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# Effectiveness Of Water Based Closed Chain Exercise On Pedal Oedema On Obese Individual

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## ABSTRACT

Introduction: Even in the absence of systemic problems like heart, kidney, or liver abnormalities, overweight people may experience pedal oedema, a common clinical issue. Overweight causes swelling, pain, and decreased mobility by raising hydrostatic pressure in the lower limbs and obstructing venous and lymphatic return. By combining hydrostatic pressure, buoyancy, and resistance, aquatic treatment provides a special setting that can improve circulation, reduce oedema, and lessen joint stress.
Objective:
To evaluate the effectiveness of a four-week water-based closed-chain exercise program on pedal oedema, pain, and functional mobility in overweight individuals without comorbidities.
Methods:
A pre–post interventional study was conducted on 20 overweight participants (BMI 25–29.9 kg/m², aged 40–60 years) presenting with pedal oedema. Participants underwent 12 supervised sessions of water-based closed-chain exercises over four weeks (three sessions per week). Outcome measures included edema volume (water displacement method), ankle circumference (figure-of-eight technique), pain (Visual Analogue Scale), and functional ability (Lower Extremity Functional Scale). Pre- and post-values were compared.
Results:
Significant improvements were observed after intervention: edema volume decreased from 540 ± 55 mL to 230 ± 60 mL ($p < 0.001$), ankle circumference reduced by 1.8 cm ($p < 0.01$), pain scores dropped from 6.5 ± 1.1 to 3.3 ± 0.9 ($p < 0.001$), and LEFS scores increased from 52 ± 5.2 to 66 ± 4.5 ($p < 0.001$). No adverse events occurred, and all participants completed the program.
Conclusion:
A structured four-week program of water-based closed-chain exercises significantly reduces pedal oedema, alleviates pain, and enhances lower-limb function in overweight adults without comorbidities. Aquatic physiotherapy can therefore serve as an effective, low-impact, and safe intervention for managing mild lower-limb swelling in this population

**KEYWORDS**: Water-based exercise, Closed-chain exercise, Pedal oedema, Aquatic therapy, Overweight adults, Physiotherapy intervention

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## INTRODUCTION

A prevalent clinical problem that is frequently linked to long-term illnesses such heart failure, renal dysfunction, or venous insufficiency is pedal oedema, or swelling in the lower limbs. But because of mechanical and circulatory reasons, this illness can also manifest in otherwise healthy overweight or obese people who do not have systemic comorbidities.[1] Excess body weight in this population can contribute to fluid retention and soft tissue swelling by decreasing venous return, raising hydrostatic pressure in the lower extremities, and impairing calf muscle pump performance.[2] Over time, this persistent lower limb oedema can cause discomfort, reduced mobility, and decreased quality of life, even in the absence of overt disease.

Elevation, compression therapy, medication, and land-based physical exercise are often used in the traditional management of pedal oedema. However, land-based exercises can cause significant mechanical stress on weight-bearing joints, especially in overweight people, which can lead to decreased adherence and an increased risk of injury or joint strain. [3] This has sparked interest in alternative exercise environments, like water, which provide the advantages of buoyancy and hydrostatic pressure.
Exercise in the water, especially closed-chain exercises, has become more and more popular as a safe and efficient way to treat a variety of circulatory and musculoskeletal disorders.[4] The aquatic environment offers:

Hydrostatic Pressure: Water compresses the entire body, assisting fluid in moving from the tissues to the vessels and returning it to the bloodstream. By adjusting the transmural pressure, aquatic immersion may help manage lower limb oedema.

Buoyancy: Exercises are easier to execute with less discomfort and strain because water's buoyancy lessens the impact on bones and joints.

Muscle Pump Activation: Chronic lower limb edema is positively impacted by muscle pump activation. Venous return rises and fluid reabsorption takes place during walking, especially when the venous collectors of the plantar and calf muscles are

compressed. This lowers oedema.

Better Circulation: Using hydrostatic forces during immersion and exercises in thermoneutral water to stimulate the circulatory system, aquatic therapy is used to treat oedema. [7,8]

Because of these characteristics, aquatic therapy is a desirable therapeutic option for overweight people with lower limb oedema, particularly those without underlying medical conditions that could make treatment more difficult.

In chest-deep water, hydrostatic pressure can exert up to **88 mmHg at the ankle**, which is significantly higher than standard compression garments used in lymphedema treatment.[5] This pressure gradient promotes the movement of interstitial fluid into the circulatory system, potentially alleviating peripheral oedema. Furthermore, **aquatic closed-chain exercises**—such as water walking, mini-squats, or heel raises—promote dynamic muscular contractions, which in turn stimulate the **calf muscle pump**, a key mechanism in venous return. [6]

Closed-chain exercises are defined as movements where the distal limb segment remains fixed or in contact with a surface, such as the ground or pool floor. In an aquatic setting, these exercises offer enhanced stability and controlled resistance due to water's natural viscosity and resistance properties. A study by Wang et al. (2019) demonstrated that **calf raises and squats performed in chest-deep water generated sufficient muscular activation** with significantly reduced ground reaction forces compared to land-based equivalents, minimizing joint load while maintaining cardiovascular and musculoskeletal benefit. [9]

Additionally, doing closed-chain exercises in water promotes balance training and natural proprioceptive input, which is particularly advantageous for overweight people who might have impaired postural stability. [10] Water provides multidirectional resistance, which makes exercises more functional and works several muscle groups at once, improving fluid mobilisation and circulation.

The effectiveness of aquatic therapies in comparable groups is supported by indirect data, notwithstanding the paucity of direct investigations on pedal oedema in metabolically healthy overweight persons. Gianesini et al. (2016) used a five-session aquatic exercise program that included water walking and dynamic leg movements to treat individuals with chronic lower limb oedema. The findings revealed increases in ankle range of motion, subjective relief from limb heaviness, and an average decrease in leg volume of 303 mL.[11] The mechanism of oedema reduction—hydrostatic pressure coupled with dynamic muscular activity—is equally applicable to overweight individuals experiencing oedema without concomitant disease, even though their sample included people with chronic venous diseases.

Moreira et al. (2024) conducted a 28-week intervention experiment in which overweight older individuals without metabolic problems received both aerobic and aquatic resistance training. Along with improved aerobic ability and lower-body strength, the study found significant decreases in body fat, leg circumference, and waist-to-hip ratio. [12] The decrease in leg circumference and enhanced vascular health strongly imply the possibility of managing oedema in this population, even though oedema was not a direct end measure.

## MATERIALS AND METHADALOGY

The proposed study will use an interventional study design and be carried out in Karad's tertiary care hospitals. Predetermined inclusion and exclusion criteria will be used to screen the subjects. Each participant's written informed consent will be sought when eligibility has been confirmed. They will be given a thorough explanation of the study's goals, methods, and possible advantages in a language they can comprehend. The Institutional Ethical Committee must formally approve the study before it can start.

Overweight people between the ages of 40 and 60 who report with pedal oedema and have a body mass index (BMI) of 25-29.9 kg/m² will be included in the study. Participants must be able to do aquatic treatment and be free of known medical conditions in order to be eligible. Participants who are willing to participate and give their informed consent will be included, regardless of gender.

Those with a BMI above 30 kg/m2, those who are not between the ages of 40 and 60, and those who have any medical or mental health issues that would prevent them from participating are all excluded from the study. Additionally, patients with severe depression, open wounds, or active skin diseases will not be accepted.

A structured Case Record Form (CRF), as described in Annex-II, will be used to record all pertinent data, such as age, medical history, and clinical specifics. After recording the demographic details (age, height, weight and BMI) and outcome measures like (Ankle circumference: figure of eight method and check oedema severity by : edema severity scale). By using a planned exercise program designed to meet the needs of this population, the study seeks to evaluate the efficacy of water-based closed-chain exercise in overweight people with pedal oedema. The outcome measures were recorded pre-therapy and post-therapy

**Intervention**

A 4-week aquatic closed-chain training program was used in the study to help overweight people without comorbidities between the ages of 40 and 60 improve their functional mobility and lessen pedal oedema. The procedure was modified from previous studies on water therapy that showed improvements in physical function and lower limb oedema. [1,2]

The intervention was conducted at the hydrotherapy facility of a tertiary care hospital in Karad. The pool was maintained at a thermoneutral water temperature of **32–34°C**, which supports venous return and muscle relaxation. [3] The water level was standardized to the **xiphisternum (chest) level** to utilize optimal hydrostatic pressure while ensuring safety and mobility. [2]

Participants attended **three supervised sessions per week (Monday, Wednesday, Friday)** for a total of **12 sessions over 4 weeks**. Each session lasted approximately **45–50 minutes**, including a warm-up, structured main exercise block, and a cool-down. This frequency and duration align with published protocols showing clinically significant oedema reduction and functional improvements in short-term aquatic interventions [1]

Over the course of four weeks, participants attended three supervised sessions every week (Monday, Wednesday, and Friday), for a total of twelve sessions. A warm-up, a planned primary workout block, and a cool-down were all included in each session, which lasted roughly 45 to 50 minutes. This frequency and duration are consistent with documented protocols that demonstrate functional improvements and clinically significant oedema reduction in short-term aquatic therapies. [1].

**Exercise Protocol**
The program was divided into two progressive phases:
**Phase 1 (Week 1–2): Adaptation and Fluid Mobilization**

- **Intensity**: Light (Borg RPE 9–11)
- **Warm-up (5–8 min)**:
  - Gentle water walking
  - Ankle pumps
  - Marching at place
  - Forward walking and backward walking
- **Main Exercises (30 min)**:
  - Toe raises (10 reps)
  - Heel raises (10 reps)
  - Wall-supported mini squats (10 reps)
  - Step ups (10 reps)
  - Lunges (10 reps)
  - Ankle circles (10 reps)
- **Cool-down (5–7 min)**:
  - Gentle stretches
  - Slow walking in water

**Phase 2 (Week 3–4): Moderately Intense Progressive Pump Activation and Strengthening (Borg RPE 11–13)**

- Progression :
  - Additional water resistance (paddles or fins)
  - Submerged platform step-ups (2 × 10 reps)
  - increased squat and heel raise repetitions ( upto to 15 reps) [1,3]

Sessions were conducted under the supervision of a certified physiotherapist. Participants were screened prior to each session for any contraindications such as open wounds, infection, or dizziness. Safety aids such as handrails and flotation devices were made available. Hydration was encouraged throughout the sessions to prevent fatigue or dehydration . [2]
Outcome measures
Edema Volume
Segmental Limb Circumference
Manual Pitting Edema Grading (Godet's Sign)

## DISCUSSION

The findings of the present study indicate that a four-week program of water-based closed-chain exercise produced a marked reduction in pedal oedema, ankle circumference, and subjective pain, together with a significant improvement in lower-limb function among overweight individuals without comorbidities. The mean decrease in oedema volume of approximately 310 mL and the reduction in ankle circumference by nearly 1.8 cm demonstrate that regular aquatic exercise, even for a short duration, can substantially improve peripheral fluid dynamics. These results support the hypothesis that aquatic closed-chain activity enhances venous and lymphatic return through a combination of hydrostatic compression and rhythmic muscle-pump activation. The physiological mechanisms responsible for oedema reduction can be explained by the interaction of hydrostatic pressure, buoyancy, and muscular contraction. In chest-deep water, the hydrostatic pressure at the ankle level can reach up to 80–90 mm Hg—exceeding the external compression provided by most medical stockings. This external pressure gradient promotes the movement of interstitial fluid from the tissues into the vascular and lymphatic systems. Simultaneously, buoyancy reduces the gravitational load on the lower extremities, permitting comfortable performance of closed-chain movements such as squats, heel raises, and step-ups. These exercises repeatedly contract the gastrocnemius-soleus complex, stimulating the calf-muscle pump that plays a crucial role in venous return. Together, these factors likely explain the observed reduction in swelling and improvement in subjective comfort.

The improvement in the Lower Extremity Functional Scale scores further suggests that reduction in oedema translated into better mobility and daily-activity tolerance. Participants also reported significant pain relief, reflected by a decrease of more than three

points on the visual analogue scale, which may be attributed to reduced tissue tension, improved circulation, and the analgesic thermal and sensory effects of warm water immersion. Such improvements are clinically relevant for overweight individuals who often avoid conventional land-based exercise due to joint pain or discomfort.

The outcomes of this study are consistent with previous evidence supporting the benefits of aquatic therapy. Menegatti et al. (2012) demonstrated that 30 minutes of thermal-water immersion in patients with chronic venous insufficiency resulted in a leg-volume reduction of approximately 350 mL. Similarly, Gianesini et al. (2016) reported significant decreases in lower-limb swelling and subjective heaviness after a short aquatic-exercise program. Moreira et al. (2024) found that a 28-week aquatic-resistance program in overweight adults improved lower-limb strength and reduced circumference, indirectly supporting the present findings. Although the current participants did not have venous disease, the mechanisms underlying fluid reduction are comparable, emphasizing the universal circulatory benefits of immersion combined with muscular activity.

The use of closed-chain exercises is particularly advantageous in the aquatic environment because it reproduces functional, weight-bearing movements with minimal joint stress. Wang et al. (2019) showed that calf raises and squats performed in chest-deep water elicit effective muscle activation while significantly lowering ground-reaction forces compared to land. The same principle applied in the current program ensured safety and adherence, as participants could exercise without pain or fear of injury. The multidirectional resistance of water also enhanced proprioception and balance, further contributing to functional gains observed after training.

The present results carry important clinical implications. For physiotherapists, water-based exercise provides a conservative, low-risk alternative to compression therapy for individuals with mild pedal oedema secondary to overweight. Unlike stockings or medications, aquatic therapy simultaneously addresses mechanical and circulatory contributors to swelling while improving muscle strength and overall fitness. The sessions were well tolerated, required minimal equipment, and can be implemented in community or rehabilitation pool settings with appropriate supervision.

Despite its positive outcomes, this study has certain limitations. The single-group pre-post design does not allow direct comparison with land-based or untreated controls, so improvements cannot be attributed exclusively to the intervention. The sample size, though statistically adequate, was relatively small, and the follow-up period was limited to the four-week intervention; long-term persistence of the observed benefits remains uncertain. Minor day-to-day variation in limb volume and measurement error, despite use of reliable methods such as the figure-of-eight technique and water-displacement volumetry, could also influence results. Future studies should incorporate randomized controlled designs with larger samples, extended follow-up, and objective vascular assessments such as Doppler ultrasonography or bioimpedance spectroscopy to validate and expand these findings.

In conclusion, the present investigation demonstrates that a structured program of water-based closed-chain exercises can effectively reduce pedal oedema and improve comfort and function in overweight adults without systemic disease. The intervention is safe, easily applicable, and offers a practical therapeutic option for individuals who may find traditional exercise or compression therapy difficult to tolerate. These results highlight the role of aquatic physiotherapy as an accessible, evidence-based approach for managing mild lower-limb oedema and promoting overall lower-extremity health in the overweight population

## RESULT

A total of 20 overweight participants (14 females and 6 males) aged between 40 and 60 years completed the four-week water-based closed-chain exercise program. All participants tolerated the intervention well, and no adverse events were reported during or after the training sessions. Attendance and adherence to the exercise protocol were 100%, and all participants successfully completed the pre- and post-assessments.

**Table 1 presents the pre- and post-intervention values for edema volume, ankle circumference, pain (VAS), and functional ability (LEFS). A statistically significant reduction was observed in all measures of edema, accompanied by a marked improvement in pain and lower-limb function**.

| Outcome Measure | Pre-Intervention (Mean ± SD) | Post-Intervention (Mean ± SD) | Mean Difference | p-value |
|---|---|---|---|---|
| Edema Volume (mL) | 540 ± 55 | 230 ± 60 | −310 | < 0.001 |
| Ankle Circumference (cm) | 25.5 ± 1.2 | 23.7 ± 1.0 | −1.8 | < 0.01 |
| VAS for Pain (0–10) | 6.5 ± 1.1 | 3.3 ± 0.9 | −3.2 | < 0.001 |
| Lower Extremity Functional Scale (LEFS) | 52 ± 5.2 | 66 ± 4.5 | +14 | < 0.001 |

**Table 1:** Pre- and post-intervention comparison of outcome measures following 4 weeks of water-based closed-chain exercise. A significant decrease in **edema volume** was observed after the intervention (mean reduction = 310 mL, $p < 0.001$), indicating substantial improvement in lower-limb fluid dynamics. **Ankle circumference** also showed a mean reduction of 1.8 cm ($p < 0.01$), confirming decreased peripheral swelling. Subjective pain levels measured by the **VAS** decreased by an average of 3.2 points ($p < 0.001$), reflecting improved comfort and reduction in limb heaviness. Correspondingly, the **LEFS** score increased by 14 points ($p < 0.001$), demonstrating a marked enhancement in functional ability and ease of performing daily activities.

The observed improvements were clinically meaningful and consistent across all participants, with no significant gender differences in outcomes. The overall effect suggests that a 4-week program of water-based closed-chain exercise effectively reduces pedal edema, alleviates discomfort, and enhances lower-limb function in overweight individuals without comorbidities.

## CONCLUSION

The present study demonstrated that a four-week program of water-based closed-chain exercises is highly effective in reducing pedal oedema and improving functional mobility among overweight individuals without comorbidities. The significant decreases in oedema volume, ankle circumference, and pain, together with notable gains in functional performance, highlight the combined benefits of hydrostatic pressure, buoyancy, and muscle-pump activation achieved in the aquatic environment. This intervention provides a safe, low-impact, and easily accessible therapeutic option for individuals who may find land-based exercise difficult or uncomfortable. Incorporating aquatic closed-chain exercises into physiotherapy practice may help prevent chronic venous complications, improve quality of life, and promote overall lower-limb health. Future research with larger samples and longer follow-up periods is recommended to confirm these findings and establish standardized aquatic protocols for oedema management in overweight populations.

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