PM R xx (2020) 1-9
www.pmrjournal.org

Narrative Review

Aquatic Therapy in Contemporary Neurorehabilitation: An Update

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Abstract

Aquatic therapy has been used extensively in a number of neurologic diseases and pathologies. This review describes disease-specific rehabilitative applications for this population. Recent research has offered scientific support for use in common neurological diseases that are part of rehabilitative practice, and very recent findings may create even firmer support for its use in these as well as other conditions. Stroke, Parkinsonism, and multiple sclerosis are areas that have recently received a significant number of published studies. Dementia is another area that has been more recently studied and received basic science support. Cerebral palsy has also had recent supportive evidence published. Available literature is reviewed to create a more evidence-based support for the use of aquatic therapy in neurorehabilitation.

Introduction

The use of aquatic therapy in the management of neurologic disease in United States has a long history, reaching its peak in the era of poliomyelitis, when it was aggressively supported by Franklin Roosevelt following his contracting the virus in 1921, during that year's epidemic.[1] The use of aquatic therapy definitely diminished following that epidemic but has remained in use for the treatment of stroke, spinal cord injury, multiple sclerosis, and Parkinson disease. In 2009, a review article was published in this journal describing the underlying physiology and rehabilitative applications of aquatic therapy and the scientific support for its use.[2] The conclusions reached in that publication remain in large part valid.

The goal of this article was to review literature published within the past 15 years pertinent to aquatic therapy in the management of neurologic disease. In the 11 years since the 2009 article, a significant body of literature has been published adding further support to the science, while exploring areas that at that writing had not been evaluated. In particular, the use of aquatic therapy in the management of brain-related rehabilitative issues is exciting and potentially offers new approaches for clinical rehabilitative care. Relevant literature was primarily accessed through PubMed and where possible using English literature. In the preparation of this review, the most relevant articles were used with a bias toward higher ranked quality-of-evidence studies using American Academy of Neurology classification categories. However, because blinding is difficult in comparing land-based with aquatic-based studies, study numbers are limited. In virtually all meta-analyses found, authors identified the significant lack of study cohort sizes, outcome metric variability and study brevity limiting firm conclusions. Although an ideal publication goal might have been to compare aquatic techniques with current land techniques for neuro-specific problems, for neither are there evidence-based and universally applied treatment methods. There are other limitations as well in assessing aquatic therapy interventions, including a lack of established metrics of intensity levels, difficulty in measuring cardiac function in water, and extremely limited research funding availability, especially within the United States.

Experience in the use of aquatic therapy has demonstrated value in many neurologic diseases, including Parkinsonism, multiple sclerosis, stroke, and dementia. Wherever possible, a discussion of the underlying neuropathology is discussed with relationship to particular physiologic attributes of aquatic therapy physiology, but in a number of cases, such direct correlation is difficult or impossible, lacking underlying science. In such

https://dx.doi.org/10.1002/pmrj.12435

situations, only case reports may be available upon which to speculate a relationship. Although the use of aquatic therapy has grown in the management of musculoskeletal disorders and sports medicine, it remains less used in neurorehabilitation. Therefore, the goal of this article is to provide current research data relevant to the use of aquatic therapy in neurologic rehabilitation with the hopeful goal of creating the best currently available evidence base to support such use.

Aquatic Immersion and Exercise Effects on the Central Nervous System

As has been previously recognized, the hydrostatic forces incurred during immersion act to propel blood, lymph, and extracellular fluid upward, first into the capacious pelvic space and further into the thorax.[3] With clavicle-depth immersion and during horizontal aquatic activities, the volume of blood moved from periphery into central circulation is around 700 mL (the vertical increase due to hydrostatic pressure, whereas the horizontal increase is due to gravity offloading plus hydrostatic effects) significantly increasing cardiac end-diastolic volume by about 30%.[3-5] Although aquatic immersion typically produces a 10%-15% reduction in heart rate, cardiac output is still significantly increased, again by about 30%.[3] The increased blood volume is distributed throughout the body, especially to the kidneys, brain, and musculature.

Recent research has demonstrated that this cardiac output increase during immersion significantly increases blood flow to the brain, with an increase in carotid diameter and blood flow velocity.[6] Similar increases in flow velocities were demonstrated in the middle and posterior cerebral arteries.[6] Further research has demonstrated that these cerebral blood flow changes also occur during aquatic treadmill exercise and that this increase was statistically greater than land-based intensity-matched treadmill exercise in the same participants.[7] A more recent study assessing the same question found a 21% increase in middle cerebral artery velocity (MCAv) during aquatic treadmill running compared to 12% increase during land treadmill, with matched exercise intensity levels.[8] In the study, Pugh and coworkers speculated that based upon their findings, water-based exercise training may induce greater cerebrovascular health benefits than traditional land-based exercise and that the therapeutic effect of this may be of significant health value. Although less relevant in rehabilitation practice, the question of cerebral blood flow during horizontal aquatic activity was addressed in a 2019 study of young adult recreational athletes and age-matched swimmers, finding that although there was no significant difference between prone MCAv on land or in water, prone swimming (breaststroke) increased MCAv by nearly 50%.[9] Thus it appears that aquatic-based activity has some potentially unique advantage in clinical matters where improvement in cerebral blood flow might be of rehabilitative value.

Another aspect of neurologic significance is the impact of immersion and aquatic exercise upon the autonomic nervous system. In work done earlier in our lab, a statistically significant effect upon both the sympathetic system and sympathovagal balance was found in both younger and older adults, with sympathetic influence reduction and an increase in parasympathetic influence during neutral and warm water passive immersion.[10] The beneficial effects of aerobic nonaquatic exercise upon the autonomic nervous system have been well documented.[11] Autonomic system dysfunction has been found to be associated with numerous chronic diseases.[12] Both passive and active aquatic exercise has been shown to positively impact the autonomic nervous system, decreasing sympathetic activity while improving sympathovagal balance through the relative increase in parasympathetic influence.[13-16] Dysautonomia is a prominent feature in Parkinsonism, Lewy-Body dementia, and other central nervous system diseases where treatment may beneficially affect multiple organ systems.[17,18]

Aquatic Therapy Use in Stroke Care

Stroke is a leading cause of disability with over 800 000 cases per year, 87% of them ischemic. Contemporary medical management has led both to decreased mortality and reduced disability, but long-term deficits remain common. Aquatic therapy has been found beneficial in many aspects of the functional limitations seen following stroke including paralysis and weakness, balance dysfunction, and gait disturbances. Research publications over the last 15 years in the use of aquatics have primarily dealt with chronic stroke residua using a variety of aquatic methodologies and were searched for those meeting level I or level II-1 evidence standards.

The aquatic environment produces buoyancy, reducing the impact of gravity, while also adding the effects of viscosity on the work of movement, both having rehabilitative implications. Studies found have assessed the impact of water depth on energy expenditure during ambulation using underwater mechanized treadmills, using flotation gear, and assessing various therapeutic techniques. A study assessing the impact of water depth to assess energy expenditure found chest-depth water immersion to decrease the energy costs of ambulation, allowing longer treatment durations, whereas shallower water increased energy costs, more closely approximating land-based energy demands.[19] In chest-depth water, for stroke patients the energy expenditure of walking in water was essentially equivalent to that of land ambulation, whereas a comparable group of healthy adults required more energy to ambulate in water, probably because of ambulation speed differences.[20] The use of lower extremity ankle flotation devices has been studied to assess gait kinematics, finding that the knee flexion angle of the affected leg in midswing was significantly improved (20° increase) along with an increase in step length, whereas ankle weights facilitated total and single leg support duration.[21] As a consequence, depending upon the clinical picture of a given stroke patient, various therapy options may produce different gains in ambulation energy expenditure and ability.

Aquatic treadmill usage has been studied to assess impact upon poststroke cardiorespiratory fitness and lower extremity isometric strength. Lee and coworkers in a single-blind randomized control study found that a 4-week course of aquatic treadmill training produced gains over a land-based aerobic exercise program in metrics of cardiorespiratory fitness (peak O_2 consumption) and isometric paretic knee flexor and knee extensor strength.[22] A 2018 randomized comparative study of 32 poststroke patients, 18 in the aquatic treadmill arm and 14 in the control arm doing land-based upper and lower body ergometry 5 days per week for 30 minutes each for 4 weeks, assessing for isometric lower extremity strength found statistically significant gains in the aquatic group's paretic leg flexors and extensors but no differences between groups in nonparetic leg strength gains. Both groups realized improvements in cardiorespiratory measures of VO_{2peak}.[23] A single-participant study of 21 subacute stroke patients using an aquatic treadmill over 15 sessions found improvement in Berg Balance Scale (BBS) scores, a 10-m walk test, and balance confidence when compared to pretest baseline.[24] In a 2018 randomized study in a cohort of 20 subacute stroke patients following a 30-minute 6-week five-times per week comparison assessing land-based aerobic exercise with aquatic treadmill exercise, investigators found the aquatic group showed greater gains in 6-minute-walk test, peak O_2 uptake, and in an endurance exercise measure.[25] A number of these and other studies have assessed balance using BBS scores but finding only comparable improvement to land-exercised control groups with no statistically significant advantage to aquatic programs, although gains were found on both cohorts. In a recent randomized study of 50 chronic stroke survivors using a dual task 6-week program of aquatic versus land training 3 days/week, dynamic balance indices were measured using Biodex systems. The aquatic dual-task participants demonstrated improvement at statistically significant levels in overall stability, anteroposterior stability, mediolateral stability, walking speed and affected limb support time.[26]

In addition to aquatic treadmill training, other therapeutic techniques have shown promise in poststroke rehabilitation. Halliwick therapy is a highly systematic therapy technique focused on postural stability and controlled mobility. Tripp and coworkers assessed the effects of Halliwick therapy on balance and postural stability on a group of 30 poststroke individuals, randomized into a group combining Halliwick therapy with conventional therapy versus a group using only conventional therapy over 2 weeks of 5 times per week 45-minute sessions. Following the 2-week trial, the Halliwick group demonstrated greater improvement in Functional Ambulation categories and in Berg Balance scores.[27] A small Brazilian study of 15 poststroke patients showed similar statistical gains in BBS results and Timed Up & Go (TUG) testing following 18 Halliwick sessions.[28] Yet another aquatic therapeutic technique is Ai Chi, a version of Tai Chi done in chest-depth water focusing on balance during controlled movement with breath control. It was combined in a 2008 study with similar metrics in a randomized comparative study of Ai Chi combined with Halliwick training, compared to conventional gym exercise following 1-hour sessions 3 days/week for 8 weeks in a group of 25 ambulatory chronic stroke patients. Statistically significant gains were seen in the aquatic group in BBS scores, knee flexor strength, and forward and backward weightbearing in the affected limb compared to the gym group.[29]

Iliescu and coworkers completed a systematic review and meta-analysis of 19 studies (17 randomized controlled trials and 2 pragmatic controlled trials) with a mean sample size of 36, concluding that aquatic therapy demonstrated statistically significant benefits over land therapy on functional reach, TUG, gait speed, and BBS. They also reviewed the literature to assess minimal clinically important difference (MCID), finding that their MCID meta-analysis on BBS was at the borderline (2.252 ± 0.552) for BBS, which had been previously noted at 2.5 to 4.66 for chronic stroke. Their calculated gait speed gains (0.049 ± 0.023) fell within MCID of 0.04-0.06, whereas TUG scores fell below MCID for chronic stroke. The authors, however, note the paucity of solid MCID data for stroke metrics.[30]

In summary, aquatic therapy has been studied quite extensively in the management of postacute stroke rehabilitation. Aquatic approaches do require physical therapist skill and oversight but in the author's experience of observing hundreds of stroke patients, generally patients find them pleasurable. The results essentially have shown the safety of such treatment approaches, with some potential advantages in muscle strength, endurance gains and in cardiorespiratory fitness levels when compared to traditional land-based stroke rehabilitation. Improvements in functional balance abilities are also seen especially with combined aquatic therapy techniques but may not be significantly different than that seen in land-based approaches.

Aquatic Therapy Use in Parkinsonism

Parkinson disease is currently estimated to affect 1 million Americans, the majority over age 50 years, but the disease affects younger Americans as well. The disease presents a broad spectrum of severity, and although medications are very useful for many, these require careful monitoring and are quite patient specific in their efficacy. Many patients with Parkinson disease have gait disturbances and balance dysfunction with high risk of falls. Land-based exercise has been demonstrated to have significant value in managing the motor effects of the disease and is to this day, a mainstay of rehabilitative management. The pathophysiology of both Parkinson and Alzheimer disease is the loss of cerebral protein homeostasis, resulting in the misfolding and aggregation of damaged proteins.[31] In particular, heat shock factor 1 (HSF-1) has been shown to affect synaptic integrity and memory consolidation, critical issues in Parkinsonism.[32] Many parts of cellular responses to inflammation and tissue injury rely on heat shock proteins and their recruitment, as their name suggests, is partially dependent upon core temperature elevation, which can be achieved through exercise when combined with warm water immersion.[31]

The use of aquatic therapy has for some decades been recommended as it can challenge balance skills without danger from falling. In the past 10 years high-quality studies have demonstrated that various aquatic strategies show promise in improving balance[33-38] and freezing of gait.[33,34,36] In a 2019 metanalysis of 19 studies assessing land-based exercise with aquatic exercise, Pinto and coworkers concluded that with high confidence aquatic exercise produced better benefits than land-based exercise on balance and functional mobility, especially for those Parkinson patients with a high risk of falling, while showing that land and aquatic exercise had similar effects on motor impairments, disease severity, and functional mobility.[39] A 2020 meta-analysis by Carroll and coworkers concluded that overall although outcomes for gait, balance, and mobility were positive for aquatic therapy, they did not appear significantly better than land-based approaches, although studies that delivered at least 3-5 sessions/week did show superior outcomes for aquatic versus land-based programs.[40] Both forms of exercise are often used in a combined approach. Aquatic exercise studies have consistently shown high patient satisfaction and adherence, and several studies have also shown gains in quality of life scores and Short Form-36 (SF-36) and Visual Analog Scale pain scores.[41-44,37] Although these numerous studies are generally positive regarding aquatic exercise and therapy, the aquatic environment is potentially hazardous for unsupervised individuals, and only one of the studies made significant mention of safety, despite no articles describing serious adverse events.[43]

A common criticism made in these analyses was that many clinical aquatic protocols were used in the articles reviewed, methodological differences making comparisons difficult. Utilization of a standardized technique and metrics would be useful. An aquatic technique often used with Parkinson disease is Ai Chi, which was mentioned earlier in stroke rehabilitation. The technique has shown benefit in balance, functional mobility, and quality of life scores.[45-47] Another nonstandardized approach used compared a 6-week, 5 times/week program of an in-water obstacle course in training individuals with Parkinson disease to a "traditional" aquatic program consisting of standardized Halliwick therapy combined with balance and postural drills. When compared to the control aquatic exercise group the obstacle course participants performed better in Gait Freezing scores and TUG scores, effects that persisted for 6 months.[48] Yet another aquatic strategy for patients with Parkinson disease uses a nonstandardized technique called dual task performance. The performance of a motor task while simultaneously performing a cognitive task requires cerebral coordination between the premotor cortex and the basal ganglia circuit, areas affected by the disease. In a 2019 paper using this principle in a randomized cohort of 25 participants (14 experimental, 11 control), participating twice weekly over 10 weeks, the experimental group improved in BBS scoring, TUG scoring, and 5-times sit-to-stand (FTSST) scores, as well as Dynamic Gait Index scores both in comparison to the control group and to baseline assessment.[34] No published studies to date have assessed which of these exercise formats are the most effective. Individuals with Parkinson disease, particularly with early stage and midstage symptoms can be efficiently treated in aquatic group exercise formats with skilled exercise leaders. Such groups generally show both high satisfaction and exercise adherence.

Aquatic Therapy Use in Multiple Sclerosis

Multiple sclerosis (MS) is diagnosed in about 200 individuals per week, with an incidence that increases with more northerly latitudes going from 57-78 cases per 100 000 in the South to 110-140 cases per 100 000 above the 37th parallel. About 85% of newly diagnosed individuals present with relapsing-remitting MS, but within a decade, about half of these will progress to the chronic-progressive form. The disease has no current cure and although medications are often of value, physical therapy intervention and exercise are of substantial benefit.[49,50] Multiple sclerosis often presents a significant challenge to affected individuals, with sensory and motor disturbances, balance and gait difficulties, and visual, affective and cognitive problems, These symptoms may wax and wane.

Potential impacts of aquatic immersion and exercise on cerebral blood flow and the autonomic nervous system were discussed previously. Because about half to two-thirds of individuals with MS are heat intolerant, the heat transmissive abilities of water may be very useful. Aquatic therapy has been used over many decades, with the aquatic environment offering advantages in preventing overheating and buoyancy providing assistance with motor weakness while also reducing risk of fall-related injury. A number of systematic reviews and meta-analyses have been published over recent years supporting the value of aquatic therapy and exercise in disease management.[51-54] Typical aquatic therapy strategies used include conventional upright gait, mobility and strengthening programs, treadmill exercises, aquatic cycling, and Ai Chi. Amedoro and coauthors in their 2020 scientific review and meta-analysis of 10 high-quality randomized controlled studies found evidence of positive impacts upon balance, gait, fatigue, and quality of life, all at a fair to very good level of scientific evidence. The study authors commented on the study limits from the small number of trial participants, the heterogeneity of participants, the limits on follow-up, and the small number of randomized controlled trials in the literature, as well as the lack of double blinding. [51] Although most studies have focused on physical function, the benefits of aquatic exercise upon depression have been noted in addition.[55]

Bansi and colleagues assessed the effects upon cytokines and neurotrophins following 3 weeks of endurance training in 52 MS participants, comparing an aquatic cycling group (28 participants) with a land-based cycle ergometer (24 participants). Following the 3-week training, the aquatic cyclist cohort showed a 23% increase in serum brain-derived neurotrophic factor (BDNF) whereas serum levels in the land cyclists showed no elevation. Nerve growth factor (NGF), tumor necrosis factor (TNF-α), and soluble interleukin 6 (IL-6) remained unchanged. The authors commented that immersion depth varied by participant height so a standard depth could not be consistent. Study primary outcomes had high variation, and baseline values in subscore groups differed.[56,57] The authors concluded that the change in BDNF may be an indication of induced anti-inflammatory influences during and following immersion, consistent with earlier research by Wiesner et al.[16]

The National Multiple Sclerosis Association has actively promoted aquatic exercise programs throughout the United States, and many communities have developed these in community facilities. Physicians involved in the care of MS patients should certainly be actively recommending exercise for all of their MS patients, and aquatic exercise can be a valuable option for many with some unique benefits from thermal control, gravity-offloading from buoyancy and potential cerebral circulation gains.

Aquatic Therapy Use in Dementia

Dementia is common in the United States, with at least 7.9 million older Americans living with dementia. Alzheimer disease accounts for nearly 70% of these. The costs of this disease are astronomical, estimated at $277 billion, average lifetime costs exceeding that of heart disease and cancer. There are as yet no medications that can consistently maintain cognitive ability, much less reverse the course of diseases such as Alzheimer disease, and pharmacologic treatment options are often ineffective and expensive. Social impact is massive.

The role of exercise in the preservation and improvement of cognitive function is becoming well-established science however.[58,59] Even in the case of dementia, exercise science has established a body of both human and animal research demonstrating a strong role for aerobic activity.[60-65] The relationship between exercise in cognitive loss prevention remains less clear, but it is reasonable to presume that exercise promotion is at the very least prudent in mild cognitive impairment (MCI) and dementia.[65,66] In recent years, aquatic exercise has been promoted as a useful exercise option in both MCI and dementia.[67] A 2015 study assessed a group of 27 older adults (average age 63.2±7.34) for cognitive and cardiovascular fitness following 6 consecutive days of moderate-to-high intensity aquatic exercise at 60%-70% maximum heart rate, compared to a control group of 33 age-, fitness-, and gender-matched adults doing their daily routine. The exercise group scored statistically higher ($P < .05$ or better) on cardiorespiratory fitness and batteries of executive function.[68] Cardiovascular fitness improved in the exercised group as well, surprising findings given the short 1-week treatment duration.

The role of amyloid β (Aβ) is unclear but the association between Aβ and Alzheimer's has long been noted. The deposition of Aβ in the brain has been associated with a decrease in serum suggesting blood to brain transfer of Aβ with the converse occurring following exercise.[69] A 2018 study of 48 females (average age 66.9) randomized into three cohorts, a control group, an aquatic exercise group, and an intensity-matched land exercise group, found serum Aβ was significantly elevated in the aquatic cohort following a 16-week progressively intense aquatic exercise program monitoring heart rate, relative perceived exertion, increasing intensity every 4 weeks.[69] In the same study, investigators measured serum heat shock protein Hsp27, a protein effective against abnormal cytoplasmic protein damage and which plays a role in cellular cytoskeletal stabilization, and cellular homeostasis and protection. In both the aquatic and land exercise groups, Hsp27 showed statistically significant elevations: 11% in the aquatic group and 5% in the land group, indicating a positive cellular response to exercise.[69]

Several case studies have been published demonstrating remarkable gains in function, well beyond that achievable through current medications.[70,71] Although case studies fall into the lowest level of evidence, the surprising finding in these case reports was the immediacy of objective change in communication function, visual tracking, and motor performance, changes not seen in other physical environments. These reports should provide impetus for controlled cohort studies in dementia. Programs have been created within nursing homes for individuals with dementia, and community groups for such individuals have been very successfully formed, potentially providing meaningful venues for outcomes assessment.[72,73]

There are some potential physiologic reasons for the use of aquatic exercise programs in MCI and dementia. As detailed in the beginning of this article, cerebral blood flow is positively affected by immersion and aquatic exercise.[7-9] This increase in flow velocity stimulates endothelial nitric oxide synthase (eNOS), which promotes vascular compliance, improving oxygen delivery to brain tissues. There is an association between cerebral blood flow and dementia, although the relationship is complex and also related to cerebral metabolism.[74,75] Similarly, the autonomic nervous system is affected, with a down-regulation of the sympathetic component and an increase in sympathovagal balance, both of which are commonly dysregulated in individuals with Alzheimer disease and dementia.[76-78] In total, the rapid behavioral and cognitive changes seen in both MCI and dementia during aquatic immersion and exercise remain physiologically enigmatic. That said, given that no alternative therapeutic approaches offer the same rapid response, and for most patients with MCI, warm water immersion is both pleasurable and benign, much further research and rehabilitative use is warranted.

Aquatic Therapy Use in Cerebral Palsy

Cerebral palsy (CP) afflicts approximately 500 000 individuals under the age of 18 years, but the total CP incidence in the United States is estimated at 764 000 so it must be recognized that over a quarter million adults remain disabled because of the condition, and life expectancy is between 30 to 70 years. The use of aquatic therapy for children with cerebral palsy has been promoted for just over 20 years. Published studies of the usefulness of aquatic therapy in this population struggle with group sizes, disability level comparability, and clinically meaningful outcome metrics. Yet because of the buoyancy effects of water and the comfort of warm water, the aquatic environment for children with cerebral palsy would seem to be ideal. One of the early papers demonstrated benefit in respiratory function in a group of kindergarten aged children with CP engaged in a twice-weekly swim program combined with one gym session, each 30 minutes in length, compared with a similar cohort of children with similar disease types treated with traditional Bobath therapy 30-minute/session 4 times/week. The aquatic group improved vital capacity results by 65%, with the control group improving 23%.[79] The authors concluded that aquatic therapy should be an important component for treating children with CP. In 2008, Fragala-Pinkham and coworkers published a report of group aquatic therapy for 16 children with disabilities including cerebral palsy, finding that following a twice-weekly program over 14 weeks, the children improved in cardiorespiratory function, timed half mile walk/run, and timed floor-to-stand 3 meter test but not in measured strength or overall motor skills. The study reported no adverse outcomes.[80] In a 2011 study of 12 adolescents with spastic cerebral palsy, treated using twice-weekly group aquatic therapy over 20 sessions, the 10 participants completing the study demonstrated improved ambulatory efficiency with reduced energy expenditure and heart rate during ambulation, again with no adverse effects.[81] A 2017 publication assessing the effects in 32 children ages 4-17 of 30 sessions of an aquatic exercise program with traditional land-based exercise on spasticity, quality of life (QOL), and motor function, both groups showed improvement in most functional measures but no significant intragroup effects, and no spasticity benefit, although the aquatic group showed greater gains in QOL scores.[82] A well-done 2017 systematic review of the literature on aquatic therapy in CP concluded that although aquatic therapy is feasible and presents minimal adverse effects, the important questions of appropriate dosing and duration remain, and better study designs were in order. Many of these issues were addressed in a 2019 study by Akinola et al, assessing the effects of a 100-minute, twice-weekly 10-week analysis of 30 children, randomized into an aquatic group treated in 29° C. water, whereas the control group received manual passive stretching and functional training interventions in the gym. At study conclusion, the aquatic group showed statistically significant ($P < .05$) gains over the land group in all dimensions of gross motor function except walking, running, and jumping.[83]

In the management of cerebral palsy, it would seem apparent from the majority of studies that a combined land and aquatic approach is most appropriate at present, with comparable gains seen in most gross motor functions but higher levels of respiratory function and of patient and parent satisfaction from aquatic therapy based upon parental impressions of their children's participation.[84]

Issues Common to Most Chronic Neurologic Diseases

Social isolation and depression are common with many chronic neurologic diseases, and the effects of both are often negative with respect to physical fitness, producing a vicious cycle. Participation in group exercise can have a beneficial impact upon social isolation, improving quality of life, cardiorespiratory fitness, and physical function. A 2019 study in Parkinson's individuals found that those participating in group Ai Chi exercise improved in depression scores, pain levels and in SF-36 QOL scores, results that were maintained for a month following the exercise intervention.[41] A 2017 qualitative study assessed QOL with respect to aquatic group exercise participants with MS, finding a very high level of support and enthusiasm in individuals participating regularly in aquatic groups. These respondents, however, noted that awareness of aquatic programs occurred through MS support groups and friends, rather than through their medical care providers. Providers were generally supportive but only upon direct questioning from the individual and rarely were aware of existing community programs and unaware of benefits.[85]

Summary

Since the 2009 scientific review of the literature on aquatic therapy in rehabilitation medicine was published, a considerable amount of scientific work has been published with particular relevance to neurorehabilitation, justifying this updated review. One of the most interesting findings from a rehabilitative standpoint is the work investigating the central nervous system and in particular the brain. The impact of increases in cerebral blood flow has just begun to be evaluated from a functional rehabilitative standpoint. The stroke literature is increasingly compelling, as is the work that has been done on multiple sclerosis and Parkinson disease. The publications on dementia are limited but also promising and far more work needs to be done on this important and growing population group. There is obvious need for research assessing aquatic therapy in the traumatic brain injury population and the physiologic effects on the central nervous system and general brain function.

It is hoped that this review will spur further trials and more experiential use in appropriate neurologic populations. In these populations, aquatic therapy time is usually pleasurable, and the author has been consistently impressed by the smiles on the faces of patients being treated in the water. Many of those patients comment that following their aquatic therapy sessions, sleep is improved and they feel more relaxed. Neurologically impaired individuals participating in community-based aquatic programs typically have high exercise adherence, a positive factor in health promotion.[86] Given the unique aquatic benefits of weight offloading, vascular alterations, cerebral blood flow changes, a reduction of risk during falls, and potential autonomic and stress protein changes, there is potential for real rehabilitative gain.

Addendum

As this is being written, we are in the early stages of the coronavirus disease 2019 (COVID-19) epidemic. Although the long-term medical implications of this epidemic remain to be seen, there is information that many of the severely affected survivors will have endured lengthy intensive care unit stays with extended periods on respiratory support. These individuals will have many of the established effects of prolonged inactivity, deconditioning and cognitive residuals from such prolonged illnesses. These may well become a new population in need of comprehensive rehabilitation, the magnitude of which remains to be seen. New complications of COVID-19 may well emerge with rehabilitative implications as well including cognitive and renal dysfunction. What has been found in such patients in the past is that the value of structured exercise has been beneficial, and what is currently being suggested is that prolonged ventilator support may result in periods of cerebral hypoperfusion as a partial cause for some of these effects. There is no current literature dealing with this population but it is not unreasonable to suggest that some of the information contained in this article may be of rehabilitative value for this group.

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Disclosure

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Disclosure: Dr Becker is author and publisher of *Comprehensive Aquatic Therapy*, 3rd Ed., Scientific Advisory panel member, HydroWorx Inc

Submitted for publication April 6, 2020; accepted June 3, 2020.