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Effects of aqua cycling as exercise therapy for lipoedema

Wirkung von Aqua-Cycling als Bewegungstherapie bei der Diagnose Lipödem

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ABSTRACT

In the following overview, the general advantages of movement interventions in water, within the physical therapy options, in the diagnosis of lip- and lymphoedema are addressed. Due to positive experiences in patients with lymphoedema, case reports concerning the use of aqua cycling in lipoedema are presented, which should trigger further investigations.

ZUSAMMENFASSUNG

In der folgenden Übersicht werden die allgemeinen Vorteile von Bewegungsinterventionen im Wasser, innerhalb der physikalischen Therapiemöglichkeiten sowie bei den Diagnosen Lip- und Lymphödem angesprochen. Aufgrund von positiven Erfahrungen bei Lymphödempatientinnen werden hier Einzelfallkasuistiken bzgl. des Einsatzes von Aqua-Cycling bei Lipödem vorgestellt, die weitere Untersuchungen anstoßen sollten.

Well-known physical methods of treating oedema

Oedema is due to the accumulation of water in the interstitial tissues when the transport capacity of the lymphatic system is exceeded. Whenever the lymphatic system is overloaded, the only conservative approach to reducing the oedema and/or the associated obesity is complex decongestive therapy (CDT) [1–3] together with an appropriate nutritional strategy.

CDT encompasses manual lymphatic drainage (MLD) and compression therapy, exercise when wearing compression, diet, and skin care. According to current knowledge, this combination therapy brings only short-lived relief to many patients. CDT has been shown to achieve a 12 % reduction in the volume of the leg [4].

Manual lymphatic drainage has a specific effect on the transport properties of the collecting lymphatic vessels [5]. In lipoedema, for example, CDT reduces only the fluid content and not the number of cells [1].

There is no alternative to liposuction for the sustained removal of fatty tissue in lipoedema. Clinical studies have shown improvement not only in the shape of the body but also in the associated symptoms [1, 6]. However, the greatest changes were seen in the quality of life. Within six months of liposuction, there were significant changes in the associated symptoms (haematoma formation, feeling of tension, heavy tired legs). Manual lymphatic drainage was prescribed following the liposuction. Rapprich et al. [1] demonstrated that lymphatic drainage had satisfactory effects in one quarter of all women presenting for liposuction, but almost half of the patients said that lymphatic drainage had no effect.

Patients are recommended not to have liposuction if they weigh more than 120 kg or have a BMI > 32 kg/m^2 (Quetelet index). Before surgery, therefore, patients should participate in recommended sporting activities and exercises [7], in order to lose weight and lower the BMI.

Exercise is therefore recommended prior to liposuction as well as afterwards. Many types of exercise and sport are not appropriate, as the swelling of the thighs gives rise to changes in gait, which may also have orthopaedic consequences. In addition, most movements have abrasive effects that in turn lead to tissue trauma [4]. The sporting activity should therefore be performed standing or sitting, making controlled cyclical running or walking movements, or in water [1]. The therapist's or trainer's access to the level of exertion and control factors such as heart rate, lactate production, and physiological muscle effort during the exercise session is either not possible or only subjectively possible using the Borg-Scale[1].

Sporting activities produce lactate depending on the performance capacity and therefore, as lactate is part of the lymphatic load, the preferred form of exercise should produce as little lactate as possible. Thanks to the specific effects achieved by submerging the human body in water (immersion), such forms of exercise will be focussed on here.

Physical effects with movement in water

Physical effects achieved by submerging the body in water are also described as immersion effects. They depend on the depth of immersion. It follows that the deeper the body is submerged in water, the greater the effects will be. Immersion effects change with the following fluid mechanical properties: density, buoyancy, hydrostatic pressure, viscosity/resistance, and thermodynamics. The hydrostatic pressure depends on the density of the water and the immersion depth of a cylindrical body, as shown in ▶ **Table 1**. The hydrostatic pressure is therefore high on the lower limbs and decreases progressively towards the surface of the water.

The pressure compresses tissue structures. This causes a redistribution of the blood, displacing it from peripheral to central (500–700 mL) [9, 10], which is associated with an increase in stroke volume and cardiac output with a simultaneous reduction in heart rate [11].

Explaining things with the Frank-Starling mechanism, there is an increased preload as seen with the orthostatic reflex. There is a central nervous system-regulated economisation of the cardiac activity. At the same time, the increased central volume leads to increased diuresis through opposing hormonal regulation (renin-angiotensin-aldosterone system (RAAS)) [11]. This diuresis is induced by atrial natriuretic peptide (ANP) [10, 12, 13] released in a reflex response to the stretching of the atrium. This hormone plays a crucial role in the RAAS to regulate water in the body. It lowers the blood pressure and stimulates the renal elimination of sodium chloride and water, which means that less fluid is retained in the interstitial tissues [12]. The kidneys also retain less water, as the secretion of antidiuretic hormone (ADH) is inhibited. This in turn leads to greater diuresis [10, 13], known as 'immersion diuresis' to divers.

1 The Borg scale is used to determine the subjectively perceived exertion. Borg [8] showed that his rating of perceived exertion (RPE) has an association with heart rate.

▶ **Table 1** Relationship of the immersion depth pressure in bar and the pressure in millimetres of mercury to explain the load on the atrium

Immersion depth (m)	Pressure (bar)	Pressure (mmHg)
0.1	0.1	75
0.2	0.2	150
0.3	0.3	225
0.4	0.4	300
0.5	0.5	375
0.6	0.6	450
0.7	0.7	525
0.8	0.8	600
0.9	0.9	675
1.0	1.0	750
1.1	1.1	825
1.2	1.2	900
1.3	1.4	975

A high ANP concentration leads to an increase in ketone production [14,15]. According to Birkenfeld et al. [15], this has a lipolytic effect that increases the metabolism of fatty acids in the muscles and transports more free fatty acids out of the adipose tissue. As a result, aqua cycling causes greater mobilisation and oxidation of fat [16].

The hydrostatic pressure also has an effect in promoting resorption [17]. In the case of oedema of pregnancy and oedema of renal origin, it has been shown that the flow of fluid from the interstitial tissues to the capillaries and lymphatic vessels is increased, thus removing water from the tissues and reducing oedema [9].

Water also conducts more heat than air (25-times greater conduction). We can therefore assume that the body will require more energy to maintain core temperature and there will thus be a greater energy requirement.

The buoyant force is an upthrust acting against gravity corresponding to the volume of water displaced by the body. The buoyancy tangibly supports the weight of the body; this effect is enhanced as immersion increases and is associated with relief of the postural and locomotor system.

The viscosity of water is 800 to 1000 times greater than that of air [18]. It determines the resistance against movement. With increasing acceleration/speed, turbulence arises behind the moving parts of the body due to the viscosity (bonding between water molecules). This turbulence is chaotic and develops an eddy that acts in the opposite direction to the movement. A dual effect is thus seen: the resistance and thus the training effects are increased and the turbulence has a pulsating mechanical effect on the lymphatic tissue.

Effect of moving in water on oedema

The benefits of aquatic exercise therapy were demonstrated by Gianesini et al. [19] with a specific exercise programme. It aimed to show that muscle pump activity positively affects chronic oedema of the lower limbs. Sixteen patients (12♀, 4♂) showed a mean reduction in the volume of the lower limbs: 303.13 ± 69.72 ml ($p = 0.00002$) and 334.38 ± 62.50 ml ($p = 0.000003$) in the right and left leg, respectively, one week after the end of the intervention. The range of motion at the ankle and the feeling of heaviness in the legs improved significantly. The study showed that movements which are painful on land and might even lead to skin injuries could be carried out in water to the patient's benefit.

A systematic review that included 11 randomised controlled trials [20] looked at the effects of various types of exercise on breast cancer-related lymphoedema (BCRL), to ascertain the role of training in this patient group.

The 458 subjects performed various types of exercise. The exercise programmes were divided into aqua lymphatic training, swimming, resistance training, yoga, aerobics, and gravity training. Four of these studies found a significant reduction in the BCRL status based on measurements of the arm volume; seven studies reported significant subjective improvement. None of the studies showed that the training had a negative effect on BCRL.

Special features of aqua cycling

Aqua cycling is like riding a bicycle in water, comparable to using an exercise bike (ergometer) on dry land. An exercise bike in water can be set to different depths and individual body proportions. The saddle has a narrow sporting shape. The handlebar is reminiscent of the various grips available with spinning bikes. Riders wear shoes and fix their feet lightly in the toe clips of the pedals. The resistance is adjusted by the size and the distance of the resistance plates from the centre of rotation (▶ **Fig. 1**).

The depth of water in which patients sit for aqua cycling should come up to a level between the navel and the sternum. Women with the clinical picture of lipoedema often have less experience with regard to sports or exercise due to their increasing physical symptoms. The sitting depth of water ensures that enough of the body mass is still above the water level and the coordination of the body is in the autonomy of the person training.

Cycling has the advantage that there is no abrupt backwards movement and, with the person sitting on the saddle, the legs are not bearing the weight of the whole body. Aqua cycling increases this advantage in that the greater part of the body, especially the part affected by lipoedema, is below the surface of the water. The physiological effects of immersion can thereby be exploited. The great advantage of aqua cycling over other forms of exercise in water is that a considerably higher frequency can be used without a reversal point.

▶ **Fig. 1** Aquarider AP500

Effects of aqua cycling

Rewald et al. [21] carried out a meta-analysis on the benefits of aqua cycling (▶ **Fig. 2**). They included 63 publications. Thirty-one of the studies compared aqua cycling with riding on an exercise bike. Only six studies evaluated the effects of aquatic cycling interventions. Most of the studies addressed metabolic differences between cycling on land and in the water. The interventions tested different protocols with respect to the physiologic effects (stress parameters, reduction in weight, strength). Four studies reported a significant improvement in the cardiorespiratory parameters compared with baseline in healthy obese people and patients with multiple sclerosis [22–25]. Aqua cycling and cycling on dry land gave rise to comparable improvements in the cardiorespiratory parameters. In addition, moderate land and aqua cycling units gave similar results in the health-related quality of life and self-reported physical exhaustion in patients with multiple sclerosis. None of the studies contained any physiological aspects of medical conditions with oedema.

Individual case reports on aqua cycling in lipoedema

In his bachelor's thesis, Becker [26] investigated whether aqua cycling in addition to the usual physiotherapy measures improved the reduction in oedema. Ten patients with lipoedema/lipolymphoedema were divided into two groups (intervention $n = 5$, controls $n = 5$) for ten weeks. Both groups were treated with MLD once or twice a week. The intervention group additionally had aqua cycling once a week. The effects of treatment were evaluated by measuring the circumference according to Kuhnke [27] to determine the volume in a before/after comparison.

A direct comparison of the mean of each leg showed a clear volume-reducing effect of 266.37±435.60 cm3 in the intervention group, while there was a volume increase of 439.95±1246.90 cm^3 in the control group (MLD only). One subject in particular contributed

▸ **Fig. 2** Example of an aqua cycling exercise session

to the average volume increase in the control group: the volume of her legs increased by 2060 cm3 (left leg) and 3105 cm3 (right leg). Becker voiced the suspicion that the subject had not been wearing her compression stockings regularly.

Also in the context of a bachelor's thesis, Kronimus and Lampe [28] investigated three individual persons also for a period of ten weeks. They tested whether aqua cycling had a volume-reducing effect on lipoedema. Data was collected using the Bodytronic® 600, a clinical examination, a specially designed questionnaire, and the 36-item short form survey (SF-36), before and after a standardised course of aqua cycling.

Two of the three patients showed a reduction in the overall leg circumference (VP1 = −58.9 cm, VP2 = 4.2 cm, VP3 = −19.8 cm), in weight (VP1 = −5 kg, VP2 = 1.1 kg, VP3 = −5.1 kg), and in pain (VP1 = −7, VP2 = −2, VP3 = 1) in the oedematous area. Two patients reported a better health-related quality of life on the SF-36 (VP1 = $6\,\%_{physical}/10\,\%_{psychological}$, VP2 = $2\,\%_{physical}/20\,\%_{psychological}$, VP3 = $6\,\%_{physical}/\text{-}5\,\%_{psychological}$).

The observations made in these theses show positive effects of aqua cycling, so that further studies should be carried out on larger populations.

CONCLUSIONS

The physiological changes that arise in the body from immersion indicate consistently positive aspects from exercise in water for all medical conditions with oedema. Taking possible disease-related restrictions such as reduced mobility into consideration, it can be seen that exercising on a bike in the water (aqua cycling) is to be encouraged. The circular pedalling motion exploits the possibility of using the viscosity as well as the water depth as a means of dynamic compression. With appropriate didactic concepts aimed at using the method specifically in lymphoedema patients, there is a possibility of supporting self-management in those affected.

With a targeted structure of the sessions, beginning by working on an upright posture and correct breathing, it is also possible to set individual exercise parameters in clients with obesity.

A further aspect of the immersion procedure with simultaneous exercise is that the lactate concentration shows dynamics that are different in water from on land [16]. Its production curve is flatter. The values in water are significantly lower than when training on land. As an accumulation of lactate inhibits ketosis and thus fat metabolism, this knowledge helps us to ensure effective training for reducing obesity [29]. The demonstrated rise in ANP [16] indicates that there will be increased diuresis.

We can therefore define the following questions to be addressed in future studies:

- If the lactate curve with incremental tests is different in water from that seen on dry land, do the dynamics follow other model relationships?
- Can the previously suspected effects, both physical and psychological, arising from the AquaFitnessClub didactic concept also be confirmed empirically?
- Can general goals for appropriate self-management be formulated for patients with oedema?

In terms of systematisation of the subject, it is important that physiotherapists and sports scientists are offered well-founded courses at the interface of sports sciences and lymphology to become aqua cycling trainers.

Conflict of interest

The authors declare that they have no conflicts of interest.

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