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Health benefits of immersion and therapeutic aquatic exercise in swimming pools and spas in health care

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Contents

1. Disclaimer

2. Introduction

This chapter is a narrative review of the health benefits derived from therapeutic interventions **in** water and includes both active (therapeutic aquatic exercise; TAE) and passive immersion treatments. Literature in which immersion and TAE have been combined mostly refer to balneotherapy or (inpatient) rehabilitation. TAE more typically is presented in literature as a stand-alone treatment for outpatients. Especially in musculoskeletal diseases, a dichotomy can be found in literature: TAE versus balneotherapy. Therefore we followed this dichotomy in the musculoskeletal section. Other sections are about TAE, realizing that these exercises can take place in water of various chemical compositions.

Balneotherapy is defined as using thermal mineral water and other natural factors (mud, gas) for treatment and rehabilitation. It is commonly used as bathing (water immersion), but interventions with active movement can also be included.

TAE can be defined as an intervention utilizing the mechanical and thermal characteristics of water during immersion , in combination with the effects of movement, aimed at a systematic approach to treat a health problem. Both balneotherapy and TAE evoke short-term and long-term adaptation mechanisms of a person with a deranged biological system (World Confederation of Physical Therapy – Aquatic Physical Therapy International network; WCPT-APTI).

Comparisons with dry land interventions have not been made due to the limited space available. A comprehensive systematic review is planned to be conducted at a later stage

We have primarily focused on persons with a medical diagnosis as described in the ICD-10 and their resultants effects (as described in the ICF)., but have restricted ourselves to diseases, which have been presented in aquatic research literature sufficiently.
The description is based on searches in health care databases (Pedro, Pubmed, Embase, Cochrane central, Cinahl) in the period May 2012 – October 2012.

We have also added a subchapter on aquatic activities for individuals without a health problems as described in the ICD-10. In this text we have focused on possibilities to maintain health in individuals whose health is endangered by lifestyle or age.

The description of the levels of evidence is based on the table of the Oxford Centre of Evidence Based Medicine (OCEBM, 2011), categorize studies to reflect the degree to which the evidence is flawed. This chapter mostly has been able to present results with evidence levels of 1 to 3. The annotation will be mostly as [1], [2] or [3].
OCEBM describes the levels, related to treatment benefits, as:

- level 1: systematic review of randomized trials or *n*-of-1 trials
- level 2: randomized trial or observational study with dramatic effect
- level 3: non-randomized controlled cohort/follow-up study
- level 4: case-series, case-control studies, or historically controlled studies
- level 5: mechanism-based reasoning

TAE and balneotherapy are interventions that in general do not give unwanted side effects or harms. Some pathologies however can be negatively influenced by the effects of immersion and TAE. In those cases, this has been stated clearly in the respective sub-chapters.

3. Fluidmechanics: effects of aquatic immersion and movement

The fluidmechanical effects of immersion in water produce immediate and significant effects upon human physiology. A wealth of published research confirms the universality of these effects across a broad swath of physiologic systems. Immersion produces neuro-musculoskeletal, cardiac, respiratory, endocrine and circulatory system changes that are substantial. (Becker, 2009, Hall et al., 1995) The properties of water that produce these effects are density, buoyancy, viscosity, and temperature. When immersion is combined with movement, also flow (turbulence) and waves have influences on the neuro-musculoskeletal system.

Because of the density of water, hydrostatic pressure increases with depth. Hydrostatic pressure along with buoyancy and resistance means most movements are performed at much lower speeds giving persons with reduced musculoskeletal performance time to react, additional it proves support to impaired joints with decreased proprioception allowing movements not possible on dry land possible. The pressure, along with turbulent flow, stimulates the pressure receptors in the skin increase proprioceptive feedback, which enhances neuromuscular control.
The increased environmental pressure creates also pressure on the vasculature centralizing blood volume, and producing a neurohumeral response that decreases sympathetic vasoconstriction, reducing systemic vascular resistance and cardiac afterload. As a consequence, stroke volume increases, and despite temperature-related alterations in heart rate, cardiac output increases.(Arborelius et al., 1972, Bonde-Petersen et al., 1992, Christie et al., 1990, Sheldahl et al., 1986) Hydrostatic pressure combined with this centralized blood volume compresses the chest wall and abdomen and increases intrathoracic blood volume with about 700 ml, increasing the work of breathing by nearly 2/3rds.(Hong et al., 1969, Agostoni et al., 1966, Choukroun et al., 1989, Choukroun and Varene, 1990).

Buoyancy is the result of the upward acting force on an immersed body and equals the weight of the displaced volume of water. The deeper the body immerses, the more buoyancy will be present and the less reaction forces with the floor of the pool can be measured. Immersion at different depth allows gradual change of loading while minimizing risk of excessive loading. As depth of water increase weight bearing decreases, immersion at C7 level (base of neck) weight bearing through the legs is reduced to 10% of own body weight (Camilotti et al., 2009, Dowzer et al., 1998).

These decrease in the effect of gravity has a gradual and significant effect on the biomechanics and physiology of the body, it is estimated that at a depth of T8-11 the body is at neutral buoyancy where movements are still mainly under the influence of gravity. As depth increases the percentage of weight bearing decreases (Harrison et al., 1992) studied the differences in weight bearing in static, slow walking and fast walking. They estimated the following (approximate % of body weight), which has recently been confirmed by Miyoshi et al., 2004):

Depth	Static position	Slow walking	fast walking
Pubis bone	60%	50%	40%
Umbilicus	75%	60%	50%
Xyphoid/sternum	80%	70%	60%

By choosing an adequate depth, the workload can be matched smoothly to the skills or biomechanical character of the patient. The reduced weight bearing through injured or painful joints, decreases muscle activation thus strain on muscles, tendons and ligaments and allows control of load on repairing tissues (Villalta et al., 2012). This is important during the rehabilitation after orthopedic surgery and musculoskeletal injury (including sports injuries) where partial weight bearing status prevents normal walking and requires use of equipment. Also in neurological disease where the musculoskeletal system is too weak to maintain an upright position against gravity or support the bodies weight during bipedal gait.
Buoyancy forces and gravity forces form a force couple with a vector; this is known as the metacentric effect. This results in a torque (rotational moment), which influences the balance position of an individual.. By allowing the torques, joints and connective tissue will be mobilized. By preventing torques, individuals will actively stabilize their trunk (with isometric contractions) or strengthen (with isotonic concentric or isotonic eccentric contractions).

The body over a short period of immersion increases output of hormones that increase sodium excretion and reduce hormone levels that retain sodium, increasing urinary output.(Epstein, 1992, Epstein et al., 1976, Pechter et al., 2003, Tajima et al., 1988) With increased cardiac output and decreased peripheral vascular resistance, blood flow to the peripheral musculature increases, and potentially to joints and bones as well.(Balldin et al., 1971) Central nervous system response to immersion is temperature dependent in magnitude, but in general, parasympathetic autonomic tone increases, while sympathetic autonomic tone decreases quite rapidly during immersion at neutral and warmer temperatures.(Becker et al., 2009, Miwa et al., 1997, Nagasawa et al., 2001, Nishimura and Onodera, 2001, Schipke and Pelzer, 2001) This may be what leads to the feeling of relaxation following warm water immersion.

As a body moves through water it is exposed to a resistance (or impedance) that is mainly related to the speed of movement. As speed increases, resistance increases with a squared function (Pöyhönen at al., 2004). This resistance is a result of pressure differences over the anterior and posterior part of the body. This results in turbulent flow formation in a relative negative pressure area created behind the body pulling the body backwards: the wake. The reason for turbulence is the viscosity of water, which in combination with it's density results in an average difference of 14 times between air and water. Resistance can also be affected by the frontal plane and the hydrodynamic shape, the length/width ratio, as well as its angle of pitch. Turbulence can be used to assist an exercise (decrease difficulty) or to resist and increase the difficulty of an exercise. Therefore the aquatic environment can provide a progressive resistance training that enables joint and connective tissue mobilization, isometric stability activity or to strengthen by using dynamic concentric, dynamic eccentric contractions and plyometric contractions. It has been shown that resistance training in water can increase muscle strength in different populations including elderly (Pöyönen et al., 2002; Tsourlou et al., 2006), post knee replacement (Valtonen et al., 2010) and following lumbar spine surgery (Kim et al., 2010). This resistance is a primary reason why walking in water is performed at up to 50% slower than on land with similar metabolic and cardiovascular responses (Masumoto et al., 2004; Masumoto et al., 2005; Masumoto et al., 2007)

Waves develop when water moves. Waves can be longitudinal (moving through a pool) or vertical. In both cases, the energy in the wave will affect posture and movement. This is especially clear when a movement is stopped or changed in direction: water that was dragged in the wake of the individual still moves and "hits" the body. This will give rise to e.g. balance reactions.

The physiologic effects of simple immersion may be an important component of the therapeutic regimen in producing cardio-respiratory conditioning, respiratory strengthening,. In combination with movement as in a wide range of rehabilitation therapies through aquatic exercise both horizontally as in swimming and vertical exercise, effects will be modified by turbulent flow and waves

4. Musculoskeletal

Low back and neck pain

Low back pain (LBP) is a common musculoskeletal problem with between 75% and 85% of the population experiencing some form of low back pain during their lifetime (Balague et al. 2007). Its resulting management and days of work lost makes it also the most costly musculoskeletal disease (Dagenais et al. 2008, Becker et al. 2010). Low back pain leads to pain, reduced function and aerobic fitness, decreased muscle strength and fear of moving (kinesiophobia).There is strong evidence that exercise therapy is effective in the management of low back pain (Hayden et al. 2011) [1].

TAE

Therapeutic aquatic exercises (TAE) can produce moderate improvements in both pain (Sjogren et al. 1997, McIlveen and Robertson 1998, Yozbatiran et al. 2004, Waller et al. 2009, Dundar et al. 2009, Bello et al. 2010, Han et al. 2011) [2] and self-assessed functioning (Sjogren et al. 1997, McIlveen and Robertson 1998, Yozbatiran et al. 2004, Waller et al. 2009, Dundar et al. 2009) [2]. There is no evidence to suggest aquatic therapy is less or more effective than dry land exercise at decreasing pain or improving function in low back pain.

Decreased muscle strength and endurance has been shown to predict and be a side effect of LBP. TAE moderately improves trunk muscle strength (Yozbatiran et al. 2004) [2] in LBP and following discectomy, following intervertebral disc injury (Han et al. 2011, Kim et al. 2010) [3] with effects similar to dry land exercises. The addition of deep water running to a multi modal physical therapy program produces small additional, but not significant, benefit to trunk extensor muscle endurance and decreased pain (Cuesta-Vargas et al. 2011) [3].

Pregnancy is associated with an increase in pelvic and lumbar spine pain with approximately 51-72% of women suffering from LBP during pregnancy (Kristiansson et al. 1996, Mogren and Pohjanen 2005). TAE given at least once a week during pregnancy is effective at reducing pain and sick days due to low back pain and/or pelvic pain during and post-partum with no negative side effects (Kihlstrand et al. 1999, Granath et al. 2006) [2].

There is limited evidence to suggest improvements are maintained at short to long term follow up (Dundar et al. 2009, Saggini et al. 2004, Olah et al. 2008) [2]. No significant side effects resulting from active aquatic exercises or therapy have been documented. It can be concluded that therapeutic aquatic exercise is a safe and effect treatment option in LBP.

Balneotherapy

Balneotherapy in the management of LBP produces significant improvement in pain (Constant et al. 1998, Constant et al. 1995, Nguyen et al. 1997, Tefner et al. 2012, Balogh et al. 2005, Demirel et al. 2008, Guillemin et al. 1994, Kulisch et al. 2009) (Coudeyre 2005 & Gremeaux 2012) [2] and in function (Constant et al. 1998, Constant et al. 1995, Nguyen et al. 1997, Tefner et al. 2012, Balogh et al. 2005, Demirel et al. 2008, Guillemin et al. 1994, Kulisch et al. 2009) (Coudeyre 2005 & Gremeaux 2012) [3] although some of the effect on pain decreases over time, the improvements in pain are still significantly better at follow up of 3-8 months. A similar pattern is seen in function however at 8 months follow up the improvements in function are no longer significant (Guillemin et al. 1994). There is conflicting evidence to show that balneotherapy can improve mobility and quality of life with a positive effect in 3 (Constant et al. 1998, Nguyen et al. 1997, Tefner et al. 2012) and no effect in one (Kulisch et al. 2009) and decrease use of analgesia (Constant et al. 1998, Constant et al. 1995, Nguyen et al. 1997) and not decreased in one (Tefner et al. 2012).

In neck pain evidence is based on 1 trial representing 51 patients (Forestier et al. 2007). With high validity but low statistical power Pulsed electromagnetic fields appears to be more effective than crenobalneotherapy at 6 month for pain, function but not for drug consumption and quality of life.

Osteoarthritis

Osteoarthritis (OA), one of the most common degenerative joint disease, primarily affects the articular cartilage and subchondral bone of a synovial joint (Heppelmann 1997). OA is most commonly found in the hands and weight bearing joints with the knee and hip joint being the most common site of symptomatic OA (Suri et al. 2012).

Symptoms associated with OA are joint pain, stiffness and weakness of muscles due to disuse which lead to significant loss of function (Peat et al. 2001, Baker et al. 2004, Pietrosimone et al. 2011, Sofat et al. 2011). This results in extensive social and medical costs to society. Aquatic therapy is recommended in many treatment guidelines including American College of Rheumatology (ACR) (Hochberg et al. 2012), European League Against Rheumatism (EULAR) (Zhang et al. 2005) and Osteoarthritis Research Society International (OARSI) (Zhang et al. 2010). Primary goals of aquatic therapy in OA are to decrease pain, mobilize joints both actively and passively, strengthen muscles, improve aerobic conditioning and increase function.

TAE

In hip and/or knee OA TAE can cause a small to moderate but significant reduction in pain (Sylvester 1990, StenerVictorin et al. 2004, Bartels et al. 2008, Gill et al. 2009, Hinman et al. 2007, Fransen et al. 2007, Foley et al. 2003, Cochrane et al. 2005, Wang et al. 2011, Lim et al. 2010) [1] and small but significant improvement in aerobic fitness (Hinman et al. 2007, Foley et al. 2003, Wang et al. 2011, Wyatt et al. 2001, Wang et al. 2007) [2]. Additionally, TAE improves self-assessed and measured function with a small to moderate effect (Sylvester 1990, Gill et al. 2009, Hinman et al. 2007, Fransen et al. 2007, Foley et al. 2003, Cochrane et al. 2005, Wang et al. 2011, Lim et al. 2010, Wyatt et al. 2001, Wang et al. 2007, Green et al. 1993, Silva et al. 2008) [1]. There is conflicting evidence related to aquatic therapy and improvements in lower limb strength despite consistent evidence related to improving function and pain (Hinman et al. 2007, Foley et al. 2003, Cochrane et al. 2005, Wang et al. 2007). This decrease in functional performance can lead to an increase in falls risk. TAE can improve balance and decrease risk of falling (Hinman et al. 2007, Silva et al. 2008, Hale et al. 2012, Arnold and Faulkner 2010) [2] although effect is small. TAE produces similar size improvements in pain, function, aerobic fitness and quality of life compared to land based exercise (Bartels et al. 2008, Wang et al. 2011, Lim et al. 2010, Wyatt et al. 2001, Silva et al. 2008, Batterham et al. 2011, Lund et al. 2008) [2].
There is little agreement on the type, intensity and duration of treatment sessions/treatment period of TAE that should be prescribed to patients with OA of the joint in the lower limbs. It appears that studies which have a higher intensity of training and appropriate progression have slightly larger positive impact, in particular with muscle strength and improvements in function (Hinman et al. 2007). Individual assessment and prescription may be the key and is proposed to improve adherence (Bennell and Hinman 2011).
Irrespective of location of OA in the lower limb aquatic exercise can significantly improve pain, function, quality of life and aerobic fitness however these are of only short term effect (Bartels et al. 2008). No significant side effects of TAE have been documents in this patient group.

Balneotherapy

All but three of the high level studies, investigating the effect of balneotherapy on osteoarthritis of the lower limb have been focused on osteoarthritis of the knee. All these studies use a combination of traditional balneotherapy treatment associating mud packs, bath and supervised TAE in mineral water and sometimes massages and exercises at home or in mineral water therefore direct comparisons are difficult affecting levels of evidence. Balneotherapy can produce a small to moderate sized improvement in pain (Verhagen et al. 2007, Balint et al. 2007, Forestier et al. 2010,

Fioravanti et al. 2010, Fioravanti et al. 2012, Karagulle et al. 2007, Sherman et al. 2009) [2]. And there is evidence to suggest that this effect lasts up to 6 months after treatment (Fioravanti et al. 2010, Karagulle et al. 2007, Nguyen et al. 1997, Sukenik et al. 1999) [2] and 9 months (Forestier et al. 2010) [2] although in general the size of effect decreases during the follow up period.
Balneotherapy has been shown, to improve self-assessed function immediately after treatment (Verhagen et al. 2007, Forestier et al. 2010, Fioravanti et al. 2010, Karagulle et al. 2007) [2] with effects lasting up to 6 months after treatment (Forestier et al. 2010, Fioravanti et al. 2010, Karagulle et al. 2007) [2]. There is conflicting evidence to show that balneotherapy can produce small improvement in knee joint range of motion and physical performance measure (stair climbing and 50ft walking test) (Karagulle et al. 2007, Kovacs and Bender 2002, Yurtkuran et al. 2006) however in most cases the benefit was not maintained even at short follow-up. There is evidence that bathing in mineral water or sulphur baths are not superior to bathing in tap water for improvements in function as measured with physical performance measures (Sherman et al. 2009, Yurtkuran et al. 2006) [3].
The addition of balneotherapy to a home exercises program is more effective at decreasing pain and increasing self-assessed function than home exercises alone (Forestier et al. 2010, Yurtkuran et al. 2006) [2]. Additionally, balneotherapy given in an outpatient setting is at least as effective as care given in the traditional in-patient SPA way thus improving possible cost effectiveness (Balint et al. 2007, Forestier et al. 2010, Fioravanti et al. 2010, Fioravanti et al. 2012, Sherman et al. 2009, Tishler et al. 2004) [2].Balneotherapy may decrease knee stiffness with improvements maintained at follow-up of up to 6 months (Forestier et al. 2010, Fioravanti et al. 2010) [2].
Although there is evidence to suggest that balneotherapy can improve pain and self-assessed function only a few level 3 studies showing a small improvement in quality of life measures (Fioravanti et al. 2012, Nguyen et al. 1997, Cantarini et al. 2007), with other studies showing no change in quality of life (Forestier et al. 2010, Fioravanti et al. 2010) With low validity the studies are in favour of a superiority of spa treatment on short wave and no treatment. The validity of studies comparing bath in mineral water and bath in tap water is not sufficient to make any conclusion.

Hand osteoarthritis
In the management of hand osteoarthritis evidence is funded on 3 trial (n=226). There is evidence to show that bathing in mineral water is superior to bath in tap water for pain but not for the other criteria. Mineral water cloud is superior to NSAI topic for grip strength, stiffness, swelling and function at 6 months (Horvath et al. 2012, Kovacs et al. 2012, GraberDuvernay et al. 1997) [3]. There is no evidence for the use of therapeutic aquatic exercise in the management of OA in the upper limb at any level.

Joint replacement

Joint replacement
Joint replacement surgery for OA or Rheumatoid Arthritis (RA) is an option when there is significant pain or loss and function. Joint replacement surgery leads to significant improvements in both pain function and quality of life (Swanik et al. 2004). Despite the success of arthroplasty residual loss of function and pain compared to non-operated joint has been measured up to 4 years post-surgery (Meier et al. 2008, Valtonen et al.

2009). There is evidence to show that physical therapy results in small to moderate short term benefit post-surgery (Lowe et al. 2007) [2].
Pre-op
Although pre-operative fitness is correlated to a better outcome post operatively, there is no evidence that an aquatic therapy program before surgery improves outcome after surgery, although when TAE is part of a comprehensive multimodal treatment plan there is more improve before and after surgery than without it (Gilbey et al. 2003) [3]. Additionally, there is evidence indicating that TAE can produce a small to moderate improve pain and function in patients on waiting list for joint surgery (Gill et al. 2009) [2].
Early post-op
There is level 3 evidence that aquatic therapy can produce a moderate improvement in range of movement (ROM) in the first 2-8 weeks following total hip (THR) or total knee replacement (TKR), there is evidence to suggest TAE is similar in improving ROM following hip or knee arthroplasty compared to other land based rehabilitation (Harmer et al. 2009, Rahmann et al. 2009). There is conflicting evidence to suggest that the addition of aquatic therapy in the first 2-8 weeks following TKR/THR produces small improvements over conventional intervention in self-reported pain, stiffness and function (Harmer et al. 2009, Rahmann et al. 2009, Liebs et al. 2012, Giaquinto et al. 2010a, Giaquinto et al. 2010b). Intensive aquatic exercise starting day 4 following surgery can produce small significant improvements in hip abductor and quadriceps strength compared to normal ward and light aquatic therapy measured at day 14 following THA/TKA (Rahmann et al. 2009) [3]. There is some evidence to suggest that a ten day intensive TAE start during the early phase (day 4 after surgery) is more beneficial following post TKR surgery than THR surgery. It appeared that starting 2 weeks after surgery with more effective than earlier following THR (Liebs et al. 2012) [3]. There is no evidence to suggest AT reduces swelling post-operatively but there is moderate evidence to suggest AT is more effect at decreasing swelling following ACL reconstruction compared to land based rehabilitation (Tovin et al. 1994, Zamarioli et al. 2008) () [2]. There is no evidence that TAE given post surgically increases risk of infection (Villalta and Peiris 2012). Related to ease of movement and mobility assumptions are made that there are benefits from TAE early during their rehabilitation following joint replacement surgery but the highest levels of evidence do not yet support its use over land training.

There is conflicting evidence that the addition of an aquatic therapy intervention in the initial period post-operatively produces sustainable improvements in function, ROM and muscle strength after knee or hip arthroplasty (Harmer et al. 2009, Rahmann et al. 2009, Liebs et al. 2012, Giaquinto et al. 2010a, Giaquinto et al. 2010b).
Although patients who have under gone hip or knee arthroplasty report significant improvements in function they still have major deficits in physical performance measures e.g. strength, functional tests, walking speed and balance (Meier et al. 2008, Valtonen et al. 2009, Mizner et al. 2003, Stevens et al. 2003, Swinkels et al. 2009). In patient over 6 months postoperatively an intensive aquatic strengthening program can produce moderate improvements in lower limb muscle strength, walking speed and ascending stairs (Valtonen et al. 2010). Improvements in strength were maintained at follow-up but mobility improvements were not sustained (Valtonen et al. 2011)[2].

Rheumatoid arthritis

Rheumatoid arthritis

Rheumatoid arthritis (RA) is a chronic, systemic inflammatory disorder that primarily affects the joints. Symptoms include pain, stiffness and joint inflammation leading a decrease in function. However, it has been shown that active exercises can improve muscle strength, functional ability, and aerobic fitness and reduce pain in people with RA without causing detrimental changes in symptoms and structures as measured with radiography. There is no consensus on what the optimal content of an aquatic therapy program should be with current guidelines recommending patient specific programs (Hurkmans et al. 2009, Cairns and McVeigh 2009, Forestier et al. 2009).

TAE

Persons with RA often suffer from severe pain affecting function and often exercises on land are uncomfortable affecting compliance. TAE produces a small to moderate size improvements in pain (Hurkmans et al. 2009, Hall et al. 2004, Hall et al. 1996, Rintala et al. 1996, Bilberg et al. 2005) [2] and self-assessed functional ability (Hall et al. 1996, Bilberg et al. 2005) functional improvements are maintained up to 3 months There is also evidence to suggest that aquatic therapy can produce small to moderate improvements in grip strength (Hall et al. 1996, Rintala et al. 1996, Smith C 1998) [2] but limited evidence for its effect on lower- and upper limb strength.
There is conflicting evidence showing that TAE produces an improvement in aerobic fitness in subjects with RA (Hurkmans et al. 2009, Forestier et al. 2009). Smith et al (Smith C 1998) reported a moderate sized improvement in VO2 max in this group. Conversely Bilberg et al (Bilberg et al. 2005) and Rintala et al (Rintala et al. 1996) reported no improvement in aerobic capacity but participants in these studies had minor impairment as a result of RA (American College of Rheumatology (ACR) classification I –II) which could have limited the possible improvement potential in these studies.
There is conflicting evidence to suggest any improvements in functional ability, pain, strength and fitness as a result of TAE are maintained at even 3 months after cessation of treatment potentially cause by the nature of the disease (Hall et al. 1996, Bilberg et al. 2005, Eversden et al. 2007). No negative effects from aquatic therapy have been reported including no exacerbations of the disease as a result of active aquatic exercise.

Balneotherapy

Even though balneotherapy is one of the oldest treatments used in the management of pain, decreased function and quality of life and stiffness in persons with rheumatoid arthritis there is evidence to show that balneotherapy has surprisingly limited benefit (Verhagen et al. 2008, Franke et al. 2007) [2]. There is evidence showing that balneotherapy can produce a small improvement in quality of life (Franke et al. 2007)[3]. The differences and weaknesses in the methodology of the studies included prevents us from making any conclusive statement on the benefits from balneotherapy in the management of rheumatoid arthritis as well as the diverse treatments administered (Verhagen et al. 2012).

Fibromyalgia syndrome

Fibromyalgia (FM) or fibromyalgia Syndrome (FMS) is a chronic non-articular rheumatological condition characterized by wide spread musculoskeletal pain (Schochat et al. 1994). Other symptoms can include decreased functioning, reduced strength and aerobic fitness, fatigue, non-restorative sleep, stiffness, depression and anxiety (Wolfe et al. 1990) for which exercise has been shown to a be a potential effective form of management (Busch et al. 2007, Busch et al. 2009).

TAE

Pain is a common complaint of persons suffering from FMS sometime making exercises difficult and person with FMS often have low motivation to exercise and compliance with training in water is often better than on land. TAE has a moderate effect on pain (Carville et al. 2008, Perraton et al. 2009, Altan et al. 2004, Assis et al. 2006, Gusi et al. 2006, Jentoft et al. 2001, IDE et al. 2008, Tomas-Carus et al. 2007, Tomas-Carus et al. 2009, Vitorino et al. 2006, Munguia-Izquierdo and Legaz-Arrese 2007) [1] and is superior when compared with no treatment, with improvements being partially maintained at short term follow-up (Perraton et al. 2009, Assis et al. 2006, Tomas-Carus et al. 2007, Evcik et al. 2008, TomasCarus et al. 2007) [2].

TAE produces a small-to-moderate improvement in self-reported functioning and quality of life (Perraton et al. 2009, Assis et al. 2006, Gusi et al. 2006, Jentoft et al. 2001, IDE et al. 2008, Tomas-Carus et al. 2007, Tomas-Carus et al. 2009, Evcik et al. 2008, de Andrade et al. 2008) [1] that is similar in effect size to dry land exercises. These improvements are maintained at short term follow up (Altan et al. 2004, Evcik et al. 2008, Gowans and deHueck 2007) [2].

There is evidence to show that TAE of moderate intensity produces a small to moderate improvement in aerobic fitness (Assis et al. 2006, Tomas-Carus et al. 2009, Mannerkorpi et al. 2009) [1]. Aquatic exercise shows similar improvements in aerobic conditioning when compared with land based exercise in FMS (Jentoft et al. 2001, Gowans et al. 1999) [2], these improvements are maintained at short term follow-up (Assis et al. 2006, Mannerkorpi et al. 2009) [2].

There is conflicting evidence to suggest AT produces a l improvement in grip strength (Jentoft et al. 2001, Tomas-Carus et al. 2007, Tomas-Carus et al. 2009, Mannerkorpi et al. 2000, Mannerkorpi et al. 2002) (Jentoft, et al 2001, Mannerkorppi et al 2000 2002, Tomas-Carus et al 2007, 2008) and lower limb strength (Gusi et al. 2006, Tomas-Carus et al. 2009).

Persons with FMS often suffer from disturbed sleeping patterns and depression. TAE can improve quality and duration of sleep (IDE et al. 2008, Vitorino et al. 2006) [2]and produces a moderate improvement in anxiety and depression (Assis et al. 2006, Evcik et al. 2008, de Andrade et al. 2008, Gowans and deHueck 2007) [2]. There is evidence to suggest that TAE results in slightly larger improvement in mood and depression compared to dry land exercise (Assis et al. 2006, Jentoft et al. 2001, Evcik et al. 2008, Gowans and deHueck 2007) [2].

There is clear evidence that aquatic exercise is beneficial in fibromyalgia with no major negative side-effects reported from participating in a structured supervised aquatic exercise program. There are large variations in the type of exercise, duration, intensity, and number of sessions recommended in the management of fibromyalgia. There is general agreement that an intervention with moderate intensity improves compliance and prevents exacerbations of pain and aquatic exercise can fulfil these criteria. There is some evidence to suggest that TAE is superior to passive water-based therapies and non-active dry land interventions when comparing effect sizes in particular for functional outcomes (Perraton et al. 2009, Altan et al. 2004, Calandre et al. 2009) [2]. There is evidence to suggest the improvements following an active aquatic program are slightly larger and maintained for longer following cessation of training (Altan et al. 2004, Calandre et al. 2009) [2].

Balneotherapy

Although the majority of randomised controlled trials found were of medium (Donmez et al. 2005, Zijlstra et al. 2005, Zijlstra et al. 2007) to low quality (Altan et al. 2004, de Andrade et al. 2008, Ardic et al. 2007, Buskila et al. 2001, Evcik et al. 2002, Neumann et al. 2001, Ozkurt et al. 2012) the results are consistent. Of these all but 3 are included in 2 systematic reviews (Langhorst et al. 2009, McVeigh et al. 2008). Balneotherapy comprising of a mixture of different interventions types and duration, can produce small to moderate sized improvements in pain and decrease trigger point count (de Andrade et al. 2008, Ardic et al. 2007, Ozkurt et al. 2012, Langhorst et al. 2009, McVeigh et al. 2008) [2] and moderate to large size improvements in quality of life and self-assessed function measures (de Andrade et al. 2008, Ozkurt et al. 2012, Langhorst et al. 2009, McVeigh et al. 2008) [2]. There is evidence showing improvements in depression scales (de Andrade et al. 2008, Ardic et al. 2007, Ozkurt et al. 2012, McVeigh et al. 2008) [3]. Effects on pain and quality of life have been shown to be maintained up to 3 months after treatment with effect decreasing at longer follow up. Only one study demonstrated an impact of balneotherapy on walking performance (Zijlstra et al. 2005) [3] and this study had a poor control of co-interventions, no other study include a physical performance measures, making any conclusion concerning the impact of balneotherapy on physical performance impossible. Only transient side effects from balneotherapy have been reported (Donmez et al. 2005, Zijlstra et al. 2005), indicating that balneotherapy is safe in the management of fibromyalgia.

Ankylosing Spondylitis

Ankylosing spondylitis (AS) is a chronic systemic inflammatory disease that affects the axial skeleton with varying impact on articular and non-articular structures. AS leads to reduced physical activity, pain stiffness, impaired spinal and chest wall mobility, reduced pulmonary function and depression (van den Berg et al. 2012, Radner et al. 2012). Exercise has been advocated in the management of AS with a particular emphasis on initiation of intervention as early as possible to prevention physical deterioration (Peters et al. 2010).

TAE

Symptoms from AS can present as early as 10 years old therefore maintenance physical function is an essential part of it management. TAE (Hidding et al. 1993) and swimming (Karapolat et al. 2009) can produce moderate to large improvements in aerobic fitness in ankylosing spondylitis [2]. There is evidence to suggest aquatic exercise and swimming can also improve respiratory function and chest wall expansion which is often restricted as a result of the diseases activity (Hidding et al. 1993, Karapolat et al. 2009, Helliwell et al. 1996) [2]. TAE in combination with home exercise can decrease pain further than home exercise alone (Helliwell et al. 1996) [2]. However, these improvements are not maintained unless training is continued (Hidding et al. 1993, Helliwell et al. 1996) [2].

Balneotherapy

On the basis of the findings from seven randomised controlled trials (van Tubergen et al. 2001, Yurtkuran et al. 2005, Cozzi et al. 2007, Altan et al. 2006, Codish et al. 2005, Ciprian et al. 2011) there is conflicting evidence for the benefit of balneotherapy on symptoms resulting from ankylosing spondylisis. Balneotherapy can produce a short term small improvement in pain (van Tubergen et al. 2001, Yurtkuran et al. 2005, Codish et al. 2005) and function (van Tubergen et al. 2001, Yurtkuran et al. 2005, Cozzi et al. 2007, Altan et al. 2006) [2],although there is limited evidence to show this improvement is maintain a longer follow up (Yurtkuran et al. 2005, Codish et al. 2005) [3]. Again there insufficient evidence to indicate balneotherapy can improve measures of physical performance with only level 3 evidence demonstrating an improvement in spinal mobility and chest expansion measured and result for these were conflicting and effect size was small (Yurtkuran et al. 2005, Altan et al. 2006, Codish et al. 2005). Similarly there is conflicting evidence to show small short term improvements in quality of life (van Tubergen et al. 2001, Yurtkuran et al. 2005, Altan et al. 2006) [2] with no improvement in one study (Colina et al. 2009), improvement is maintained at longer follow up in only one study (van Tubergen et al. 2001) [3], 26 week in one study (Yurtkuran et al. 2005) [3]. The addition of balneotherapy to an exercise program is of no significant additional benefit on pain but did cause a small but significant improvement function and spinal mobility (Altan et al. 2006) [3]. There is conflicting results for effect of balneotherapy on stiffness (van Tubergen et al. 2001, Yurtkuran et al. 2005) [3]. Only minor transient side effects (moderate gastrointestinal problems, preseumed a result of non-steroidal anti-inflammatory medication) were reported in one article (Yurtkuran et al. 2005)(Yurtkuran et al. 2005) and no side effects reported in two studies (van Tubergen et al. 2001, Cozzi et al. 2007). Stiffness is not improved in one study (van Tubergen et al. 2001) between 4 to 40 weeks and improved in one study (Yurtkuran et al. 2005). Quality of life (or well-being) is improved until 3 week in one study (Altan et al. 2006) (Altan 2006), 16 week in one study (van Tubergen et al. 2001) , 26 week in one study (Yurtkuran et al. 2005) and not improved in one study (Colina et al. 2009).

Due to low study quality, conflicting results in all outcomes except pain, different interventions given and poor control of co-intervention it has to be concluded there is no evidence supporting the use of balneotherapy in the management of AS but there is no indication it causes harm either.

5. Sports rehabilitation

The aquatic environment is used in sports extensively both directly with participation in swimming, aqua fitness classes, water polo and diving and also with hydrotherapy. Water is utilised for rehabilitation following sporting injuries, in aquatic plyometrics, with deep water running for cardiovascular fitness and also with recovery following exercise.

There is level 2 level evidence to show that aquatic rehabilitation significantly improves

- walking, balance and pain in acute knee and ankle ligament injuries (Kim et al., 2010)
- function, pain, strength and swelling following anterior cruciate ligament reconstruction (Tovin et al., 1994, Zamarioli et al., 2008).

Land-based exercise leads to similar changes but there may be additional benefits with aquatic exercise and more rapid improvements in some outcomes early in rehabilitation.

There is level 2 evidence that aquatic plyometric exercise increases sprint time or agility, strength (Robinson et al., 2004, Gulick et al., 2007, Arazi and Asadi, 2011) and vertical jump (Robinson et al., 2004, Gulick et al., 2007) similar to the outcomes in land-based plyometric exercise.

Deep water running may be used as an alternative to running when high level weight-bearing function is limited by pain or injury. Cardiovascular fitness is maintained in runners using deep water running over 3-6 weeks (Gatti et al., 1979; McLuckie and McKenzie, 1991; Eyestone et al., 1993; Wilber et al., 1996; Bushman et al., 1997).

Recovery is a complex individual process involving the reestablishment of psychological and physiological resources and performance abilities over time (Kellmann 2002). Passive immersion in cold water or contrast therapy (alternating between cold and hot water) is used widely in recovery following intense exercise. There is level 1 evidence that cold water immersion is effective in reducing delayed onset muscular soreness and increasing muscle power (Leeder et al., 2012). Contrast therapy was found to have insufficient evidence related to improving physiological parameters in a systematic review but there were functional beneficial effects (Hing et al., 2008). Practical recommendations for improving physical performance include whole body immersion of 14-15 min of either cold water immersion (10-15 °C) or contrast therapy, with hot water at 38-40°C (Halson 2011). The contribution of the ideal variables related to hydrostatic pressure and temperature needs further investigation along with the option of active recovery in water.

6. Neurology

Cereborvascular accident or stroke

Cerebrovascular accidents (CVA or stroke) are the third most common cause of death and are the main cause of permanent disability in the western world, where they also rank first as regards the loss of years of disability-adapted independent life
The National Stroke Association (2010) regards swimming as a beneficial exercise and the Canadian Stroke Network (2010) recommends also swimming as a means to participate in moderate exercise

Aquatic therapy is not a traditional part of the rehabilitation of persons with a stroke. Research about aquatic therapy for stroke patients is only published since 2004 and always about active aquatic therapy. The kind of activity is very diverse, ranging from proprioceptive balancing exercises (Park et al., 2011a and 2011b) to high level aquatic fitness (Chu et al., 2004).

Most papers describe aquatic therapy for the chronic stroke patients, although the inclusion for chronic stroke ranged from 3 months to over 12 months post-stroke. More recent also research on patients who are still in hospital or a rehabilitation centre has been published (Bae, 2005; Chetlin et al., 2010; Han, 2012).

In general, patients were included who have a fairly good functional capacity , being described in various ways. This means that no information exists about the more severely affected patients with e.g. somatosensory or memory deficits.

Most of the described health benefits have been reached with a frequency of 3 times per week (with a range from 2 to 6 times per week) and duration between 1 and 12 weeks.

Two systematic reviews (Mehrholz et al., 2011; Rammage, 2010) have been conducted about aquatic therapy after stroke, in which the primary outcomes were activities of daily living and balance respectively.. The reviewed trials have been included in the listing underneath.

Moderate to high level evidence, with effects having been described either in terms of statistical significantly, moderate to high effect size or changes over the minimal detectable change, has been found at various levels of the ICF for:

- Strength of muscles around the hip (Chu et al., 2004), knee (Noh et al., 2008; Chu et al., 2004) and ankle (Wang et al., 2010) [1]
- Aerobic capacity (Chu et al., 2004) [2]
- postural balance, measured on land with either motometric tests or instrumentally measuring control of the centre of gravity (Bae, 2005; Noh et al., 2008; Chan et al., 2010; Lee et al., 2010; Park et al., 2011 a and 2011b; Han, 2012) [2]
- Functional independence (Huijbregts et al., 2008; Chetlin et al., 2010; Wang et al., 2010) [1]
- Quality of Life (Aidar et al., 2007) [2]

The effects on gait parameters (distance, velocity and quality) is equivocal, authors have reported conflicting evidence. In interventions where gait has been trained (shallow or deep water walking), results are statistically and clinically significant (Chu et al., 2004; Tripp, 2011) [2]. Authors who have measured gait, but trained balance without displacement have not found significant effects (Noh et al., 2008; Chan et al., 2010; Park et al., 2011a) [2].

Literature seems to indicate that the increase of motor function is mostly related to the lower extremities and the trunk in static and dynamic balance.

Early stage post stroke patients were addressed by Bae (2005), Chetlin et al. (2010), Tripp (2011) and Han (2012), but no differences in beneficial health effects with patients after discharge

Aquatic therapy programmes have shown good adherence and adverse effects have not been reported. Literature has not given the possible long-term effects of aquatic therapy programmes.

Multiple Sclerosis (MS)

MS is a chronic disease of the central nervous system. The variable distribution of the damage in the myelin sheath of nerves may lead to loss of strength, sensation, co-ordination, balance and excessive fatigue causing progressive, but unpredictable limitations of function in daily life as well as quality of life.

There is no effective treatment for MS, rehabilitation programs do not change the level of impairment. However, literature suggests that exercise aimed to improve daily functioning of individuals with MS are effective at the level of activity and participation (Rietberg et al., 2005). No one specifically targeted exercise program was more successful than others (Khan et al., 2007). This also counts for the limited, but emerging evidence for aquatic activities, which varied from aerobic training to active relaxation. Most of the studies are of level 3 evidence.

Therapeutic aquatic exercises are suggested or advocated by e.g. the Multiple Sclerosis International Foundation (http://www.msif.org), the American National Multiple Sclerosis Society (http://www.nationalmssociety.org) or the American Physical Therapy Association (APTA, 1997). Literature doesn't report any adverse effects on e.g. fatigue or bladder control.

In general, positive effects tend to return to baseline within a few months when individuals stop exercising after an intervention.
The reported short term effects are statistical significant with moderate to even high effect sizes for:

- Quality of Life (Sutherland et al., 2001; Roehrs et al., 2004; Rafeeyan et al., 2009; Kargarfard et al, 2012) [2].
- Walking speed and dynamic balance (Salem et al., 2010 and 2010a) [3].
- Aerobic condition tested instrumentally (Sutherland et al., 2001; Pariser et al., 2006; Bansi et al., 2012) [2].
- Pain and spasticity (Castro et al., 2012) [2].

Only Sutherland (2001) included mood as outcome parameter; he found statistical significance, but a low effect size [2].

An important topic in MS is fatigue and possibilities to influence fatigue positively. Sutherland et al. (2001), Roehrs et al. (2004) , Castro et al. (2012) and Kargarfard et al. (2012) show positive self-rated effects of their aquatic programs, while Salem et al. (2010, 2010a) and Bansi et al. (2012) do not report any positive findings. No relationship with a low EDSS or length of interventions can be derived. The effect of aquatic activities on fatigue therefore remains conflicting [2].

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It is not clear if there are differences in the effects of aquatic activities for various disability levels of MS, as measured by Kurtzke's Expanded Disability Status Scale, since the research covered most of the EDSS steps: 1 – 8.

Thermosensitivity and – lability to high temperatures is present in 80% of the individuals with MS, mainly showing after immersion as tingling (Guthrie and Nelson, 1995). This is why the chosen water temperatures in general were cool (28-31 C^0), but even 36 C^0 has been reported to be tolerated well (Castro et al., 2012). It should be noted that 20% of the individuals with MS are sensitive for cold water.
The cooling effect of water prolongs exercise time (Bansi et al., 2012), although Chiara (1998) did not report positive effects of exercises in cool water (24 C^0) in terms of less fatigue, lower oxygen consumption or less spasticity.

Parkinson's disease

Parkinson's disease is a progressive neurological disease with a degeneration of dopamine producing cells in the brain. The clinical diagnosis is based on bradykinesia plus minimal one of these three symptoms: muscular rigidity, tremor at rest, balance problems not caused by other specific reasons. Due to the impairments in anatomical structures and functions, activity limitations and restrictions in participation develop gradually.
The benefits of exercising for persons with Parkinson's disease are well described in e.g. the Dutch/European Parkinson guideline (KNGF 2004) and a systematic review (Tomlinson et al., 2012), in which aquatic therapy is supported. Also patient associations advocate aquatic activities, e.g. The American Parkinson Disease Association (2001).

The research has mainly included Parkinson patients in the Hoehn & Yahr stages 2 and 3: bilateral involvement without balance impairment to some postural instability, but physically independent. Research has shown in general that improvements disappear within some weeks after cessation of the intervention.

Short-term – level 2 evidence - effects show, although scarce, that active aquatic activities produce a significant improvement with moderate to high effect sizes in:

- self-administered activities in daily living (Vivas et al., 2011;Ayán and Cancela, 2012; Brugghemans, 2011)
- Quality of Life (Brefel- Courbon et al., 2003; Ayán and Cancela 2012a)
- Static and dynamic balance (Queiroz et al., 2007; Brugghemans, 2011; Vivas et al., 2011)

There is conflicting evidence about the effects of aquatic activities on the self-administered general motor performance on the Unified Parkinson 's Disease Rating Scale (Brefel-Courbon et al., 2003; Queroz et al., 2007; Brugghemans, 2011; Ayán and Cancela 2012 and 2012a) [2].

No evidence has been found of the effects of aquatic activities on walking distance and – time (Vivas et al., 2011; Brugghemans 2011) [2] and also the effect of aquatic therapy on pain is not clear (Queiroz et al., 2007) [3]

It seems that a more intense aquatic resistance program offers more health benefits than low intense active or passive programs (Brefel-Courbon et al., 2003; Ayán and Cancela 2012a) (level 2)

The reported effects were obtained after interventions periods between 4 and 12 weeks, and in water temperatures between 26 and 34 C^{O}.

No adverse effects from aquatic therapy has been reported, with no exacerbations of the disease as a result of active aquatic training.

7. Pediatrics

In addition to traditional therapy, swimming and recreational water activities are widely used for children with disabilities. Nevertheless extensive literature reviews have only been conducted in aquatics for children with neuromotor impairments, Cerebral Palsy (CP) (Getz, Hutzler, & Vermeer, 2006; Blohm, 2011) and adolescents with neuromuscular and musculoskeletal diagnoses (Dumas & Francesconi, 2001). For the present work 5 data banks were searched for all types of studies published between from 2000 to 2011 including children and adolescents (0-21 years old) with a disability using aquatic or swimming intervention. Articles were excluded on children with temporary respiratory illness and policy statements.

Sixty-three articles (out of 511) were relevant to the topic, and 41 intervention studies were analyzed. n most cases aquatic activity programs are organized on individual basis according to each participant's unique therapy goals, incorporating several techniques and components which are not always well described. Water temperature (M = 31°: 24°-33°) was reported in only 36.6% of studies. Programs lasted in general from 10 to 14 weeks (min 6 wks; max 36 wks) with 2 or 3 sessions of 45-60 minutes a week. Intensity was mentioned in only 33% of the studies

Only 31 percent of 63 studies, fall in the group of level I and level II evidence. The largest number was found in the groups of "Nervous system" (n=17; n=13 with intervention programs) and "Mental and behavioural disorders" (n=20; n=14 intervention). Body function and activity components of the ICF were measured almost twice as much as participation and personal factors. It is difficult to compare results and calculate effect sizes. There was a wide variety of selected outcome measures, varying across studies; and secondly, many articles depicted their results in figures so actual numbers could not be distinguished for further analysis. In addition, some studies failed to report the maximal score possible for particular checklists or tests, which were not commonly known.

Studies showed some improvements: in the GMFM dimension D from 2.14% to 28%; dimension E 5% to 18%; but the total score 4% to 11%. Not all these changes were statistically significant but they were clinically relevant (Oeffinger, et al., 2008).

Pulmonary function tests (PFTs) did not show unequivocal results, however there was a trend for improvements. The RCT with a large sample size of 30 participants (Wang & Hung, 2009), showed statistically significant improvements in forced expiratory volume in one second (FEV1(%)) and forced expiratory flow between 25%–75% of forced vital capacity (FEF25–75 (%)), but the seemingly positive differences from pre- to post- intervention for the same outcomes in the RCT of Weisgerber et al. (2003) was not significant (n=8). These improvements ranged from 4.21% to 15% in FEV1(%); 2.14% to 10% in FVC(%); 3.54% to 18% in FEF25–75(%) and 0.5% to 3% in FEV1.0/FVC (Tiffeneau index) after an aquatic intervention.

The childhood health assessment questionnaire (CHAQ) was used in children with Juvenile idiopathic arthritis (JIA). In one study large improvements was reached with a land-based treatment (0.3 points or 25% from the pre-test results) at 6-month follow up (Epps, et al., 2005) and no improvement with a combined water land treatment. Another study however found a clinically relevant improvement of 27.69% or 0.18 points (Takken, et al., 2003) after an aquatic program.

All relevant studies showed improvement in swimming skills. The results of Swimming Classification Scale (SCS) and the YMCA water skills checklist showed significant improvement for the experimental group of 34.2% and 11.4% accordingly (Fragala-Pinkham, Haley & O'Neil, 2011). The Water Orientation Test Alyn (WOTA) showed clinically significant improvements (Ennis, 2011; p.7), with a mean increase of 24.42% after the 10-

week aquatic program. The Humphries' Assessment of Aquatic Readiness (HAAR) showed an average increase of 22.51% (Pan, 2011) to 37.66% in each stage (Pan, 2010).

In a 12-week long study (Klijn, Van der Baan-Slootweg & Van Stel, 2007) a statistically significant improvement in BMI, while the other (Vajda, et al., 2007) showed an increase in the BMI in all study groups, but not significant. Four studies analyzing the PEDI demonstrated an increase ranging from a 1.7% in PEDI mobility caregiver assistance scale to 64.3% difference in the PEDI functional skills domain in children with CP.

In conclusion the results for studies with children with disabilities are diverse in intervention type and outcome measures used. Nevertheless there are several advantages to water activities for this population.

8. Geriatrics

Exercise has proven to be beneficial for elderly and water seems to be an appropriate environment for these persons to exercise, nevertheless no recent review has concentrated on this population and the evidence remains unclear.
Five data banks were searched for relevant literature published between from 1980 and 2011. Studies retained for examination were randomised controlled trials including samples of mean age 55 yrs or older, with or without chronic disability. Interventions were limited to active aquatic therapy (exercise). Outcomes measures used were cardiovascular fitness, flexibility, balance, strength, body composition, pain, mobility and Quality of life using several scales.

Relevant text were screened by two reviewers resulting in 32 articles being retained. The samples examined ranged from 11 to 249 persons (M = 89.9) and mean age ranged from 58 to 82 years. The intervention period lasted from 4 to 24 weeks with 1 to 3 sessions a week (total minutes of treatment 240 min to 4320 min), with one exceptional study lasting 2 years. Most interventions involved some form of exercise in a pool and not actual swimming. In general group sessions were used and the exact qualifications of session leaders was not always clear if mentioned. Water level when reported ranged from waist level to deep chest level (axillary region). Water temperature was between 26° and 34° C. Fourteen studies examined a healthy population and 7 dealt with persons with Arthritis and related problems. Thirteen of these studies were published in the last 3 years.

The evidence indicates beneficial effects of aquatic exercise on function in elderly. Consistently significant evidence was found for improvement in cardiovascular fitness (12% - 42% representing up to a 2SD improvement after approximately 36 walking sessions in water over 12 weeks This was also 10% better than for the land exercise group). Meaningful but less consistent evidence was found for improvements in flexibility (±11%), balance, strength (5% to 30%) and body composition (3.4% increase in lean body mass and 8% decrease in skin-fold thickness). Only 1 study reported an adverse effect of aquatic therapy.

9. Cardiology

During sedentary activities including simple immersion and bathing as well as during exercise aquatic immersion produces significant effects upon cardiac function. Along with immersion-produced blood volume increase, there is a reduction in systemic vascular resistance and cardiac afterload. As a consequence, stroke volume increases, and despite temperature-related alterations in heart rate, cardiac output increases.(Arborelius et al., 1972, Bonde-Petersen et al., 1992, Gabrielsen et al., 1993) These findings have been demonstrated in healthy subjects in numerous studies in addition to these referenced. In individuals with left ventricular dysfunction and congestive heart failure, the effects are somewhat blunted but remain significant.(Gabrielsen et al., 2000) In severe and uncompensated heart failure, these effects may produce pathological hemodynamic changes(Meyer and Leblanc, 2008), whereas in mild to moderate failure they have been shown in Level 1 evidence to be beneficial both during the period of immersion and thereafter, with long term improvements seen in cardiac function, general physical function and quality of life in studies of lengthier aquatic exercise interventions.(Cider et al., 2003, Cider et al., 2005, Cider et al., 2006, Caminiti et al., 2011, Gruner Svealv et al., 2009) Swimming activity is substantially different from vertical aquatic exercise, both with respect to cardiac effects and the cardiac demand. Swim skill level plays a substantial role in the cardiac demand equation, and Level 1 and 2 studies have shown swimming to produce quite high cardiovascular and hormonal stress, with even occasional heart rhythm disturbances, which were not perceived by the swimmer.(Magder et al., 1981, Meyer and Bucking, 2004) Similar concerns of arrhythmias have emerged in studies of SCUBA diving.(Lai et al., 2005)

As a consequence of these studies, one can quite safely advise these general guidelines:

1. There is Level 1 evidence that aquatic immersion and exercise is both safe and potentially therapeutic for individuals with mild to moderate compensated heart failure and with infarctions older than 6 weeks. Swimming in these populations may be advised judiciously in individuals with good previous swimming skill levels.
2. Aquatic immersion beyond xiphoid level and aquatic exercise should not be used in individuals with uncompensated heart failure, very recent myocardial infarctions (less than 6 weeks) or recent myocarditis (within 6 months.) A Level 1 review of common and rare harms has concluded that even though the individual may perceive a positive effect of immersion, there is no guarantee of ventricular tolerance.(Meyer and Leblanc, 2008) The recommendation based upon this review is that the ability to raise stroke volume by >30% might provide a useful guide to allowing aquatic activity participation in these populations.

10. Pulmonology

During aquatic immersion hydrostatic pressure compresses the chest wall, and blood is driven from the periphery into the thoracic cavity. The respiratory consequence of these two events is that the workload of breathing increases substantially, while vital capacity decreases very slightly.(Agostoni et al., 1966, Hong et al., 1969) Prolonged exposure to this increased workload can produce strengthening of the inspiratory musculature, with an increase of respiratory function including vital capacity, total lung capacity, inspiratory reserve volume and forced 1-second expiratory volumes (FEV_1).(Clanton et al., 1987, Pherwani et al., 1989) Because of this training effect, there is Level 1 evidence that the use of immersion and aquatic exercise may potentially be useful in the management of chronic obstructive lung disease.(Amann et al., 2010, Belman and Mittman, 1980, Covey et al., 2001, Garcia et al., 2008, Kurabayashi et al., 1999, Larson et al., 2002) Such training techniques have been shown to be safe and useful.(Perk et al., 1996, de Souto Araujo et al., 2012) Aquatic exercise has been shown in Level 2 studies to be beneficial in improving respiratory function in both spinal cord injury (Pachalski and Mekarski, 1980) and cerebral palsy(Hutzler et al., 1998).

Asthma is a common pathologic issue in which aquatic activity has been used therapeutically, and also a clinical problem in which aquatic activity has been causally implicated. Because a cause of asthmatic exacerbation is cold dry air, swimming has been promoted as a venue for maintaining cardiorespiratory fitness in individuals with both mild and moderate asthma.(Bar-Or and Inbar, 1992, Fitch et al., 1976, Wang and Hung, 2009, Weisgerber et al., 2003, Wicher et al., 2010, Weisgerber et al., 2008) However, high frequency of intensive aquatic training has been associated with respiratory symptoms and airway hyper-responsiveness felt due to exposure to chlorine byproducts.(Bernard, 2007, Bernard et al., 2006, Bernard et al., 2009, Carlsen et al., 2011) There is unquestionable value in increasing cardiorespiratory fitness in asthmatics, and aquatic exercise and swimming has been shown through Level 1 and 2 evidence to benefit this increased functional status. At present, the weight of existing evidence supports such use, despite the potential risks involved.(Goodman and Hays, 2008)

In summary, the aquatic environment significantly alters the physiology of respiration. This alteration may be of therapeutic benefit in the management of chronic lung pathologies and general deconditioning and in increasing cardiorespiratory fitness in these populations.

11. Metabolic syndromes

This chapter will deal with metabolic problems related to the metabolic syndrome, of which type 2 diabetes mellitus type 2 (T2DM)) is the most common and is regarded as a lifestyle disease. Most of the research has been done in mixed groups of male and female, typically 40 years of age or higher. Females tended to cover the majority of participants.

Among non-genetic metabolic disorders, the metabolic syndrome has the highest prevalence and has been described in the WHO criteria (1999) as:
the presence of any one of diabetes mellitus, impaired glucose tolerance, impaired fasting glucose or insulin resistance, AND two of the following:

- Blood pressure: ≥ 140/90 mmHg
- Dyslipidemia: triglycerides (TG): ≥ 1.695 mmol/L and high-density lipoprotein cholesterol (HDL-C) ≤ 0.9 mmol/L (male), ≤ 1.0 mmol/L (female)

- Central obesity: waist:hip ratio > 0.90 (male); > 0.85 (female), or body mass index > 30 kg/m^2
- Microalbuminuria: urinary albumin excretion ratio ≥ 20 μg/min or albumin:creatinine ratio ≥ 30 mg/g

Standards, guidelines and recommendations for treatment of T2DM are widely available. As an example, the standard of the Dutch Association of Physical Therapy (KNGF 2009) suggest that individuals with T2DM should have an active lifestyle, train muscle power and endurance, decrease overweight, train cardiovascular endurance and increase self-efficacy. More specifically related to aquatic activities,, management of individuals with T2DM can be found in the diabetes information pack by the Aquatic Physiotherapy Group of the Australian Physiotherapy Association. (Elliot & Gilkes, 2010) or in Hornsby (2007).

Immersion

Persons with T1D excrete less sodium during immersion than healthy persons with similar responses in those with and without autonomic neuropathy. Hormonal volume homeostatic responses do not show differences between T1D and healthy persons (O'Hare 1989, Goenka 2008) [3]. Olah (2011) found changes within the physiological range of anti-oxidant, inflammatory and metabolic indices – e.g. blood lipids – in hypertensive or obese patients [2]. Immersion lowers fasting glucose with some 10% in hyperglycaemic T2D (Hooper, 1999) [3].

TAE

Aerobic movement in water at levels between 40% and 70% of the Heart Rate Reserve (HRres.) decreases post-exercise glucose in T2D with 21-34%, women reacting with a higher decrease (Deleon, 2005, Katsura 2010) [3].
A significant post-exercise reduction in blood glucose was also found by Marrone (2009) in a cohort of T1D children, participating in free-play swimming activities [3].
The effects of aquatic aerobic exercise on fasting glucose in T2D patients with impaired glucose tolerance is equivocal: De Leon (2005) shows a 20% decrease over a 6 week period, Jones (2008) shows a decrease of 44% after 12 weeks exercising at 60% HRres. and Connors (2012) 10% after 8 weeks [3]. More recently Cox (2010) and Cider (2012) didn't find effects on the markers of metabolic control as mentioned above [2].

Related to T2D are overweight and obesity. Aquatic research includes body mass indexes (BMI) from 25-42, showing no differences between training in water or on land. Also in water, body composition can change positively and is characterized by modest to even statistical significant decreases in the waist-to-hip ratio, waist girth, body weight, skinfold thickness, BMI or % fat (Takeshima 2002, Gappmaier 2006, Nagle 2007, Greene 2009, Jones 2008, Meredith-Jones 2009, Katsura 2010, Cox (2010), Lim 2010, Wouters 2010, Kaddissy 2011, Conners 2012) [2 and 3].
Takeshima (2002), Bageri (2010), Cox (2010), Katsura (2012) and Nuttamonwarakul (2012) showed that water exercises and swimming elicits a decrease in cholesterol, trichlycerids, low density lipids or glycosylated hemoglobin. [2]. Bageri (2010) showed as well an increase of high density lipids. [2].

Also these authors administered aerobic programmes between 40% and 60% of the HRres, in line with the ACSM guidelines. Green (2009), Meredith-Jones (2009), Wouters (2010) and Nuttamonwarakul (2012) found that aerobic capacity increased significantly [2]. Significant decreases in the resting systolic blood pressure (Meyer, 2006; Nuttamonwarakul ,2012)[2] and resting diastolic blood pressure (Nuttamonwarakul ,2012)[2] have been reported. Nuttamonwarakul (2012) also found significant effects on resting heart rate, whereas Wouters did not. This evidence remains conflicting.

Katsura (2010) found significant effects on trunk muscle endurance in obese women after an 8 week training period [3].

In addition, Nagle (2007) and Wouters (2010) describe the positive effects on health related quality of life [3]. Wouters further specifically mentions the effects on self-efficacy and Nagle on adherence.

An important topic, namely aquatic activity in persons with osteoarthritis and obesity have been found by Cadmus (2010) and Lim (2010) to be significantly better during the aquatic intervention in terms of quality of life and pain. [2].
T2D patients can increase work rate, walking capacity and muscle function (Cider 2012) [2].

Information is lacking about the beneficial effects of aquatic activities in persons with developed stage metabolic syndrome; suffering from DM, hypertension, cardiac failure, obesity and osteoarthritis.

Only a few studies included follow-up measurements. Cox (2010) found in a 6 months follow up that individuals showed a significant decrease of body weight, waist circumference and cholesterol, showing a long term improvement in cardiovascular risk factors [2]. Goto (2006) and Kamioka (2009) previously also had found a significant decrease of hyperlipaemia in follow-up of 12 months in both studies.

Detrimental effects on the vascular system have not been described . Pechter (2003) found in - non-DM – patients with chronic kidney disease even beneficial effects of aquatic activities in terms of less proteinuria and increase of the filtration rate. [3]. Cider (2012) specifically wrote in their conclusion that aquatic exercise is safe for individuals with a combination of cardiac heart failure and T2D [2] and Olah (2011) didn't find adverse effects for obese and hypertensive individuals after balneological treatment [2].

12. Women's Health

Pregnancy and labor

Prescribed physical activity which may include aquatic exercise is necessary to facilitate healthy uncomplicated pregnant and post partum women. (Katz et al, 2002, Ohlsson et al, 2001, ACOG, 2006, Cavalcante et al, 2009, Artal and O'Toole, 2003, SOGC, 2003, Bacuick, 2008) The hydrodynamic principles of both buoyancy providing unloading, and hydrostatic pressure assisting with edema reduction facilitate a safe, effective exercise environment for pregnant and post partum women. In addition to general fitness levels, aquatic exercise before, during and after labor positively impacts maternal: edema, metabolic status, weight gain, mood and quality of life, and musculoskeletal issues (addressed in orthopedic section). Cluett et al (2012) provide a Cochrane review of 12 RCTs (3243 women) compiling immersion data across the childbirth stages. Positive outcomes include: decreased analgesia use during the 1st stage, decreased length of labor's first stage, and no detrimental maternal or infant sequalae (Bgeginski R et al, 2009). Aquatic exercise is also indicated for edema control of the lower extremities (Kent et al, 1999, Smith and Michel, 2006, Young and Jewell, 2000) and labia (DiPasquale and Lynett, 2003) with no negative outcomes. More recent investigation assesses mood and quality of life of pregnant and post partum women. These studies report indicate minimal improvement in mood and quality of life with the addition of aquatic exercise (Polman, 2009, Parker and Smith, 2003, Granath et al, 2006). Most recently mechanistic studies investigate maternal glucose and infant health with aquatic exercise during pregnancy (Baracat et al 2012).

Based on the available published evidence, these definitive statements are provided with regard to aquatic exercise and individuals during or post uncomplicated pregnancy.
1) Obstetric and gynecologic guidelines now include aquatic exercise as one means to improve the general fitness/health of pregnant and post partum women.
2) Water immersion during the first stage of labor appears to decrease the need for analgesia and decrease the length of this labor stage with no detrimental maternal or infant impact.
3) Aquatic exercise may positively impact lower extremity and labial edema during/post pregnancy.
4) Emerging data supports with aquatic exercise a minimal improvement in the quality of life of pregnant/post partum women.
5) One recent RCT indicates improved maternal glucose levels and infant health with pregnancy activity with aquatic exercise as a component.

Breast cancer

Exercise during and post cancer treatment reduces cancer recurrence risk and mortality (Warburton et al, 2006); increases physical functioning (Ingram, 2007, Stevinson et al, 2004); and facilitates physiologic and psychological benefits (Ingram, 2007, Stevinson et al, 2004, Schmitz et al, 2010, Galvao, 2005, Knols et al, 2005). In two recently published Cochrane Reviews, exercise improved health related quality of life factors for individuals during and post cancer treatment. (Mishra et al, 2012, Mishra et al, 2012)

The systematically reviewed 99 randomized controlled trials (RCTs) investigated the effectiveness of exercise on overall health-related quality of life (HRQoL) outcomes and specific HRQoL domains (e.g. physical, psychological, economic, social, and spiritual well-being, and key disease and treatment symptoms such as sexual functioning, neuropathy or cognitive changes, and chronic fatigue) among adult post-treatment cancer survivors, and the compiled data supported a positive impact with exercise.

Specific studies assessing the relationship of aquatic exercise for individuals during or post CA treatment include effective intervention for women with breast cancer related lymphedema (BCRL). Jamieson and Box reported a decrease in edema volume and arm tightness. (Jamieson, 2005, Box et al, 2004) These researchers were supported by Tidhar and Katz-Leurer (2009) who also reported aquatic exercise to be safe and effective in reducing BCRL volumes. Geigle and Ambroza (2010) completed a single-blind, cross over, randomized trial with women diagnosed with BCRL using a community based aquatic exercise intervention. Overall volumes decreased in both extremities. Important in all the aquatic exercise studies with individuals during and post CA treatment, no open skin areas existed and medical management team agreed that moderate exercise would be beneficial to the participants.

Based on the available published evidence these statements are provided with regard to aquatic exercise and individuals experiencing or post cancer treatment.

1) Since 60% of the cancer survivors are 65 years of age or older, the aquatic environment offers one optimal environment for exercise during or after CA treatment. The hydrodynamic principles of buoyancy buffer gravity's impact on challenged musculoskeletal, cardiovascular and neurological systems for individual during and after CA treatment.

2) Precautions to aquatic exercise for individuals during or after CA treatment include medical oversight to monitor 1) immune system reserve especially in regard to potential immune compromise, and 2) energy potential to tolerate moderate exercise.

13. Aquatic activities to prevent ill health

Benefits of swimming to control or prevent ill health

This sub-chapter identifies some of the many benefits to be gained from swimming and aquatic fitness. The importance of physical activity for chronic disease prevention has become generally well accepted. Exercise in a variety of intensities and forms, including yoga, walking, biking, and swimming, has many health benefits for people, including those diagnosed with chronic diseases (WHO, 2010).

All forms of aerobic exercise are assumed to be effective for reducing body weight and improving cardiovascular risk factors (Thompson *et al.,* 2003). Walking and swimming are often recommended to increase physical activity and to improve health especially in older people (Littman *et al.,* 2005) and is generally associated with a low risk of injury compared to many other sports (Pons-Villanueva *et al.,* 2010). In essence, swimming can be practised by a range of people from the very young to the elderly, as well as those with mobility restrictions such as the disabled or pregnant.

Physiological benefits of swimming

Regarding physiological benefits of swimming, swimming in cold water may result in significant additional physiological alterations such as metabolic, cardiovascular and hormonal changes in swimmers who participate regularly. These changes may however be detrimental to unaccustomed persons (Kolettis and Kolettis, 2003). However, adaptive measures may enhance immune responses in winter swimmers (Arcaro *et al.,* 2002).

Depression and stress

Depression is characterized by a lack of "motivation" rather than a lack of "physical space" to move around. Berger and Owen (1983) showed a clear benefit to swimmers in terms of less tension, depression, anger, confusion, and more vigour after exercising than before. The benefits of swimming to reduce symptoms of depression are also supported by Saiiari *et al.,* 2011 and Sun and Alkon (2003) and by Tanaka *et al.,* (1997) to lower the resting blood pressure in hypertensive previously sedentary middle aged adults.

Liu *et al.* (2011) proved that swimming exercise could play a beneficial role in combined stress by up-regulating HSP70 level and down-regulating iNOS level in brain.

Beneficial effects on people with restricted mobility

The effects of aquatic exercise on people suffering with reduced mobility have been documented in a number of papers and the results of these studies seem to suggest that aquatic exercise can be beneficial to this group of people. The potential benefits include increased cardiorespiratory endurance, strength, and coordination and improved swimming and water safety skills. An aquatic exercise programme completed in a group setting may also encourage increased socialization and self-confidence for children with autism and other disabilities (Prupas *et al.,* 2006; Yilmaz *et al.,* 2004; Vonder Hulls *et al.,* 2006). The properties of water including buoyancy and hydrostatic pressure make it easier for children of all abilities to participate (Kelly and Duras, 2006).

Gorter and Currie (2011) for example, discuss the benefits of aquatic exercise for children and adolescents suffering with cerebral palsy who find land-based physical activity difficult. For these individuals water provides a weight-bearing environment which is important for reducing the impact on joints. In addition, water activities can be fun and enhance motivation and interest (Retarekar *et al.,* 2009). Braunton and Bartlett (2010) identified swimming as one of the most frequent activities reported by adolescents with cerebral palsy participating in their study.

Pan (2011) provides evidence that swimming can assist with improving motor skills and physical fitness in children with autism spectrum disorders (ASD). It has been found that children with this disorder have difficulties with gross motor development as well as gross and fine motor skills. Many children experience more success in attaining movement skills in an aquatic environment as opposed to a land-based setting because of the buoyancy of the water and the decreased effects of gravity (Prupas *et al.,* 2006). In addition, pools are available both in therapeutic and community settings, offering an opportunity for participation and social interactions. Getz *et al.,* (2007) have proposed using aquatic intervention to encourage perceived social acceptance for children with cerebral palsy. Huettig and Darden-Melton (2004) also show improvements in swimming skills during a period of intervention for four children with ASD. Yilmaz *et al.,* (2004) reported significant effects in motor performance and physical fitness of a 9-year-old child with ASD who participated in a 10-week swimming programme. In addition, the child experienced a reduction in stereotypic autistic movements (e.g., spinning, rocking, and delayed echolalia).

The benefits of aquatic exercise in other groups of people with limited mobility such as obese persons, pregnant women or people suffering with osteoarthritis have also been shown (Cadmus *et al.,* 2010). The influence of aerobic swim conditioning on levels of maternal physical fitness and selected maternal and foetal circulatory parameters were investigated by Sibley *et al.,* (1981). They showed that those women who swam regularly for ten weeks were able to maintain their initial fitness levels over twelve weeks of increasing gestation, while control subjects were not able to do so. These findings suggest the effectiveness of a swim conditioning programme in countering a potential decrease in fitness levels. Importantly, maternal blood pressure, pulse, and foetal heart rate response remained within clinically normal limits during swim conditioning for experimental subject.

Benefits to middle and older age groups

Studies have shown the benefits of swimming in later years.

Jennings (1997) showed the effects of central and peripheral cardiovascular adaptations to three months of intense swimming training in middle aged sedentary men and women. They conclude that intense swimming training for 12 weeks produces adaptations including greater capacity for vasodilation in skeletal muscle and an enhanced heart capacity. Nualim *et al.,*

(2011) confirm swimming as an effective endurance exercise for preventing loss in central arterial compliance in middle-aged and older people. Nualim *et al.,* (2012) showed that swimming produces hypotensive effects and improvements in vascular function in previously sedentary older adults.

Finally, it has been suggested that the health benefits conveyed by a swimming pool may be closely linked to the facilitation of social contact, and a supervised facility for young children. This statement stems from a study undertaken in Glasgow, UK where use of the pool facility for social contact was directly linked to reports of relief of stress and isolation, and improved mental health. Pool closure was one in a series of amenity closures and area decline and was used to represent other area changes. Health impacts were strongly linked to the pool closure. The pool opening was associated with local area regeneration, similar but less prominent links between swimming pool provision and health were reported (Thomson, 2003). In addition, Master's swimming is extremely successful and has been shown to create a positive environment for older athletes to stay fit and to develop friendships (Cooper *et al.,* 2007). Social benefits may therefore be one of many positive health outcomes associated with of having a pool in a community. Woolger and Power (2000) have showed that children's ability in swimming was positively related with the relationship with parents as sport socializers. Social aspects of swimming pool use are further discussed in section XX.

In conclusion, swimming has many benefits for people of all ages and health status. It has been shown it is useful for both prevention of ill health as well as for aiding those with existing medical or mobility concerns.

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