Aquatic Therapy: a valuable intervention in neurological and geriatric physiotherapy. A narrative review.

Sanne Lambeck[1], Johan Lambeck[2]

[1]Physiotherapist, Sint Maartenskliniek in Ubbergen/Nijmegen, Netherlands .
[2]Physiotherapist, Association IATF in Valens, Switzerland. lambeck@freeler.nl , Linkedin

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... hydrostatic pressure and heat affect cerebral vascular function ...

... only 30 to 50% of the speed is required to have a comparable energy consumption ...

... exercise in water is an important stimulus for angiogenesis ...

... water is an anti-inflammatory environment, with positive neurotrophic effects ...

Abstract

Aquatic therapy has long been a valuable resource that we should not lose sight of. There are also many interesting developments in this form of therapy, also well justified for the neurological and geriatric patient. Training of fall prevention, aerobic capacity and

influencing neuroplasticity (and the associated (anti) inflammatory processes and cognitive tasks), using the possibilities offered by aquatic therapy, will be discussed below.

Introduction

The treatment of the geriatric patient is usually aimed at self-reliance and participatory physical functioning (1) by, among other things, offering exercises to prevent falls when standing or walking. Possible dysfunctional systems that can be addressed are the myofascial system, the cardio (cerebro) vascular system, the immunometabolic system and the neurocognitive system. This narrative review provides an overview of the effects that immersion and exercise in water can have on the above systems to support the evidence-based decision that the geriatric physiotherapist makes about the choice to include aquatic therapy in the treatment plan.

A large number of systematic reviews and meta-analyses have now been published on aquatic therapy in the elderly (with a disease): since 2015 on stroke (2, 3, 4, 5, 6, 7), Parkinson's (8, 9, 10, 11 , 12), MS (13, 14), neurology general (15) and elderly general (16, 17). The general conclusion is that aquatic therapy is effective, but has a moderate effect size compared to therapy on dry land, which is sufficient to include aquatic therapy in a treatment plan. But in 2017 Cumming published the report “The health & wellbeing effects of swimming” on behalf of Swim England (18). In Chapter 1 on the physical health benefits, the author concludes: “The unique nature of the aquatic environment as a medium for exercise and physical activity has been comprehensively described. What is evident is that water-based exercise can confer a number of specific advantages, as compared to land-based exercise. Water-based exercise prescription should be a key consideration for health care clinicians and commissioners ”. The Dutch physiotherapy guideline for stroke also endorses the usefulness of aquatic therapy for improving muscle strength of the paretic leg in patients with a chronic stroke, with recommendation level 1 (19). It must be said that literature was used until 2012. Much more has been published since, strengthening the evidence.

We agree with Cumming's conclusions and the Dutch guideline. In our opinion, the poor results of the reviews and meta-analyzes are partly due to exercise programs in which the stimulus to adapt a tissue or system was insufficient, resulting in moderate treatment results. The dosage and type of exercise described in the present review were not used in most of the publications and should be helpful when designing aquatic programmes.

Increase cerebral blood volume during immersion

The hydrostatic pressure when standing or sitting in water up to chest height causes peripheral venous blood to move to the mediastinum (the effect of compressive stockings) within seconds. The result is an increase in cardiac output of approximately 30% (20) with an increase in cerebral perfusion of approximately 7%, in combination with an increase in the flow rate in the supplying arteries. This was measured in 2014 by Carter in the median cerebral and posterior cerebral arteries (21). Tarumi in the same year pointed out the importance of cerebral blood flow for cognitive functions (22).

The increase in flow rate also increases shear stress between the endothelium of the vessel wall and the moving blood , the stimulus for an elevated expression of eNOS (endothelial nitric oxide synthasis), an enzyme that catalyzes the production of nitric oxide (23). The result is a relaxation of smooth muscle fibers in the vessel wall, leading to vasodilation. The repeated immersion resulted in a sustained increase of eNOS with an adjustment in cerebral vascular compliance.

Immersion has an effect on the autonomous nervous system. Mano in 1985 had already linked hydrostatic pressure to a decrease in heart rate and a decrease in sympathetic activity: the deeper in the water, the more the decrease (24). Recent literature confirms this and indicates that temperature also has an influence: between about 30^0 C and 37^0 C the sympathetic activity decreases (25). The immersion effect on the parasympathetic nerve can also be measured, usually as sympathovagal balance, expressed in a number for the heart rate variability (HRV). HRV indicates the variation between the time intervals between consecutive heartbeats. The higher the variation between time intervals, the better the sympathetic and parasympathetic systems work in harmony with each other. lowering stress. Hildenbrand found little difference between the elderly and the young in HRV when immersed in different temperatures: 31^0, 36^0 and 39^0 C. (26). HRV increased with immersion temperature, which is partly explained by a higher parasympathetic activity. The higher - afferent - parasympathetic activity is primarily related to the regulation of hormonal volume homeostasis via the pituitary gland, which increases diuresis (20) and is temperature dependent (27).
A higher HRV is associated with an increase in prefrontal cortical activity (28, 29) and with faster reaction times and fewer errors during executive tasks (30). Stimulation of the vagal nerve (which plays an important role in the parasympathetic nervous system) improves working memory function (31) and decision making (32).

In addition to this bottom-up relationship, there is also a top-down relationship (33): activity of the prefrontal cortex influences HRV. The prefrontal cortex is an important structure for executive functions. The involvement of executive activities in aquatic therapy makes sense: it enhances the effect of immersion on the autonomous nervous system. We will come back to this relationship in the section on exercise.

In conclusion, there are indications that hydrostatic pressure and heat positively influence cerebral vascular function and areas of the brain involved in executive functions through different pathways.
For the effects of immersion on the function of the heart, lungs and kidneys, we refer to the extensive review by Pendergast (20).

Training aerobic capacity: "what is good for the heart is good for the brain".
As already mentioned, cardiac output increases during immersion up to the collarbones; it is independent of the body position. At normal water temperatures in an aquatic therapy pool between 30^0 and 34^0 C, heart rate is the same or slightly decreased compared to land. This means that the stroke volume, even at rest, is exposed to a – small - training stimulus. This higher stroke volume persists during (submaximal) exercise, provided the pumping function of the heart is not compromised. With a lower movement intensity (for example measured in Watts) the same physiological effects can be achieved as on dry land (for example measured in % maximum oxygen uptake)

In that case, the large body of literature is unambiguous: the physiological adaptation mechanisms of aerobic training are the same when training in water as on dry land, also according to the reviews by Hall (34) and Pendergast (20). This means that people who cannot or with difficulty train on land (for example due to stiffness, pain, obesity, danger of falling, fear of movement) can do so in the water, as for example in the recommendation of the American College of Sports Medicine (35) or in the Canadian best practice recommendation on aerobic exercise after stroke (36).
The reviews by Daly (37), Bergamin (38) and the meta-analysis by Waller (17) show that even healthy elderly people have better effects on aerobic capacity from training in water than from training on land, although the effect size is small

Energy consumption during movement in water depends on the buoyancy force and the resistance of the water. The resistance increases quadratically with the speed. Both depend on the depth that is used. When standing and jumping, relatively little energy will be required for the anti-gravity musculature at sufficient depth. Walking or jogging in water shows that only 30 to 50% of the speed on dry land is needed to have a comparable energy consumption (2.6 to 3.5 versus 5.5 to 13.4 km / h) (39). Since the energy consumption changes by the third power of the speed, the energy consumption can also be reduced very easily and quickly when the speed is reduced. This means that people can practice longer and with a higher dose before they are (too) tired, so they can repeat more often in the sense of distributed or massed practice.

Also important is that cerebral blood flow increases with the amount of exercise. In healthy subjects, Pugh compared exercise in water and on land with comparable oxygen use (40). The flow velocity in the middle and posterior cerebral arteries was 8 to 10% higher in water (see Figure 1). Parfitt found a similar flow velocity in the middle cerebral artery when walking on an underwater treadmill at a speed of 4 km / h or when running on a treadmill on dry land at 65% of VO2 max (41). As already described, there is a relationship between flow velocity, endothelial shear stress and release of eNOS, among others, during immersion. This relationship is maintained during exercise (42): “what is good for the heart is good for the brain”.

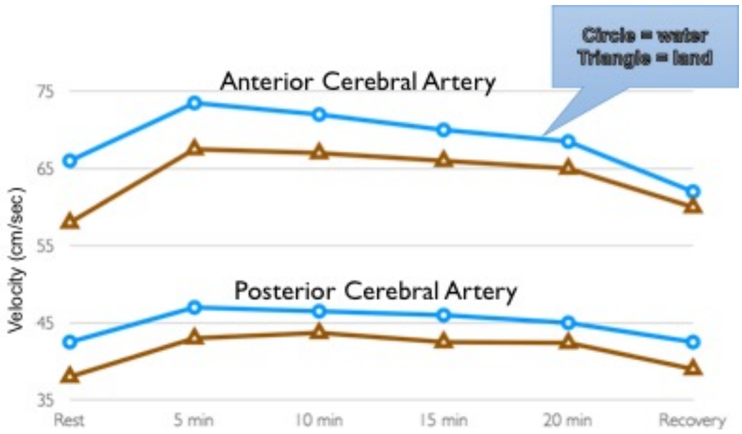

Figure 1. Exercise on dry land and in water with the same intensity (on a bicycle ergometer) results in a significantly higher blood flow in water in the two cerebral arteries (with a higher flow rate). Pugh, 2015 (40), version B. Becker, 2018, with permission.

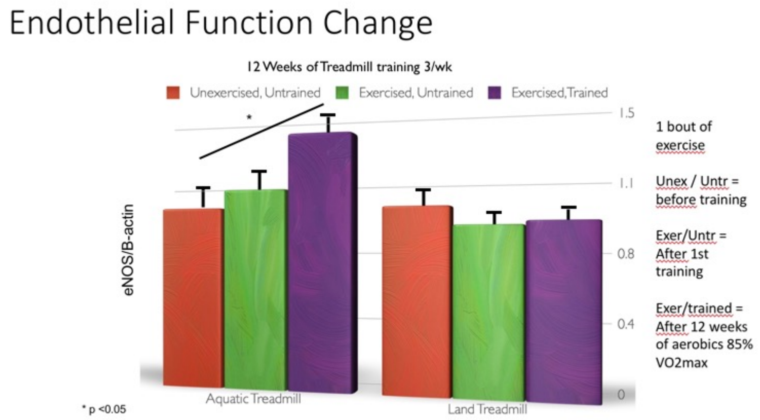

Figure 2. This graph shows that there is a significant increase in eNOS after 12 weeks of training in water compared to training on land at the same intensity. Lambert, 2014 (42), version B Becker, 2018, with permission.

The flow rate initiates endothelial changes. This results in a decrease in the stiffness of the arterial wall, important for the regulation of blood pressure. In water, the diastolic blood pressure is about 15% lower than on dry land, the systolic and mean arterial blood pressure change somewhat too (but does not increase!) (20). The long-term effects of training in water and training on land are comparable (43).

Anti-inflammatory and neurotrophic effects

Movement in water has effects on the immuno-metabolic system, especially on the relationship between glucose metabolism and immune processes in the central nervous system.

Neuroinflammation is an inflammation of nervous tissue in which the immune system of the central nervous system becomes chronically active and the expression of growth factors such as the brain-derived neurotrophic factor (BDNF) is reduced. This process is linked, among other things, to various neurodegenerative disorders with loss of volume and function of brain structures such as the hippocampus (44). Neuroinflammation can also arise in chronic low-grade inflammation and is partly related to age - inflammaging (45) - in combination with, for example, a passive lifestyle (46), resulting in insulin resistance (47, 48). Chronic pain is also neuro-inflammatory (49). Neuroinflammation is linked to cognitive decline. Brain structures related to executive functions show a greater number of markers of neuroinflammation than, for example, the primary motor or sensory cortices. (50). Neuroinflammation in neurodegenerative disorders is associated with insulin resistance in the brain (51).
In addition to the dysregulation in insulin metabolism, there is also an imbalance between pro-inflammatory and anti-inflammatory cytokines, such as the interleukins IL-6 and IL-10.

But the imbalance also exists between other cytokines such as leptin and adiponectin. Leptin concentrations are linked to the amount of adipose tissue. The large amount of literature clearly shows: there is a marked relationship between (problems of) the metabolic system and the immune system. Strengthening the immune system with positive effects on the (glucose) metabolism takes place partly through exercise (52). Meijer adds that exercise is only effective when patients themselves combine kinetic, sensory, cognitive and social challenges in the sense of environmental enrichment (53).
Environmental enrichment was also used in another context by Krakauer: in the early rehabilitation of arm function in stroke patients, he used virtual reality with the key words high-dose, playful, movement exploration (54). It is about movement: exercise is a must and is good for the brain (55).

Anti-inflammatory effects have been shown when training muscle function. Training produces an inflammatory response, characterized, among other things, by an increase in the amount of cytokines (IL-6 and IL-10) and of BDNF, both locally and systemically. BDNF has a neuroprotective, anti-inflammatory function (56), but is also involved in the energy metabolism , in particular of cells in the central nervous system.
The increase depends partially on the number of active muscles, the training time and the intensity of the training. This means that in research both “normal” aerobic training is used, with a measurable increase in BDNF from 70% VO_2 max, and high intensity interval training (or Tabata) (57). Kang found that a 16-week aerobic exercise in healthy elderly people (intensity up to 70% of the VO_2 max) showed an increase in BDNF, linked to better memory function (as part of executive functions, measured by the MMSE) (58) .
BDNF has a central role in brain plasticity due to physical activity and environmental enrichment, which increase the amount of BDNF in the serum as well as in the brain. Håkansson found that the serum BDNF level increased clinically significantly after an intensive exergame activity with an RPE between 11 and 13. This was also significantly correlated with working memory activity (59).

Exercise in water also increases anti-inflammatory cytokines and BDNF, along with a decrease in pro-inflammatory cytokines. The first clue came from a study of swimming rats with diabetes by Teixeira (60). Results were that regular exercise in water (3 times a week for an hour for 8 weeks) significantly decreased the pro-inflammatory cytokines IL-6, TNF-α, CRP and increased in the anti-inflammatory cytokines IL-10, IL-4.

Pochmann, in her paper on modulation of cytokines in Parkinson's, mentions that water is an anti-inflammatory environment, which weakens the immune response. The immune response is the increased activity of the pro-inflammatory part of the immune system. In this study, aerobic training (60% of VO_2 max) and resistance exercises (2x / week, 60 min) were performed, based on ACSM guideline, supplemented with playing (61).
There is an inverse relationship between pro-inflammatory cytokines and growth factors such as BDNF (62). Bansi found that aerobic exercise in water at 60% of VO_2 max in patients with MS significantly increased the amount of BDNF after 6 weeks (63). In an aerobic training group on land, the amount of BDNF did not change, in line with Cabral (57) and Kang (58).

Ayan showed the same relationship between - the changes in - Insulin-like Growth Factor (IGF-1) and the trail making test in young elderly people after an exercise program in water

(64). The trail making test measures cognitive flexibility, one of the executive functions. Poor results on the trail making test are correlated with poor performance on an obstacle course (65).

In conclusion, there is evidence that neurotrophic effects in water occur at moderate aerobic intensities, which is of interest in individuals who are - musculoskeletally - impaired in increasing movement intensity. There is a link with training cognitive / executive functions that can also be trained by moving in water.

Neuroplasticity
Neuroplasticity is the nervous system's ability to respond and adapt to environmental conditions. This includes a series of functional and structural mechanisms involving neural and neurovascular reorganization: synaptogenesis, neurogenesis and angiogenesis (66). Angiogenesis is necessary for the other adaptations: supply of blood is necessary for neuronal processes, stimulated by BDNF and the vascular endothelial growth factor (VEGF) (67). Exercise is an important stimulus for angiogenesis and exercise in water has an added value because of the aforementioned effects on the cerebral circulation. It may be assumed that movement is essential as the ultimate basis for (sensorimotor) neuroplasticity. Movement is motor learning and was already described by Schmidt and Lee in 1999 as: "The realization of a - relatively permanent - change to skilled motor behavior, resulting from exercise, adapted to the characteristics of the environment, linked to error detection" (68). When we apply error detection to (re) learning balance skills, a pool is ideal. For example, a balance error might mean a stumbling reaction: necessary in ADL. Tripping is a must (69): error-augmented learning processes increase neuroplasticity and the re-acquisition of skills.

Movement must be meaningful; depending on the environment. An enriched environment, as described earlier in this article, has enormous behavioral and neurobiological consequences (70, 71, 56). The elements of environmental enrichment are: (moderate) intensive exercise, social contact, learning something new, being challenged, movement exploration, modulation of attention, somato-sensory stimulation, solving a problem. In one phrase: play and get tired!. This is perfectly possible in water: intensive movement games in a safe way, coupled with training of balance for posture and gait. Moreover, when this is accompanied by successful experiences (succeed in jumping or walking fast, patient tripped but didn’t fall, movement hurts less, someone is nicely tired) this is also good for self-efficacy, embodiment, resilience, pleasure and other for example in the “positive health model” (72).

Executive functions
Some elements of environmental enrichment belong to the executive functions (EF). These are cognitive control processes of task-oriented actions and adjustments of (movement) behavior in complex or new situations (73). Numerous sub-functions have been described, usually in three main categories:

- Cognitive flexibility: making an alternative planning / solving problem.
- Response inhibition: slowing down or stopping behavior / attention modulation, concentration.
- Using the working memory: select information and hold it temporarily.

Executive functions are located anatomically in the prefrontal cortex in particular, on which the vagal nerve also projects. The literature establishes a relationship between executive functions with reaction speed (74), maneuverability or motor agility (75, 74), negotiating obstacles (65), walking with dual tasks (65) and in a more general sense; instrumental ADL (76).

Since 2012, various articles have been published about executive functions and movement in water. Abou-Dest compared the differences in the EF between a group of elderly people who regularly swim and a group of people with a mainly sedentary lifestyle (77). Effect sizes on tests measuring EF in favor of the swimming elderly averaged 1.23 (Cohen's d). No correlation was found with aerobic capacity. This was confirmed in a follow-up study by Albinet (78). Water aerobics and swimming at 40-65% of the heart rate reserve were compared with a stretching program. There was only an increase in EF in the group assigned to aqua aerobics and swimming, strongly correlated with heart rate variability, i.e. with sympathovagal balance (which improves during water immersion). Again: no relationship with aerobic capacity. Sato (79) and Kang (80) looked at EF in two forms of water exercise in independent elderly people and people with mild dementia respectively. In the randomized groups, either a simple program was offered or a “water cognitive” program with elements such as: dual tasks, social contact and play. Both authors concluded that the EF changed significantly better in the water cognitive group. Kang offered his program with an intensity between the 10 and 13 of rate of perceived exertion (RPE). Fedor used a comparable intensity of 60-70% of the maximum heart rate (81). He compared the EF between a usual care group and a group that exercised six times an hour of aerobic exercise in the water in only one week, with significant changes in the EF. The control group did not change. Less intensive forms of movement are also effective. Bressel found that healthy older adults made between 111-192% more listening errors in an auditory double task while standing on land in a “staggered” position (one foot diagonally behind the other) compared to standing staggered in chest-deep water (82). Nissim used Ai Chi (active relaxation with standing balance tasks in the water) and compared this to T'ai Chi (83). There was a clear difference in both working memory and balance (measured with the POMA) between the two groups in favor of Ai Chi.
In summary: the possibilities for exercising executive functions are at least as good in water as on land. In addition to the regular reasons: the possibility to exercise and play aerobically (exergame). The extras are: the increased parasympathetic activity, the higher cerebral blood flow, the anti-inflammatory environment and the high probability that neurotrophic factors increase in water at lower intensities. The amount of research is still small, but promising.

This also applies to the effects of exercise in water on dementia. Myers published a spectacular case study on a mostly non-responsive Alzheimer patient through modified Halliwick and Watsu. A quote from the article: “The patient continued to perform aquatic therapy exercises at increasingly advanced levels over the subsequent 3 months, and he eventually could obey a command to walk in the water to the edge of the pool, retrieve a pool toy, and bring it back to the aquatic therapist. Staff noticed that for 2 to 3 hours after his aquatic therapy sessions he was smiling more and talking more clearly without his usual trouble finding words. He even joked with the staff” (84). Aquatic therapy of this patient can be viewed at https://www.youtube.com/watch?v=aQP1p8lWQys . Modified Halliwick was

also used in another case study of a patient with end-stage Alzheimer's disease. Again, aquatic therapy resulted in better and adequate communication, as well as less assistance with transfers and going (85).
The literature is further limited. In addition to the research by Kang (80) already discussed, there are two publications by Neville (86) and Henwood (87) about the Watermemories Swimming Club in Australia. This is a general program with elements of stamina, strength, flexibility and balance. Positive effects on psychological factors, well-being and pleasure have been described. A well-described intervention - Aquamentie - combines Halliwick and Ai Chi with the environmental enrichment and stimulation of executive functions described above (88). Van de Rakt has also published an extensive description of the practical possibilities in water, based on the concept of Waterspecific Therapy-Halliwick (89).

Balance skills and fall prevention
Fall prevention is an important exercise goal for people with balance problems. There are many causes that ultimately have to be tackled in a tailor-made program. Aquatic therapy can be a part: the environment is safe and all kinds of elements of fall prevention can be practiced. Clinically relevant changes in outcome measures such as the Berg Balance Scale (BBS), Tinetti's POMA test or the Timed Up and Go (in the sense of Minimal Clinical Important Change / Improvement or Minimal Detectable Change) are numerous, recent examples are Aidar (90), Silva (91), Clerici (92), Ku (93) and Temperoni (94). Aquatic therapy has even better effects than dry therapy according to Iliescu (5). Her systematic review showed this clinical message: “There is strong evidence that aquatic therapy is more effective than land-based therapy alone for improving aspects of mobility and balance post stroke”. Pinto's conclusion in his meta-analysis on aquatic therapy in Parkinson (PD) patients is that “Aquatic therapy may be an excellent alternative for individuals with PD who lack confidence to perform movement tasks, have postural instability, and a high risk of falling” (11) . A very recent meta-analysis by Kim is about the comparison of aquatic therapy and land-based therapy of dynamic balance in the elderly, with and without disabilities (95). Ten randomized trials were included, of which 5 on PD and 5 on healthy elderly people, osteoporosis or heart complaints. There was no subgroup analysis for PD, so Kim concluded in general that the effect measures of aquatic therapy compared to therapy on land are on average slightly larger for dynamic steady-state equilibrium, proactive equilibrium and equilibrium on a test battery.

The first good publication about fall prevention was by Simmons (96). This randomized trial had four arms: sit in water, sit on land, exercise on land, and exercise in water. The average functional reach at the start was between 21.6 and 23.1 cm. The functional reach in the two groups that sat was on average between 23.6 and 24.4 cm at the end. The land exercise group scored an average of 28.7 cm and the water group had a score of 34 cm. A few important parts of the program were:

- Walking with knee lifts: necessary to be able to step over obstacles and practice recovery steps (97). Training adequate recovery steps (long and high steps) is important so that feet can be placed sufficiently in front of the body's center of gravity to increase the support surface, in combination with the push-off force of the supporting leg (98). The buoyancy of the water helps with this.
- Walking sideways with cross-over steps: necessary with medio-lateral loss of balance.

- Getting up on the toes: training muscle power of the calf muscles
- Making circles with the pelvis: moving the body's center of gravity.

The hypothesis behind the large change in functional reach in the water was that the subjects could make larger movements of the body's center of gravity without fear of falling, but also that balance errors were made that contributed to updating the posture control. Meanwhile, we find more topics important, but this still rarely used in aquatic therapy (research):

- practice with dual tasks
- use unexpected perturbations; let people stumble or trip
- jump and run: agility
- gait variability: dare to walk in all kinds of (fantasy) ways
- go and stand with a narrow base
- keep balance without additional use of the hands and arms
- fitness training as part of fall prevention
- use executive functions during movement tasks

When learning new motor strategies, someone needs (a lot of) time for feedback: water gives that feedback time to react. This slowness, together with safety, also gives the therapist time to wait for balance adjustments to “show up”.

Functional and challenging tasks involving executive functions can sometimes be better practiced in an environment that is less dangerous than dry land, where there is less risk of falls and injury, and also providing more participation and compliance (99, 100).

Aquatic therapy enables to start movement training at an early rehabilitation stage, when there are still major problems with upright against gravity. Tyson found that the main reasons for low dose and intensity in stroke units were pain, fatigue, and concentration (101). We hypothesize that the factors pain and fatigue are less prominent in aquatic therapy, supported by Tripp, who used Halliwick therapy in early rehabilitation. He found clinically relevant differences compared to the land group on the Berg Balance Scale and the Functional Ambulation Categories (102). Early start is an important predictor for later stage participation. And logically this is also an advantage for the early use of all tissues and thus prevent disuse as much as possible. Water is ergonomic for the therapist too: it supports the patient.

A study by Lim about energy consumption in people with a stroke shows lower energy consumption when walking at a self-selected walking speed in chest-deep water, which means that longer practice sessions are possible (103). Exercising in shallower water however results in an increase in energy consumption, equaling energy consumption when walking on land (at the same walking speed). In addition to walking speed, the water depth in which one walks is therefore also a variable in cardiac load, as has also been argued before.
Also, group activities in water are safe and economical: treating and challenging persons mentally and physically needs less therapists. The pleasure that comes from being able to move and play with little risk, for a longer period of time, is important. Success experiences and self-confidence that often go along with this also form an important basis for the

positive influences such as reducing depression and anxiety (104, 105). In addition, patients often state that after an aquatic therapy session they sleep better and feel more relaxed. A 2019 study also shows that persons with PD who participated in an Ai Chi program not only scored lower on depression scales and pain scores, but also better on quality of life (SF-36). These results were still measurable one month after the intervention (106).

It is therefore important to gain a lot of challenging exercise experience at the limits of balance, preferably in a rich / varied and inviting environment (107) at moderate intensity. Moreover, because of the continuous movement of the body's center of gravity in water, more than on land, the motor cortex is quickly activated. This also applies to the sensory cortex, due to water pressure, flow and temperature (108).

Figure 3. Concentration during a difficult dual task appeals to executive functions.

Figure 4. The therapist unexpectedly withdrew the hands and the patient quickly initiates a solution to the balance problem.

Figure 5. The patient quickly walks over the obstacles. Moving water limits visual control and appeals to working memory (where were the obstacles about).

Figure 6. Gaining movement experience at the limit of balance, in a safe environment, by using a reaching pole. This also facilitates extension.

Priming effect of aquatic therapy
Aquatic therapy is intended to carry-over to land with measurable effects. These effects exist as described in detail in this article. A phenomenon that has only recently emerged in literature is conceptual motor priming by aquatic therapy. Priming is preparation to make associations; a reinforcing intervention in which a change in motor behavior is based on previous stimuli. In concrete terms, this would mean that it makes sense to repeat on dry land what has been practiced in the water. This has recently been confirmed by Sato (29). He found that (even) passive immersion provides cortical inhibition of the cholinergic area of the prefrontal cerebral cortex. This area is important in memorizing a visual motor task. After immersion, the cholinergic activity increased again and with it the ability of the cerebral cortex to retain. Although the evidence is still very limited, Sato concludes that immersion in water facilitates movement on land.

Summary
Aquatic therapy is a well-known intervention that now has a large body of knowledge. The effects of the hydrostatic pressure are the basis for important homeostatic adjustments in the brain circulation. As a result, there are neurotrophic effects (such as an increase in anti-inflammatory cytokines and BDNF) that partly form the rationale for exercising e.g. executive functions as part of postural and movement motor skills. This can be important in the context of fall prevention. Water lends itself well to gaining a lot of movement experience (variability), whereby the boundaries of balance can be explored, in a safe and rich environment. Physiological stimuli on land and in water are comparable, if not better in water, which is important for people who have difficulty in achieving this training stimulus on land.

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