwater training produced a significant improvement in the toe pressure of the affected limb, from 57.0 ± 19.5 mmHg, to 67.3 ± 14.4 (p value = 0.012) (Table 1).

Furthermore there was a significant improvement of the claudication distance from 95.1 ± 57.6 meters to 223.1 ± 114.2 meters (p value = 0.023).

Table 1. Statistical comparison of claudication indices of the affected limb between before and after exercise

| Parameters | Affected limb pre training | Affected limb post training | mean difference | p-value |
|---------------------------|----------------------------|-----------------------------|-----------------|---------|
| ABI (%) | 0.6 ± 0.1 | 0.7 ± 0.1 | 0.1 | ** |
| Toe pressure (mmHg) | 57 ± 19.5 | 67.3 ± 14.4 | 9.8 | * |
| Claudication distance (m) | 95.1 ± 57.6 | 223 ± 114.2 | 128 | * |

DISCUSSION

This study was conducted to investigate the effect of the supervised underwater training on improving walking capacity of PAD-patients, aiming to improve their physical activity abilities in order to raise their quality of life and to avoid further deterioration of the disease. The study also aimed to compare the results of the supervised underwater training with land-based supervised training conducted by other researchers.

The study was began with 20 subjects, who started the exercise program but only 7 patients completed the whole exercise program. This may be because it was difficult for the patients to commit to 3 sessions per week since it involved changing clothes, wearing safety jackets and taking showers after every session. Alternatively, it may be that they were not convinced of the benefits of the new procedure as they did not notice improvement in the early sessions and refused to play the role of a laboratory animal.

The study revealed that 12 weeks of simple supervised underwater aerobic training improved the ABI and the toe pressures by 15%, in addition to a 58% increase in the maximum walking distance. This improvement in walking ability would have a positive effect on quality of life by improving the patients' ability to practice their routine daily activities²⁰.

The improvement of toe pressure and ABI noted in this study might have been related to increased blood flow to the calf muscles and improvement of cardiorespiratory capacity, allowing the subjects to walk further on the treadmill before the start of claudication¹⁶. Such improvement in walking quality might also have resulted from improvement of oxygen extraction and muscle carnitine metabolism in the lower extremities²¹. Exercise training also may have enhanced the expression of the vascular endothelial growth factor messenger RNA from the affected muscles²². In addition, the training program may have assisted in the development of collateral circulation, this was demonstrated in previous experimental studies on animals^{23, 24}. It has also been reported that four months of water based exercise produced significant adaptation in body composition, strength of the upper and lower limb muscles, aerobic capacity and exercise tolerance among patients with coronary artery disease¹⁹.

The advantages that Underwater training such as walking in a swimming pool, may have advantages over the regular land exercise that assist in improving the exercise capacity, especially among cardiovascular patients, since it reduce joint stress, has greater expenditure of calories, and provides greater water resistance than air resistance²⁵.

Previous studies using supervised land-based exercise

to manage PAD-patients report that when the patients practicing self directed walking exercise for at least three times per week, will have less functional decline during the subsequent years²⁶.

A review of randomized controlled trials of 12 weeks-supervised land-based exercise training for PAD-patients (1 hr twice a week) performed by different authors revealed diverse results. The improvement in the mean walking distance ranged from non-significant up to 43%²⁷. Whereas, this study found a 58% increase in the mean walking distance.

The results of this study show that underwater exercise may be considered as an effective method of rehabilitation for patients with peripheral vascular insufficiency. Most land-based exercise training programs for patients with intermittent claudication requires the patients to walk on a treadmill until the onset of the claudication pain. This, the patient will still have leg muscle pain at the end of the exercise that may cause more tightness and spasms of the muscles for several hours after the exercise session. However, underwater exercise is almost pain free due to the relief of joint pressure and the direct effect of warm water, which helps vasodilatation and blood flow. Moreover, the water-based exercise program was found to be safe and effective.

This study demonstrated that a twelve week program of underwater exercise is an effective conservative treatment programs for low risk PAD-patients with I.C. It improved their ambulatory capacity and enhanced their quality of life of those patients. We recommend this program over the land-based programs as it is more comfortable to the patients and is less dangerous, especially for cardiopulmonary and arthritis patients, as well as appearing to be more effective.

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