AQUATIC PHYSIOTHERAPY

FOR NEUROLOGICAL CONDITIONS

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CONTENTS

PURPOSE

Recent research suggests that there is need for education and promotion regarding the use of evidence-based aquatic physiotherapy for neurological clients (Carrol et al 2022a; Chard 2017; Marinho-Buzelli et al 2022; Marinho-Buzelli et al 2023 – details in Appendix 1).

The purpose of this document is to assist in the understanding of both the breadth and key findings of peer-reviewed literature in this area of practice and thus enable clinicians to apply this information to their practice, for optimal client outcomes. It outlines current research evidence regarding the use of aquatic physiotherapy for clients with common neurological conditions – Parkinson's disease (PD), stroke, multiple sclerosis (MS), acquired brain injury (ABI) and spinal cord injury (SCI). It is not designed to be an exhaustive literature review, nor does it outline research on all neurological conditions.

This review has a focus on higher grades of evidence, including systematic reviews (SRs) and randomized controlled trials (RCTs), but also refers to existing published clinical guidelines and to relevant qualitative studies, which provide insight into the barriers, enablers and clients' lived experiences of aquatic therapy.

METHODOLOGY

A PubMed database search was instigated in September 2023, using search terms outlined in Appendix 2. The search specified a 10-year date range. Updated searches were completed in February 2024 and June 2024, using a 1-year date range. Several underlying references were utilised.

Only findings relating to the five neurological conditions specified above were extracted from the studies and only results pertinent to aquatic interventions (including comparisons) are reported. Results have been organized under mixed and specific diagnostic groups of neurological clients, starting with Level 1 evidence (systematic reviews and meta-analyses), moving through to relevant RCTs (Level 2 evidence) and then onto other pertinent research. For RCTs, PEDRO quality assessments (Physiotherapy Evidence Database) were completed by the author if no other quality assessments had been performed (Appendix 3).

Considered critical to the understanding of aquatic physiotherapy for neurological clients, both the application of clinical reasoning regarding aquatic physiotherapy for this population and the literature surrounding safe and effective use of the aquatic environment are presented.

EVIDENCE OVERVIEW

As more trials examining the effects of aquatic physiotherapy have been published, more systematic reviews have also been undertaken. Five recent systematic reviews (two with meta-analyses) have involved aquatic exercise/therapy for multiple neurological conditions (Fail et al 2020; Marinho-Buzelli et al 2015; Methajarunon et al 2016; Moritz et al 2020; Oh et al 2021). In summarizing the relevant findings, aquatic therapy may be of benefit to those with stroke, Parkinson's disease and multiple sclerosis, particularly in the areas of balance, gait and quality of life (QOL).

Faíl et al (2022) performed a meta-analysis on the benefits of aquatic exercise in adults with or without chronic diseases and found that water-based training improved a number of health-related measures in adults with a stroke or PD.

POPULATION	Incorporated in the study alongside health adults were adults with chronic diseases, including those with: • stroke (n=253) • PD (n=113)
STUDY DESIGNS & QUALITY	9 underlying studies included adults with stroke and Parkinson's disease: • 6 RCTs (4 stroke, 2 PD) • 2 non-RCTs (1 stroke, 1 PD) • 1 randomised clinical trial (PD) 65% of randomized studies including adults with chronic diseases were assessed to be of low risk of bias according to the Cochrane risk of bias tool (although 30% of the key criteria for adults with diseases had an unclear risk of bias).
INTERVENTION	Water-based training Dosage varied: • Frequency - 2-5 sessions per week • intervention period - 4-12 weeks
COMPARATOR	From 9 relevant underlying studies: • land therapy - 3 studies – 2 stroke, 1 PD • different water therapies - 2 PD studies • control group -2 stroke studies • no comparator - 2 studies – 1 stroke, 1 PD. Pre- and post- measures were used to determine intervention effects.
RELEVANT RESULTS	META-ANALYSIS FINDINGS There was a statistically significant standardized mean difference (SMD) in favour of aquatic exercise (versus the comparator or using intervention effect calculations) for the following outcomes: • ADULTS WITH HEART DISEASES (10 studies n=430) including STROKE (5 studies n=253) ➢ <u>quality of life (QOL)</u> - SMD= -0.81 95% Confidence Interval (CI) -1.32, -0.29 Z=3.06 p=0.002 ➢ <u>overall results</u> - incorporating subgroups of anthropometrics, balance, cardiorespiratory fitness, lipid profile, quality of life and strength - SMD= -0.36 95% CI -0.59, -0.12 Z=3 p=.003)

	• PARKINSON'S DISEASE (4 studies n=113) ➢ Pain - SMD= -1.05 95% CI -1.82, -0.28 Z=2.67 p=0.008 ➢ cardiorespiratory fitness - SMD= -1.24 95% CI -2.01, -0.47 Z=3.18 p=0.001 ➢ balance - SMD= -0.31 95% CI -0.6, -0.02 Z=2.13, p=0.003 ➢ gait - SMD= -1.06 95% CI -1.80, -0.31 Z=2.79 p=0.005 ➢ quality of life - SMD= -0.74 95% CI -1.26, -0.23 Z=2.84 p=0.005 ➢ overall results – incorporating subgroups above as well as strength and flexibility - SMD= -0.69 95% CI -0.94, -0.45 Z=5.5 p<0.00001
SUMMARY	Water-based training produce benefits in health-related measures in adults with a stroke or Parkinson's disease.

Results from the meta-analysis by Moritz et al (2020) on the effects of adding aquatic physiotherapy to usual care for people experiencing a neurological condition, found that individuals with a stroke demonstrated improved functional ability with the addition of aquatic physiotherapy.

POPULATION	A total of 490 individuals with a neurological disorder were incorporated in the study: • stroke (n=431) • PD (n=59).
STUDY DESIGNS & QUALITY	10 underlying studies: • 7 RCTs (6 stroke, 1 PD) • 3 non- or quasi-randomised trials (2 stroke, 1 PD) Using the PEDRO scale to assess quality: • high quality – 2 studies -1 stroke, 1 PD • moderate quality - 4 stroke studies • low quality – 4 studies - 3 stroke, 1 PD
INTERVENTION	Aquatic physiotherapy in conjunction with usual-care land-based physiotherapy. This was implemented in two ways: • by addition (3 studies) or • by substitution of sessions (6 studies, 1 study did not specify) The aquatic physiotherapy intervention varied and included: • Halliwick • Bad Ragaz • Ai Chi techniques • walking exercises • strengthening training • task-specific training • balance training • combinations of these. Dosage varied: • session duration - 30-60 minutes • frequency - 2-21 sessions per week • intervention period - 2 weeks – 6 months
COMPARATOR	Usual-care land-based physiotherapy
RELEVANT RESULTS	There was insufficient clinical homogeneity to complete a meta-analysis of the included trials. SYSTEMATIC REVIEW FINDIINGS • STROKE There were significant differences in favour of combining land and water therapy for:

	➢ balance (Furnari et al, 2014; Park & Roh, 2011) ➢ walking (Furnari et al., 2014) ➢ mobility (Chan et al, 2017; J. Park et al, 2011) ➢ ADLs (Paizan et al., 2009) • PARKINSON'S DISEASE There were no significant differences in favour of either substituting or adding aquatic therapy to conventional land therapy (Ayan et al 2014; Palamara 2017)
SUMMARY	Aquatic physiotherapy in combination with usual care physiotherapy improves activity limitations in people with stroke.

The other three systematic reviews focused on the effect of aquatic therapy on particular outcomes. Oh et al (2021) assessed the effect of aquatic exercise on physical function and quality of life (QOL) in individuals with a neurological disorder. The consolidated results from underlying studies demonstrated that aquatic exercise had similar effects to land therapy with regards to balance and quality of life; it improved quality of life in the stroke and MS populations; and it improved at least one physical function measure in each of the stroke, MS and PD populations.

POPULATION	This review incorporated adults experiencing a neurological disorder (n=253), including: • Stroke (n=30) • MS (n=40) • PD (n=131)
STUDY DESIGNS & QUALITY	6 of the 8 underlying RCTs/pilot studies included stroke, MS or PD participants: • Stroke – 1 study • MS – 2 studies • PD – 3 studies Using the PEDRO scale to assess the quality of the 6 relevant studies: • excellent quality - 1 MS study • good quality - 2 PD studies • fair quality - 3 studies – 1 stroke, 1 MS, 1 PD Using the Down & Black quality index: • in all but one study, there was a high risk of bias with regards to blinding of outcome assessment. • In 50% of the studies there was a high risk of bias regarding blinding of participants and personnel • Otherwise, the overall risk of bias was low
INTERVENTION	Aquatic interventions varied in the 6 relevant studies: • general aquatic exercise (warm up with walking, upper and lower body stretches, cardiovascular exercise, trunk stretches, gait re-education and cool down) – 4 studies -2 MS, 2PD • Ai Chi -– 1PD study • Ai Chi and Halliwick - 1 stroke study Dosage varied: • frequency - 2-5 sessions per week • intervention period - 5-12 weeks
COMPARATOR	• conventional land exercise - 4 studies (1 stroke, 3 PD) • control group -1 MS study • no comparator -1 MS study
RELEVANT RESULTS	The meta-analysis results indicated that, overall, aquatic exercise groups for all neurological conditions had a similar effect (no significant difference) to control groups with regards to balance and quality of life.

	SYSTEMATIC REVIEW FINDINGS • STROKE (Eyvaz et al 2018 n=30) – significant improvements in both groups regarding: ➢ balance (BBS, TUB, FIM) – higher BBS results in the aquatic group ➢ quality of life – higher SF-36 results in the aquatic group • MULTIPLE SCLEROSIS (2 studies n=40) – significant improvements in: ➢ quality of life in the aquatic group with regards to pre- and post- intervention scores (Roehrs & Karst 2004) and in comparison to control group results (Kargarfard et al 2012). ➢ fatigue (MFIS) in comparison to a control group (Kargarfard et al 2012). • PARKINSON'S DISEASE (3 studies n=31) – significant improvements in: ➢ dynamic balance in favour of the aquatic group (multiple outcome measures used) (Kurt et al 2018) ➢ disability in favour of the aquatic group (Carroll et al 2017) ➢ trunk posture – only in the aquatic group (Volpe et al 2017)
SUMMARY	"The findings indicate that aquatic exercise program could be helpful when treating neurological disorders and should be considered as a means of reducing pain while increasing physical function and QOL in standard clinical research programs."

Methajarunon et al (2016) reviewed the effect of aquatic exercise on balance in persons with MS, PD or post-stroke. The authors summarised that aquatic interventions improved balance in the post-stroke and PD populations and postural control and mobility in the MS population.

POPULATION	This review incorporated 221 adult participants experiencing one of three neurological conditions: • MS (n=91) • PD (n=20) • Stroke (n=110)
STUDY DESIGNS & QUALITY	8 underlying studies: • 4 RCTs (1 PD, 3 stroke) • 4 quasi-experimental (3 MS, 1 PD). Using Downs and Black quality index: • good quality - 1 PD study • fair/moderate quality - 7 studies • authors expressed concern regarding small sample sizes and risk of both selection and publication bias.
INTERVENTION	Aquatic interventions varied and included: • Ai Chi -1 MS study • Community-based aquatic exercise -1 MS study • Obstacle training - 1 stroke study • Task-oriented training - 1 stroke study • "Aquatic exercise" -1 MS study, 2 PD studies, 1 stroke study Dosage varied: • session duration - 35-60 minutes • frequency - 2-6 sessions per week (most commonly 2-3 per week) • intervention period - 4-12 weeks
COMPARATOR	• land-based exercise - 4 studies -1 PD study and 3 stroke studies • home-based exercise - 1 MS study • Pilates and a control group -1 MS study • no comparator - 2 studies - 1 MS and 1 PD
RELEVANT RESULTS	Due to the heterogeneity of study designs, participants and outcome measures, it was not possible to conduct a meta-analysis.

	SYSTEMATIC REVIEW FINDINGS • MULTIPLE SCLEROSIS Significant differences in favour of aquatic interventions were found in relation to: ➢ postural control (Bayraktar et al 2013; Marandi et al 2013; Salem et al 2011) ➢ TUG and 6MWT results (Bayraktar et al 2013) ➢ gait speed (Salem et al 2011) • STROKE There was a statistically better improvement in favour of aquatic exercise v land exercise in relation to: ➢ static balance (Jung et al 2014b; Park & Roh 2011) ➢ dynamic balance (Lee et al 2010) • PARKINSON'S DISEASE There was a significant improvement in: ➢ BBS results with regards to pre- and post- intervention scores (Jacobs et al 2012) and in comparison to a land-based intervention (Vivas et al 2011). ➢ FRT in both aquatic and land-based groups (Vivas et al 2011)
SUMMARY	The findings suggest that aquatic exercise improves balance in those with multiple sclerosis and post-stroke and mobility in those with multiple sclerosis. The authors stated that no conclusions could be drawn regarding this therapy in the Parkinson's populations due to the small sample size available.

In reviewing the effect of aquatic therapy on the mobility of those with neurological diseases, Marinho-Buzelli et al (2015) found that aquatic therapy improved balance and aspects of gait in those living with PD, MS or post-stroke.

POPULATION	This analysis included 374 adults with neurological conditions. Most common conditions were: • MS (n=98) • stroke (n=98) • PD (n=61)
STUDY DESIGNS & QUALITY	14 of 20 underlying studies included MS, stroke or PD adults: • 3 RCTs (2 stroke and 1 PD) • 3 quasi-experimental non-randomised studies (1 MS, 1 stroke, 1 PD) • 8 before-and-after studies (4 MS, 1 stroke, 3 PD) A modified Downs and Black quality index was used to assess methodological quality: • Fair quality – 10 studies – 3 MS, 3 stroke, 4 PD • Weak quality – 4 studies – 1 MS, 1 stroke, 2 PD
INTERVENTION	Aquatic therapy – "any method of therapeutic movement, exercise or activity in a pool." Therapy protocols varied and included: • Methods such as Ai Chi, Halliwick and Watsu (a passive treatment) • Swimming • Exercises focusing on aerobic work, strengthening, balance, coordination Dosage varied: • session duration - 40-60 minutes • frequency - 1-5 sessions per week (most commonly 2-3 per week) • intervention period - 2 weeks – 8 months
COMPARATOR	In the 14 studies incorporating MS, stroke or PD populations: • no comparator - 7 studies – 3 MS, 1 stroke, 3 PD • land/conventional therapy - 3 studies – 2 stroke, 1 PD • control group - 3 studies - 2 MS, 1 stroke • different aquatic therapies - 1 PD study

RELEVANT RESULTS	A meta-analysis could not be conducted due to the diversity of the studies. SYSTEMATIC REVIEW FINDINGS • DYNAMIC BALANCE ➢ Significant improvements, as assessed by TUG, were found in: ▪ 3 MS studies (Salem et al 2010, Salem et al 2011, Useros-Olmo et al 2010) ▪ 1 stroke study (Montagna et al 2014) ▪ 1 PD study (de Andrade et al 2010) ➢ 2 stroke studies found significant improvements using different outcome measures - COP measures (Lee et al 2010) and load forces (Noh et al 2008) • WALKING ➢ Significant improvement in walking speed in 2 MS studies (Salem et al 2010, Salem et al 2011) ➢ Improvement in gait kinematics in 1 PD study (Rodriguez et al 2013) ➢ In 2 stroke studies with land comparators, one study showed similar improvements in gait parameters in both groups (Noh et al 2008) and one showed greater improvement in gait speed in the aquatic group (but the land intervention comparator involved an upper limb program) (Chu et al 2004)
SUMMARY	Aquatic therapy is beneficial in improving dynamic balance and walking in those experiencing PD, post-stroke or MS.

PARKINSON'S DISEASE

A Cochrane Review recently assessed the effects of physical exercise for this population (Ernst et al, 2023) and included findings from eleven studies investigating the effects of aquatic-based training. Pertinent findings include:

- "Aqua-based training, gait/balance/functional training, and training that consists of several exercise types (i.e. multi-domain training) might have a moderate beneficial effect on movement."
- "Aqua-based training probably has a large beneficial effect on quality of life."
- "The evidence suggests that the effect of aqua-based training on QoL was superior to the effects of gait/balance/functional training and multi-domain training. The effect of aqua-based training on QoL may also be increased compared to dance and strength/resistance training, but the CIs touched or extended across the line of no effect. The evidence also suggests that the effect of aqua-based training on functional mobility and balance was superior to the effects of gait/balance/functional training, strength/resistance training, and multi-domain training."
- "We found that many types of physical exercise can help improve movement and quality of life for people with PD. We found scant evidence that certain exercise types work better than others. Therefore, for movement and quality of life, we think physical exercise is important, but the exact exercise type might be less important. Still, it is possible that some symptoms may be relieved best with specific types of training made for people with PD. The types of training we included seemed to be quite safe."

Two recently published meta-analyses evaluating the effect of different therapies for those with PD incorporated aquatic therapy in their analyses. The network meta-analysis by Qian et al (2023) found aquatic exercise not only significantly improved static steady-state balance compared to control groups but that it was the best performing therapy in this regard (SMD 0.94 P score 0.85). The meta-analysis results from el Hayek et al (2023) found that nonstandard physical therapy (the most common of which was aquatic physiotherapy) produced similar results to standard physical therapy in measures of gait, balance, and Unified Parkinson's Disease Rating Scale (UPDRS) scores.

Five recent meta-analyses focused solely on aquatic exercise/therapy for those with Parkinson's disease (Braz de Oliveira et al 2023; Carroll et al 2020; Dai et al 2023; Gomes et al 2020; Liu et al 2023). Despite use of many of the same RCTs, the five meta-analyses differed with regards to outcome focus and size.

STUDY	OUTCOME FOCUS	NO. OF RCTS	NO. OF PARTICIPANTS
Dai et al 2023	Lower limb motor function and quality of life	10	298
Braz de Oliveira et al 2023	ICF classifications	12	380
Liu et al 2023	Balance (but also measured other outcomes)	5	135
Carroll et al 2020	Multiple outcomes	14	472
Gomes et al 2020	Function and quality of life	15	435

Furthermore, findings were not consistent across all five meta-analyses. A summary of the varying findings is presented below.

OUTCOME MEASURE	SIGNIFICANT META-ANALYSIS RESULTS IN FAVOUR OF AQUATIC INTERVENTION OVER LAND THERAPY	NO SIGNIFICANT DIFFFERENCES BETWEEN GROUPS IN META-ANALYSIS RESULTS
BALANCE	• Dai et al 2023 • Braz de Oliveira et al 2023 • Liu et al 2023 • Gomes et al 2020	• Carroll et al 2020 (using BBS)
MOBILITY/GAIT	• Dai et al 2023 (using TUG) • Carroll et al 2020 (using TUG) • Gomes et al 2020	• Braz de Oliveira et al 2023 • Liu et al 2023 (although a sensitivity analysis showed a superior continuation effect)
QUALITY OF LIFE	• Dai et al 2023 • Gomes et al 2020	• Braz de Oliveira et al 2023 • Liu et al 2023 • Carroll et al 2020

However, overall, the meta-analyses' results suggest that aquatic therapy has positive effects on the balance, gait and quality of life of those with Parkinson's disease. These effects appear to be similar, if not superior, to the effects of traditional land therapy. These findings are consistent with Cochrane review conclusions.

A recent meta-analysis with a wide outcome focus (Dai et al 2023) found that aquatic intervention was at least as effective as land therapy or control regarding motor function but superior to land therapy or control in relation to improvements in balance, walking and quality of life.

POPULATION	This analysis included 298 adults who had had Parkinson's disease for more than a year.
STUDY DESIGNS & QUALITY	All 10 of the underlying studies were RCTs. Assessed against the Cochrane risk of bias tool, the studies were assessed as being of moderate quality (with high risk of bias with regards to performance bias and lack of clarity regarding selection bias)
INTERVENTION	Aquatic intervention varied (although all included a warm-up and cool down) and included: • trunk movement, postural stability and balance work • aerobic work • gait training/walking • stretches • Ai Chi • dual tasks Dosage varied: • session duration - 45-60 minutes • frequency - 2-7 sessions per week • intervention period - 3-11 weeks
COMPARATOR	• land drill - 6 studies • land drill plus multidisciplinary intensive rehabilitation treatment – 2 studies • "routine treatment" – 1 study • control – 1 study
RELEVANT RESULTS	META-ANALYSIS FINDINGS • Statistically significant weighted mean differences (WMD) in favour of aquatic exercise in: ➢ Balance (assessed via BBS) -9 studies n= 280 WMD = 2.234, 95% CI: 1.112–3.357, Z = 3.9, p < 0.01

	➢ Walking ability (assessed via TUG) - 9 studies n=280 WMD= −0.911, 95% CI: −1.581 to −0.241, Z = 2.67, $p < 0.01$ ➢ QOL (assessed via PDQ-39) - 5 studies n=146 WMD = −5.057, 95% CI: −9.610 to −0.504, Z= 2.18, p= 0.029 • No significant difference was found in motor function as assessed by UPDRS III
SUMMARY	"Aquatic exercise can effectively improve the balance function, walking ability, and quality of life of patients with PD, but the improvement effect on the motor function of patients is not significant, limited by the number and quality of the included studies."

The results of the largest study that also looked at a wider range of outcomes (Carroll et al 2020) concluded that aquatic therapy resulted in a significant improvement in functional mobility and also highlighted that a reduced falls risk may ensue.

POPULATION	472 adults with Parkinsonism disorders (e.g., Idiopathic PD, Progressive Supranuclear Palsy, and Lewy Body Dementia) were included in this analysis. However, only results from 265 subjects were incorporated in the meta-analysis.
STUDY DESIGNS & QUALITY	14 RCTs were included in the study and 7 RCTs were used in the meta-analysis Using the PEDRO scale to assess methodological quality, rankings were from low to high quality but the median score was 7/10 (good quality), with 8 RCTs of "good" quality. Using the Downs and Black quality index, the median score was 23.4/27, with one study reaching the maximum score.
INTERVENTION	Aquatic therapy varied and included: • Ai Chi (4 studies) • dual task work • obstacle work • gait training • balance • Halliwick Dosage varied: • session duration - 30-60 minutes • frequency - 2-7 sessions per week • intervention period - 3-11 weeks
COMPARATOR	• land-based physiotherapy – most studies • other aquatic therapy or water-based intervention – 1 study • V healthy controls – 1 study
RELEVANT RESULTS	Testing was done in: • ON medication phase in 5 studies • OFF medication phase in 5 studies, with medication withheld 8-12 h before assessments META-ANALYSIS FINDINGS – AQUATIC THERAPY V LAND THERAPY Functional Mobility (assessed via TUG) (6 studies n=191) • A statistically significant difference was found in favour of aquatic therapy - MD –1.5secs, 95 % CI –2.68 to –0.32 secs; p=0.01, I^2=13% • 3 studies using only Ai Chi found a statistically significant difference in favour of aquatic therapy (Kurt et al 2017, Pérez de la Cruz 2017, Pérez de la Cruz 2018) • 3 studies using only "aquatic therapy" did not find a statistically significant difference between therapies (Volpe et al 2014, Volpe et al 2017, Palamara 2017)

	SYSTEMATIC REVIEW FINDINGS 2 underlying studies reported a significant reduction in falls following aquatic therapy (Volpe et al 2014, Volpe et al 2017)
SUMMARY	"Aquatic therapy had positive outcomes for gait, balance and mobility that were comparable to land-based physiotherapy in the early stages of PD. The optimal dosage, content and duration of aquatic interventions for PD could not be confirmed in this meta-analysis." Regarding dosing: • the authors stated that "Many trials appeared to be under-dosed and therapy duration was low" • Results from underlying studies suggest that a minimum of 3 aquatic sessions a week may be necessary for "clinically meaningful improvements" • Only 4 of 14 studies met the European physiotherapy guidelines for exercise in PD ≥3 45-min sessions/week for 8 weeks

Two clinical guidelines concerning therapy for those with Parkinson's disease provide guidance with regards to aquatic therapy. Carroll et al (2022b) present internationally agreed guidelines for evidence-based aquatic therapy for this population, including key information regarding:

- Referral
- Screening
- Assessment
- Therapy – including structure, safety, tailoring, dosage, elements to include.

And the American Physical Therapy Association Clinical Practice Guidelines (Osborne et al, 2022) state that "aquatic therapy may be considered to reduce fear of falling and improve quality of life", in relation to balance training.

Qualitative studies have also been published regarding aquatic therapy for Parkinson's disease. Terrens et al (2021) investigated perceptions of aquatic physiotherapy in those with Parkinson's disease and found that:

- "Aquatic physiotherapy was well-accepted. Participants felt their function improved and felt safe in the water."
- Enablers included an improvement in function, fewer falls and group socialization
- Barriers included safety when getting dressed, fatigue and transport

A year later, Carroll et al (2022a) sought the opinions of those with Parkinson's disease about access and participation in aquatic therapy. The study found:

- "Most participants reported "wanting to keep moving" as an important influencing factor for uptake in aquatic therapy."
- "All participants who had aquatic therapy experience reported holistic benefits such as enhanced well-being, feeling looser, less stiffness, and moving more freely."
- "Social support and group cohesion were strong motivators for long-term adherence to aquatic therapy."
- "Many participants highlighted the importance of attending aquatic therapy with a suitably qualified professional who has a sound theoretical understanding of Parkinson-related impairments"
- "Barriers to participation in aquatic therapy reported by some participants included a lack of credible information sources, transport, and cost."

In 2011, a Cochrane Review concluded that evidence for or against aquatic therapy for stroke clients was inconclusive, due to the small overall sample size (Mehrholz et al 2011). However, the conclusion did note that:

"There were significant differences in favour of water-based exercises for people after stroke for activities of daily living and muscle strength, but these results are based only on a single study. However, adverse events and drop-outs did not appear to be more frequent in those participants who received water-based exercises. This indicates that the use of different types of water-based exercises appears to be acceptable to most participants in the trials included in this review."

Since 2011, there have been a significant number of published RCTs and subsequent systematic reviews that evaluate the effects of aquatic therapy for stroke survivors. The results of eleven of the systematic reviews with meta-analyses were examined (Chae et al 2020; Ghayour Najafabadi et al 2022; Giuriati et al 202; Iliescu et al 2020; Li et al 2021; Nascimento et al 2019; Nayak et al 2020; Saquetto et al 2019; Veldema et al 2021; Xie et al 2019; Zughbor et al 2021). All eleven found that aquatic therapy improved balance in this population. Overall, results also support the use of aquatic therapy for improving gait (particularly speed), muscle strength (lower limb), mobility/functional independence, quality of life, cardiorespiratory fitness, proprioception and spasticity.

Of these studies, Veldema et al (2021) completed a systematic review and meta-analysis incorporating the largest number of subjects (961) and the largest number of outcomes. The authors found water-based therapy was effective in relation to improving balance, gait, spasticity and quality of life and was superior to land-based therapy with regards to balance and proprioception.

POPULATION	961 adults with a stroke were included in the analysis.
STUDY DESIGNS & QUALITY	All 28 underlying studies were RCTs. Regarding methodological quality, there was significant variability in the PEDRO scores of the underlying studies (from poor to good quality), the average score being 5.2 (between fair and good quality).
INTERVENTION	Water-based therapy interventions varied greatly and included: • Halliwick • Ai Chi • Watsu • Bad Ragaz as well as • aquatic treadmill walking • balance exercises Dosage varied: • session duration - 20-60 minutes • frequency - 2-6 sessions per week • intervention period - 2-12 weeks
COMPARATOR	• land-based intervention – 21 studies • no comparator – 6 studies • different aquatic therapy methods – 1 study

RELEVANT RESULTS	META-ANALYSIS FINDINGS • AQUATIC INTERVENTION V NO INTERVENTION Significant effect sizes were found in favour of aquatic intervention in: ➢ Balance - 4 trials n=96 effect size 0.90 95% CI 0.04-1.76 ➢ Gait – (including TUG measures) - 4 trials n=196 effect size 0.80 95% CI 0.25-1.36 ➢ Health-related QOL (HRQOL) – emotional status - 3 trials n=184 effect size 0.64 95% CI 0.14-1.14 ➢ Spasticity - 1 trial n=120 effect size 0.91 95% CI 0.54-1.29 ➢ Overall improvement in outcomes - 6 trials n=251 effect size 0.76 95% CI 0.15-1.37 • AQUATIC INTERVENTION V LAND-BASED THERAPY Significant effect sizes were found in favour of aquatic intervention in: ➢ Balance - 17 trials n=572 effect size 0.77 95% CI 0.06-1.47 ➢ Proprioception -3 trials n=124 effect size 0.71 95% CI 0.14-1.28
SUMMARY	• "Water-based therapy is highly effective in supporting gait, balance, spasticity ….and moderately effective in supporting emotional status and health-related quality of life in stroke patients." • The meta-analysis results suggest that aquatic therapy is superior to land-based interventions regarding balance and proprioception. • "The current evidence on balance and walking ability is good. In contrast, the evidence on emotional status and spasticity is very limited." • "The type of aquatic therapy method impacts its effects" • "The current evidence is insufficient to support this therapy form within evidence-based rehabilitation. However, the available data indicate that this therapy can significantly improve a wide range of stroke-induced disabilities. Future research should devote more attention to this highly potent intervention."

In the second largest analysis (Saquetto et al 2019), the authors compared water-based exercise with and against various combinations of other therapy options and found that water-based exercise, either as a substitute or as an adjunct to land therapy, was effective in improving a number of physical measures and also quality of life.

POPULATION	This analysis incorporated 807 adults with any disability following a stroke
STUDY DESIGNS & QUALITY	All 24 underlying studies were RCTs. Using PEDRO to assess methodological quality, the overall quality of the studies was assessed as being moderate - average score 4.9/10: • Good quality - 6 studies • Fair quality – 16 studies • Poor quality – 2 studies
INTERVENTION	Water-based exercise (including aerobic and strength exercises in warm water): A alone - 9 studies B in conjunction with land-based therapy - 6 studies C in conjunction with physiotherapy - 2 studies

	Dosage varied: • session duration - 30-60 minutes • frequency - 2-6 sessions per week • intervention period - 2-12 weeks
COMPARATOR	A & B - land-based exercise C - land exercise in conjunction with physiotherapy
RELEVANT RESULTS	META-ANALYSIS FINDINGS • WATER-BASED EXERCISE AS A SUBSTITUTE FOR LAND EXERCISE (9 STUDIES) Significant standardized mean differences were found in favour of water-based exercise in: ➢ Muscle strength (assessed using different outcome measures) -3 RCTs n=69 SMD=0 .63 95% CI 0.15-1.12 Z=2.56 p=0.01 ➢ Balance (BBS) - 4 RCTs n=80 SMD=1.55 95% CI 0.5- 2.58 Z=2.94 p=0.003 ➢ Mobility (TUG) - 2 RCTs n=48 SMD=-1.22 seconds 95% CI -2.04 to -0.40 Z=2.92 p=0.004 ➢ Aerobic capacity (Peak VO2) - 2 RCTs n=33 SMD= 3.64 mL/kg/minute 95% CI 0.66-6.62 Z=2.39 p=0.02 • WATER-BASED EXERCISE & LAND EXERCISE VERSUS LAND EXERCISE ALONE (6 STUDIES) Significant standardized mean differences were found in favour of water-based exercise in addition to land exercise in: ➢ Balance (BBS) - 5 RCTs n=149 SMD=1.69 95% CI 0.9- 2.5. Also reported in Figure 3A as 4 studies MD=2.34 95% CI 1.31-3.38 Z=4.43 p<0.00001 ➢ Gait speed (assessed using different outcomes measures) - 4 RCTs n=185 SMD=0.64 95% CI: 0.34-0.93 Z=4.18 p<0.0001 ➢ Functional reach (FRT) -2 RCTs n=50 SMD= 2.1 cm 95% CI: 1.1- 3.0 3 Z=4.23 p<0.0001 ➢ QOL (SF-36) - 2 RCTs n=180 ▪ Role limitations due to physical functioning - SMD=11.24 95% CI 6.75-15.72 Z=4.91 p<0.0001 ▪ Role limitations due to emotional problems - SMD=11.66 95% CI: 7.15-16.18 Z=5.06 p<0.00001 ▪ Vitality - SMD= 8.65 95% CI 5.42- 11.88 Z=5.25 p<0.00001 ▪ General Mental Health - SMD= 8.52 95% CI 2.00-15.03 Z=2.56 p=0.01 ▪ Social Functioning - SMD= 8.10 95% CI 3.22-12.98 Z=3.25 p=0.001 ▪ Bodily pain - SMD= 8.28 95% CI 5.02-11.54 Z=4.98 p<0.00001 ▪ No significant improvements in Physical Functioning and General Mental Health • WATER-BASED EXERCISE AND PHYSICAL THERAPY VERSUS LAND EXERCISE AND PHYSICAL THERAPY (2 STUDIES) Significant standardized mean differences were found in favour of water-based exercise in addition to physiotherapy in: ➢ Joint position sense (joint position sense test) - 2RCTs n=106 SMD=0.85 95% CI 0.35-1.35 Z=3.32 p=0.0009
SUMMARY	"…our meta-analysis indicates that water-based exercise was more effective than land exercise for improving muscle strength, balance, mobility, aerobic capacity, and joint position sense in post-stroke persons. Moreover, combined water-based exercise and land exercise was more effective than land exercise for improving balance, mobility, gait, functional reach and quality of life, and joint position sense."

Two other reviews found significant results in favour of aquatic therapy over land therapy with regards to functional independence (Giuriati et al 2021; Li et al 2021). Giuriati et al (2021) found a significant improvement in favour of aquatic therapy in the Modified Barthel Index (6-8 weeks) (2 studies, n=67, MD=

9.49 95% CI 0.74-18.24 Z=2.13 p=0.03). Li et al (2021) found significant improvements in favour of aquatic therapy in both the Fugl–Meyer Assessment (FMA) (3 studies, n=134, MD = 3.84, 95% CI 1.64 - 6.04, Z= 3.42 p = 0.0006) and the Functional Independence Measure (FIM) (2 studies, n=46, MD = 6.1, 95% CI 4.05 - 8.15, Z= 5.82 p < 0.00001).

Many of the eleven reviews concurred on significant findings in favour of aquatic therapy. However, despite reviews including many of the same RCTs, there were variances in the conclusions, due to differences in methodology, as outlined in the following table.

OUTCOME	CONCENSUS FINDINGS	DIFFERENT FINDINGS
Balance	All reviews but Nayak et al (2020) found that, in at least one measure of balance, aquatic therapy was superior to land therapy for improving balance.	Nayak et al (2020), using 6 underlying studies, did not find that the addition of aquatic therapy to land therapy produced a significant improvement in BBS or FRT When assessing aquatic therapy as a substitute for land therapy, Zughbor et al (2021), using BBS as a balance outcome measure, found a significant difference <u>in favour of land-based therapy</u> from 9 studies (n=222 MD=2.93, CI 1.11-4.74, Z=3.16, p=0.002). However, the same study did find significant differences in favour of aquatic therapy using anteroposterior and mediolateral sway as balance outcome measures.
TUG – aquatic V land therapy (outcome measure used as either measure of balance or mobility)	Ghayour Najafabadi et al (2022), Saquetto et al (2019), Giuriati et al (2021), Iliescu et al (2020), Chae et al (2020) and Xie et al (2019) found significant improvements in favour of aquatic groups	Li et al (2021) did not find a significant improvement in TUG in favour of the aquatic group, based on 3 underlying studies. (The Ghayour Najafabadi and Chae reviews used 8 and 6 underlying studies respectively)
Walking speed – aquatic V land therapy	Ghayour Najafabadi et al (2022), Iliescu et al (2020), Nascimento et al (2019) and Xie et al (2019) found statistically important improvements in favour of the aquatic groups	Saquetto et al (2019) did not find a statistically important improvement in favour of the aquatic group from 3 underlying studies. The other analyses used 5 (different) underlying studies, except Xie et al (2019) who used only 2 underlying studies. Zughbor et al (2021) found a significant difference <u>in favour of land-based therapy</u> from 4 studies (n=96 SMD=0.82, CI 0.39-1.25, Z=3.75 p=0.0002. 2 of the underlying studies were not often used in other analyses.
Walking speed – aquatic & land therapy v land therapy	Saquetto et al (2019) found statistically important improvements in the aquatic group & land group over simple land therapy	Nayak et al (2020), using 2 studies (only 1 of which was used by Saquetto) did not find statistically important improvements in the aquatic group & land group over simple land therapy
Muscle strength – aquatic v land therapy	Saquetto et al (2019), Giuriati et al (2021) and Chae et al (2020) found significant mean differences in muscle strength (as measured by Nm of torque) in favour of the aquatic groups	Nascimento et al (2019) failed to find significant mean differences between the groups. This study did use Nm/kg as the outcome measure, unlike the other 4 studies. It used the same 3 underlying studies as Chae et al (2020).

Since the publication of the eleven meta-analyses, two further RCTs that assess the effectiveness of aquatic therapy have been published.

Bei et al (2023) found that early intervention water exercise as a supplement to conventional limb function training was beneficial for improving lower limb function in the stroke population.

POPULATION	This study included 160 participants within one month of experiencing their first stroke and having a lower limb dysfunction
STUDY DESIGN & QUALITY	RCT Using the PEDRO scale, this study was of good quality (6/10)
INTERVENTION	Hydrotherapy PLUS conventional limb function training. Hydrotherapy consisted of 2 parts: 1 Direct current electric stimulation water bath therapy applied to participants' limbs in the water 2 Gait training in the water Hydrotherapy dosage (48 sessions): • session duration - 30-40 minutes • frequency - 6 sessions per week • intervention period - 8 weeks
COMPARATOR	Free-hand assisted gait training PLUS conventional limb function training
RELEVANT RESULTS	Prior to intervention, there were no statistically significant differences between groups on any of the 6 outcome measures performed. However, post-intervention there were significant improvements in all 6 outcome measures in favour of the hydrotherapy group: ➢ limb motor function score table – Fugl Meyer assessment (FMA) - t=5.700 $p<0.05$ ➢ Functional Walking Scale -Functional Ambulation Category scale (FAC) - t=3.055 $p<0.01$ ➢ Berg Balance Scale (BBS) - t=4.824 $p<0.05$ – (possible error as same as MBI) ➢ Modified Barthel index (MBI) - t=4.824 $p<0.05$ – (possible error as same as BBS) ➢ National Health Center Stroke Scale (NIHSS) - t=3.480 $p<0.01$ ➢ Modified Rankin scale (MRS) - t=2.290 $p<0.05$
SUMMARY	Early water exercise training in participants with a first stroke is beneficial for balance, gait and function

Gu et al (2023) found significant improvement in balance, mobility and gait in chronic stroke participants when conventional hydrotherapy was augmented by aquatic lower extremity strength training.

POPULATION	This study included 56 post-stroke participants. (The abstract specifies a timing of more than 6 months after 1st stroke but the inclusion criteria specifies 1-5 months post-stroke and patient characteristics table indicates a shorter time-frame post-stroke.) Participants required a degree of standing equilibrium and transferring ability AND ≥ grade 3 muscle strength in the hemiplegic iliopsoas, quadriceps femoris and "triceps" calf muscle.
STUDY DESIGN & QUALITY	RCT Using the PEDRO scale, this study was of good quality (6/10)
INTERVENTION	The intervention involved aquatic lower extremity strength training PLUS conventional hydrotherapy. The aquatic strength training occurred for 15 minutes, replacing 15 minutes of conventional hydrotherapy session time. It involved use of an aquatic quadriceps femoris training machine designed by the researchers and adapted for three training patterns: 1 use of buoyancy aids for resisting hamstring work 2 use of weights for resisting quadricep work

	3 use of baffles to increase turbulence and resist both hamstrings and quadricep work The progressive training pattern was specific to the needs of the client Dosage: • Total aquatic exercise session duration - 45 minutes • Frequency - 5 sessions per week • intervention period - 6 weeks
COMPARATOR	Conventional hydrotherapy, which consisted of: • equilibrium functional exercise training • stretching exercises • strength and endurance training Assistance from others was allowed when patients were exercising to prevent accidental falls.
RELEVANT RESULTS	Prior to intervention, there were no statistically significant differences between groups on any of the outcome measures performed. However, post-intervention there were significant improvements in favour of the aquatic strength training group in: ➢ Berg Balance Scale (BBS) - t=2.299 p=0.025 ➢ Timed Up and Go (TUG) - t=-6.874 p<0.001 ➢ Two Minute Wheeled Mobility Test (2MWMT) - t=6.618 p<0.001 ➢ Gait Analysis (Biodex Gait Trainer 2): ▪ stride length paralytic side - t=3.494 p=0.001 ▪ stride length non-paralytic side - t=2.923 p=0.005 ▪ stride frequency - t=3.089 p=0.003 ▪ walking speed - t=3.298 p<0.002
SUMMARY	"Aquatic strength training can improve postural balance and lower extremity motor functions in chronic stroke patients"

A recently published qualitative study (Marinho-Buzelli et al, 2023) outlined the stroke population's experiences with aquatic therapy. The authors concluded that "health-care professionals and clients reported numerous benefits of aquatic therapy post-stroke including, but not limited to, improvements in mobility, balance, wellbeing, and socialization."

Three indicative quotes from clients were:

- "… I learned to do things which I thought I would never do again…I walk across without someone holding on to me."
- "It's also safer. You fall in the water, you don't get hurt."
- "I learned how to be sociable again, because depression and anxiety really is terrible."

Two relevant quotes from healthcare professionals were:

- "…wow, look at all these goals we can achieve, but it's masked with this fun activity that people want to participate in."
- "Well, definitely there's less resources needed for in the water versus on land. And I've spoken how you can change the position from a patient to go from supine to standing in a matter of seconds. Whereas on land you might need more people and pieces of equipment in order to make that happen."

There have been 6 recent systematic reviews (4 with meta-analyses) assessing aquatic therapy for those with multiple sclerosis (Amedoro et al 2020; Corvillo et al 2017; Hao et al 2022; Naeimi et al 2024; Shariat et al 2022; Schoeneberg et al 2020). Their findings suggest that aquatic physiotherapy has beneficial effects on fatigue, balance, walking ability, depression, pain and quality of life in this population.

The largest of these meta-analyses (Shariat et al 2022) found aquatic therapy to have a greater positive effect than conventional intervention on fatigue and balance in those experiencing MS.

POPULATION	794 adults (aged 19 years or older) with multiple sclerosis were included in the review. Only 493 subjects completed the trials.
STUDY DESIGNS & QUALITY	16 underlying experimental trials: • 10 RCTs • 2 non-randomised controlled trials • 3 case series • 1 case report Joanna Briggs checklists were utilized to assess the quality of the studies. • RCTs varied between 8-12/13 yes answers (with an average of 10.2/13) • one controlled trial has 2/9 no answers • the 3 case series' and one controlled trial had fully positive answers • the case report received only 1/8 no answer
INTERVENTION	Aquatic therapy interventions varied, including: • Halliwick • Ai Chi • Plyometrics • aquatic cycling • aquatic aerobics • swimming • water exercises Dosage varied greatly: • session duration - 45-135 minutes • frequency - 2-7 sessions per week • intervention period - 3-20 weeks
COMPARATOR	• land-based exercise therapy – 4 studies • control/conventional therapy – 7 studies • different aquatic interventions – 1 study • no comparator – 4 studies
RELEVANT RESULTS	META-ANALYSIS FINDINGS Aquatic therapy had a significantly positive effect compared to conventional treatment group on: • FATIGUE via: ➢ <u>Modified Fatigue Impact Scale (MFIS)</u> ▪ <u>physical fatigue</u> – 4 trials n=163 SMD= -1.29; 95% CI -1.65 to -0.93 Z=7.07 p<0.00001 ▪ <u>cognitive fatigue</u> – 4 trials n=164 SMD= -0.75; 95% CI -1.08 to - 0.43; Z=4.51; p<0.00001 ▪ <u>psychological fatigue</u> – 4 trials n=163 SMD= -1.25; 95% CI -1.59 to -0.9; Z=7.01; p<0.00001 ➢ <u>Fatigue Severity Scale (FSS)</u> - 3 trials n=138 SMD= -0.53; 95% CI -0.86 to -0.20; Z=3.11; p=0.002 • BALANCE (BBS) – 2 trials n=48 SMD=1.19; 95% CI 0.62-1.76: Z=4.11; p<0.0001

SUMMARY	"Aquatic therapy has positive effects on fatigue and balance. Further research is needed to confirm the clinical utility of aquatic therapy for multiple sclerosis patients in the long term."

These results back up the findings of Amedoro et al (2020) regarding fatigue and balance. This 2020 analysis was based on 11 RCTs (many of which were also underlying studies in Shariat et al, 2022) and had a total of 438 participants. This analysis also found significant results in favour of aquatic therapy over conventional therapy with regards to:

- BECK DEPRESSION INVENTORY (BDI) at eight weeks follow-up - 2 studies, n=94, MD = −5.63, 95% CI −6.99 to −4.27 Z=8.11 p< 0.00001)
- SIX-MINUTE WALKING TEST (6-MWT) at eight weeks follow-up - 2 studies, n=72, MD =−83.24, 95% CI −110.84 to −55.64) Z=5.91 P < 0.00001)

The meta-analysis by Hao et al (2022) looked at different exercise therapies for those with MS. The study included aquatic exercise in their network meta-analysis and found relative to the control groups, aquatic exercise groups were statistically superior in terms of balance and

- FUNCTIONAL WALKING ABILITY (TUG) - 2 studies, n= 58, MD = −2.58, 95% CI = −5.88 to −0.72. Aquatic exercise achieved the number one SUCRA probability ranking in terms of reducing the TUG time (78.8% ie 78.8% of treatment outcomes performed poorer than this treatment).

The fourth meta-analysis (Naeimi et al, 2024), employing only pre- and post- aquatic therapy intervention comparisons, demonstrated a significant improvement in balance (BBS), fatigue (MFIS and FFS) and depression (BDI).

The two systematic reviews, Corvillo et al (2017) and Schoeneberg et al (2020) found results comparable to the meta-analyses but also highlighted improvements in quality of life and reduction in pain.

With regards to assessing the effect of aquatic therapy on pain in this population, the most significant underlying RCT was undertaken by Castro-Sánchez et al (2012). An Ai Chi program in the water produced a significant decrease in pain in MS participants from baseline and the pain decrease was significantly greater in the intervention group than the comparator group at weeks 20 and 24.

POPULATION	This study included 73 individuals with multiple sclerosis
STUDY DESIGN & QUALITY	RCT According to Corvillo et al (2017) this RCT was determined to be of good quality (75%) according to the modified Downs and Black quality index
INTERVENTION	Ai Chi. Dosage (40 sessions): • session duration - 60 minutes • frequency - 2 sessions per week • intervention period - 20 weeks
COMPARATOR	The comparator was relaxation exercises in a therapy room (incorporating abdominal breathing and contraction-relaxation exercises)

Dosage (40 sessions):

- frequency - 2 sessions per week
- intervention period - 20 weeks

RELEVANT RESULTS

RESULTS REGARDING PAIN MEASURES

- PAIN (VAS)

  V baseline – whilst the control group showed no significant differences in pain VAS score versus baseline at any time point, the experimental group showed a significant reduction in pain VAS score at:
  - ➢ week 20 (P< 0.028), with a 50% reduction in pain levels
  - ➢ week 24 (P< 0.035)
  - ➢ week 30 (P< 0.047)

  Between group differences - the experimental group demonstrated significantly lower pain VAS scores that the comparator group at:
  - ➢ week 20 (P< 0.044)
  - ➢ week 24 (P< 0.049)

- MCGILL PAIN QUESTIONNAIRE (MPQ) – PAIN RATING INDEX (PRI)

  V baseline - whilst the control group showed no significant differences in PRI score versus baseline at any time point, the experimental group showed a significant reduction in PRI score at:
  - ➢ week 20 (P< 0.037)
  - ➢ week 24 (P< 0.043)

  At week 30, the experimental group no longer showed a significant pain reduction versus baseline

  Between group differences – the experimental group demonstrated a significantly lower PRI score than the control group at
  - ➢ week 20 (P< 0.044)
  - ➢ week 24 (P< 0.031)

- MPQ – PRESENT PAIN INTENSITY (PPI)

  V baseline - The experimental group showed a significant reduction in PPI at week 20 (P< 0.034)

- ROLAND MORRIS DISABILITY QUESTIONNAIRE (RMDQ)

  V baseline -
  - ▪ Significant decreases in RMDQ scores were found in both groups at:
    - ➢ Week 20 (P< 0.021, experimental group; P< 0.033, control group)
    - ➢ week 24 (P< 0.026, experimental group; P< 0.048, control group)
  - ▪ Significant decreases in RMDQ scores were found in the experimental group alone at week 30 (P< 0.028).

  Between group differences - the experimental group demonstrated significantly lower scores than the control group at:
  - ➢ week 20 (P< 0.044)
  - ➢ week 24 (P< 0.042)
  - ➢ week 30 (P< 0.027)

- RESULTS REGARDING OTHER MEASURES

  Significant improvements in favour of the intervention group were found regarding:
  - ➢ Spasm
  - ➢ Fatigue
  - ➢ Disability
  - ➢ Depression
  - ➢ Autonomy

SUMMARY

According to this study's findings regarding pain, an Ai-Chi aquatic exercise program can reduce pain in MS patients. It can also improve spasm, fatigue, disability, depression and autonomy.

Another RCT, Bansi et al (2013), found a significant improvement in cardiorespiratory fitness in MS persons participating in an aquatic cycling program, as well as a significant increase in the level of brain-derived neurotrophic factor (BDNF), important for brain health.

POPULATION	This study initially selected 60 participants with MS, with expanded disability status scale (EDSS) scores between 1.0 and 6.5. However, only 52 completed the study.
STUDY DESIGN & QUALITY	RCT Corvillo et al (2017) determined that this RCT was of very good quality (85.7%) according to the modified Downs and Black quality index
INTERVENTION	Aquatic bike cycling sessions (heart rate controlled, adjusted for water conditions) Dosage: • session duration - 30 minutes • frequency - 5 sessions per week • intervention period - 3 weeks PLUS normal rehabilitation program, including 75 minutes of physiotherapy (including 45 minutes of progressive resistance training) per weekday
COMPARATOR	Land cycling using ergometer Dosage: • session duration - 30 minutes • frequency - 5 sessions per week • intervention period - 3 weeks PLUS normal rehabilitation program (as above)
RELEVANT RESULTS	• CARDIORESPIRATORY MEASURES Both groups showed significant improvement ($p<0.001$) in cardiorespiratory measures over time. In the aquatic cycling group improvements were that: ➢ <u>Maximum workload</u> achieved in cardiopulmonary exercise test (CPET) improved by 12.3W ➢ <u>VO_2 peak</u> increased by 1.7ml/(kg^{-1}xmin^{-1}) ➢ <u>HR peak</u> increased by 8.5 beats per minute • BDNF LEVELS Only the aquatic cycling group showed a significant increase in BDNF • over time: ➢ <u>At rest</u>, an increase of 3387.1 pg/ml p=0.046 ➢ <u>Immediately post-CPET</u>, an increase of 5908.0 p=0.010 • At the end of the intervention, between rest and post-CPET measures, an increase of 4519 p=0.002
SUMMARY	Aquatic fitness activity can improve cardiorespiratory functions in the MS population Exercising under immersion can activate BDNF regulation of those with MS, compared to overland training

Furthermore, a pilot study implementing Ai Chi (Bayraktar et al 2013), found a significant improvement in muscle strength in this population.

POPULATION	This study incorporated 23 females with MS. Only 18 of the participants completed the trial.
STUDY DESIGN & QUALITY	Blind control pilot study – allocation performed on the basis of preference Corvillo et al (2017) determined that this RCT was determined to be of good quality (75%) according to the modified Downs and Black quality index
INTERVENTION	Ai Chi Dosage: • session duration - 60 minutes • frequency – 2 sessions per week • intervention period - 8 weeks
COMPARATOR	Home exercise program
RELEVANT RESULTS	STRENGTH RESULTS Strength was assessed using a hand-held dynamometer and measured in pounds V baseline measures - whilst there were no significant changes in strength in the comparator group, in the Ai Chi group there were significant increases in the median pound measures for: ➢ Shoulder flexion and abduction ➢ Hip flexion, extension and abduction ➢ Knee flexion and extension
SUMMARY	Ai Chi can be beneficial for improving strength in the MS population

Two recent qualitative studies investigated perspectives around aquatic exercise for persons with multiple sclerosis. Chen et al (2022) found that "among individuals who had tried aquatic exercise, aquatic exercise was preferred over non-aquatic exercise, and 100% reported that they would recommend aquatic exercise to other persons with MS." They also found that "the most frequently reported barriers for aquatic exercise were lack of access to pools and its associated expense."

Chard's qualitative study in 2017 found that "an aquatic exercise history was not a prerequisite for the adoption of aquatic exercise. Rather, participants described aquatic exercise routines as stemming from recognition of a decline in physical function combined with encouragement and invitations to join aquatic programs." The aquatic activities described included both MS-specific and generalized aquatics courses and the authors found that class satisfaction rested "on the instructor, class "fit" and a feeling of acceptance."

There is little research published regarding aquatic therapy for the acquired brain injury (ABI) population and two recent systematic reviews make limited reference to aquatic therapy (Xu et al 2017 and Wheeler et al 2017). Xu et al relied solely on an RCT by Driver et al (2009) for its aquatic reference (which is presented in this section).

Results from the most recent RCT involving aquatic therapy and participants with an ABI (Curcio et al 2020) suggest that aquatic therapy is effective in improving balance, function and quality of life in this population.

POPULATION	This study included 20 adult inpatients during the post-acute intensive neurorehabilitation program for severe traumatic brain injury (sTBI), Glasgow Coma Scale score ≤8 for >24 hours and Level of Cognitive Functioning ≥7
STUDY DESIGN & QUALITY	RCT Using the PEDRO scale, this study was of good quality (8/10)
INTERVENTION	Aquatic therapy (AT) in one-on-one sessions with a physiotherapist. Aquatic therapy focused on “enhancing dynamic postural stability.” “The exercises started with a 5-minute warm-up combining arm movements and breathing exercises. Repetitive exercise sequence starting from a kneeling position, proceeding to a sitting position, and ending with a supine position was performed for 20 minutes. Step exercises preparatory for gait were performed for 20 minutes using a step and two floating aids. Gait exercises were performed first with the upper limbs placed on two floating aids and then during a dual-motor task (i.e. catching a ball thrown by the physiotherapist).” Dosage (12 sessions): • session duration - 45 minutes • frequency - 3 sessions per week • intervention period 4 weeks PLUS multidisciplinary neurorehabilitation.
COMPARATOR	Conventional training in one-on-one sessions with a physiotherapist Dosage (12 sessions): • session duration - 45 minutes • frequency - 3 sessions per week • intervention period - 4 weeks PLUS multidisciplinary neurorehabilitation.
RELEVANT RESULTS	Both the aquatic therapy group and the conventional therapy group showed significant improvements v baseline scores regarding: ➢ Berg Balance Scale (BBS) ➢ Modified Barthel Index (MBI) ➢ Tinetti Balance and Gait (TBG) ➢ Quality of life after brain injury Scale (QOLIBRI) No significant differences were found between the groups.
SUMMARY	Aquatic therapy was as effective as conventional physiotherapy in improving balance, function, gait and quality of life. In patients with sTBI, during the post-acute intensive neurorehabilitation program, aquatic physiotherapy “could complement the multidisciplinary neurorehabilitation to improve motor functions and quality of life.”

Another RCT (Driver et al 2004) observed that, for participants with an ABI, aquatic therapy (versus non-active intervention) significantly improved a number of physical measures, including fitness.

POPULATION	This study included 16 outpatient adults with a brain injury that occurred more than 1 year prior to intervention and a score above level 6 on the Ranchos Los Amigos Scale of Cognitive Functioning
STUDY DESIGN & QUALITY	RCT Using the PEDRO scale, this study was of fair quality (5/10)
INTERVENTION	The aquatic exercise program was executed with each participant having an individual instructor and included both aerobic and resistance training components. "Participants always wore Polar Heart rate monitors to ensure that heart rate was kept within 50–70% of the individual's maximum heart rate." Dosage (24 sessions): • session duration - 60 minutes • frequency - 3 sessions per week • intervention period - 8 weeks
COMPARATOR	The comparator was an 8-week vocational rehabilitation class based around improving reading and writing skills
REELEVANT RESULTS	V base-line scores, whilst there were no significant improvements found in the control group, there were statistically significant improvements in the aquatic exercise group in: • ROM MEASUREMENTS USED DURING WALKING: ➢ hip flexion on the right (t=-4.914; moderate effect size (ES) 0.53) and left side (t=-4.255) ➢ right hip extension (t=-4.816) with a large ES= 2.54 ➢ knee flexion on the right (t=-4.890; large ES= 1.65) and left side (t=13.133; large Es= 0.77). ➢ elbow flexion in the right (t=-4.081; large ES=1.06) and left side (t=-3.257; large ES=1.04). • FLEXIBILITY (sit and reach) (t=-2.966; $p< 0.05$) • GRIP STRENGTH for the right (t=-3.055) and left (t=-4.320) • BODY COMPOSITION (skin fold thickness) (t=6.125; ES=0.51) • ERGONOMETRY: ➢ cycle ergometry time (t=-7.638; ES=2.69) ➢ cycle wattage (t=-13.748; ES=2.01)
SUMMARY	Aquatic exercise can improve fitness parameters in the ABI population. "Increases in fitness were reported as having a positive impact on the functional capacity of individuals in the exercise group as well as enhancing the individual's ability to complete activities of daily living successfully."

Two other RCTs focused their attention on the effectiveness of aquatic therapy on improving mood, self-esteem and efficacy for those with a brain injury. Driver (2009) discovered that aquatic physical activity had a beneficial effect on mood for those with an ABI.

POPULATION	This study included 16 outpatient adults (35-45 years of age) with a brain injury that occurred more than 1 year prior to intervention and a score above level 6 on the Ranchos Los Amigos Scale of Cognitive Functioning

STUDY DESIGN & QUALITY	RCT Using the PEDRO scale, this study was of good quality (6/10)
INTERVENTION	The aquatic exercise program was executed with each participant having an individual instructor and included both aerobic and resistance training components. "Participants always wore Polar Heart rate monitors to ensure that heart rate was kept within 50–70% of the individual's maximum heart rate." Dosage (24 sessions): • session duration - 60 minutes • frequency - 3 sessions per week • intervention period - 8 weeks
COMPARATOR	The comparator was a vocational rehabilitation class based around improving reading and writing skills. Dosage (24 sessions): • session duration - 60 minutes • frequency - 3 sessions per week • intervention period - 8 weeks
RELEVANT RESULTS	PROFILE OF MOOD STATES (POM) MEASURE • V control group, there was a significant improvement in favour of the aquatic exercise group in the total score (F=5.65, p<0.05) • V baseline, there were no significant improvements in any of the POM subscales in the control group but there were significant improvements in the following variables of the POM for the experimental group: ➢ tension F=6.62, p<0.05. ➢ depression F=7.20, p<0.05. ➢ anger F=6.01, p<0.05. ➢ vigour F=-9.98, p<0.05. ➢ fatigue F=4.68, p<0.05. ➢ confusion F=3.65, p<0.05 ➢ friendliness F=-4.29, p<0.05. • V recreational exercises (using ANOVA), there were: ➢ significant differences between pre-scores for the experimental group and recreational exercisers (F=4.89, p<0.05). ➢ but no significant difference between post-score results for the experimental group and recreational exercisers (F=1.12, p>0.05).
SUMMARY	Participation in aquatic exercise may positively influence mood for individuals post-TBI. "Increases in mood may positively influence other areas of rehabilitation, including social and physical activities, a return to work, independence and a decreased need for care."

Driver et al (2006) also demonstrated that aquatic physical activity can improve physical self-concept and self-esteem and health-promoting behaviours in those with an ABI.

POPULATION	This study included 18 outpatient adults (25-47 years of age) with a brain injury that occurred more than 1 year prior to intervention and a score above level 6 on the Ranchos Los Amigos Scale of Cognitive Functioning
STUDY DESIGN & QUALITY	RCT Using the PEDRO scale, this study was of fair quality (5/10)

INTERVENTION	The aquatic exercise program was executed with each participant having an individual instructor and included both aerobic and resistance training components. "Participants always wore Polar Heart rate monitors to ensure that heart rate was kept within 50–70% of the individual's maximum heart rate." Dosage (24 sessions): • session duration 60 minutes • frequency 3 sessions per week • intervention period 8 weeks
COMPARATOR	The comparator was an 8 week vocational rehabilitation class based around improving reading and writing skills
RELEVANT RESULTS	• HEALTH PROMOTING BEHAVIOURS (HPLP-II) MEASURE V baseline, there were no significant improvements in any of the HPLP-II subscales in the control group but there were significant improvements and large effect sizes in the following variables of the HPLP-II for the experimental group: ➢ health responsibility t(9) =-2.675, p< 0.05, EFFECT SIZE (ES) 0.91 ➢ physical activity t(9) =-3.109, p<0.05, ES 1.24 ➢ nutrition t(9)=-4.199, p<0.01,ES 0.66 ➢ spiritual growth t(9)=-4.013, p< 0.01, ES0.82 ➢ inter-personal relationship t(9)=-7.791, p<0.001, ES1.12. • PHYSICAL SELF-CONCEPT AND SELF-ESTEEM (PSDQ) MEASURE V baseline, there were no significant improvements in any of the PSDQ subscales in the control group but there were significant improvements and moderate-to-large effect sizes in the following variables of the PSDQ for the experimental group: ➢ self-esteem t(9)=-8.500, p< 0.001, ES 2.09 ➢ co-ordination t(9)=-5.237, p<0.001, ES 2.66 ➢ body fat t(9)=-5.200, p<0.001, ES 0.51 ➢ strength t(9=-9.798, p<0.001, ES 0.83 ➢ flexibility t(9)=-6.547, p< 0.001, ES 0.99 ➢ endurance t(9)=-6.547, p< 0.001, ES 2.33.
SUMMARY	Aquatic exercise may increase health promoting behaviours, physical self-concept and self-esteem in the ABI population. "By providing physical activity programmes that may enhance an individual's self-esteem, it may be possible to positively impact an individual's health-promoting self-care behaviours by increasing an individual's locus of control in a particular area."

Huang et al (2024) recently published a meta-analysis assessing the effect of three different methods of body-weight support training (BWST), including aquatic training, on the lower limb motor function of those with an SCI. Aquatic training was found to improve the lower extremity motor score in SCI participants (and was as efficient as the other two methods).

POPULATION	From the underlying studies, 864 adults with an SCI were included in the analysis.
STUDY DESIGNS & QUALITY	All 19 underlying studies were RCTs. Using the Cochrane Systematic Review Manual 5.1.0: • moderate risk of bias - 18 studies • high risk of bias – 1 study According to the application of GRADE, the quality of evidence was low to very low
INTERVENTION	Conventional rehabilitation training AND one BWST method: 1 Body weight support treadmill training (BWSTT) 2 Robot-assisted gait training (RAGT) 3 Aquatic exercise – 3 RCTs with 119 subjects
COMPARATOR	Conventional rehabilitation training
RELEVANT RESULTS	RELEVANT META-ANALYSIS FINDINGS LOWER EXTREMITY MOTOR SCORE (LEM) ACCORDING TO THE INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI) • V conventional rehabilitation training alone - Significant differences were found in favour of each intervention. For aquatic exercise (water walking) + conventional rehabilitation training (3 RCTs n=119) the significant differences were MD = 5.31 95% CI = 0.54–10.07, Z= 2.18 P = 0.03 • Comparison of BWST methods - Network meta-analysis showed no significant difference between the 3 BWST methods for improving LEM. The best probability ranking was RAGT (P = 0.60), followed by aquatic exercise (P = 0.21) and BWSTT (P = 0.19).
SUMMARY	Aquatic exercise (water walking) may improve lower limb function in those with SCI. There is no statistical difference in the positive effect of aquatic exercise and the positive effects of BWSTT or RAGT

Two recent systematic reviews assessing aquatic therapy/exercise for those with SCI have also been published (Li et al 2017; Palladino et al 2023).

The most recent of these reviews (Palladino et al 2023), incorporated only 71 individuals with a SCI from 3 underlying RCTs (one of high quality and two of low quality, as assessed by the Cochrane risk of bias tool). The review concluded that "patients who underwent rehabilitation treatment in water had results that were greater than or similar to those obtained in patients who received standard or alternative treatment." The authors also stated that "the aquatic environment provides a rehabilitation tool able to facilitate movements, physical and cardiovascular exercise, resistance training, and body relaxation. The best results can be expected from the combination of hydrotherapy and land-based interventions."

The other systematic review (Li et al, 2017) incorporated 143 individuals with an SCI from 8 underlying studies (none deemed of high quality by the Downs and Black scale and only one being an RCT). In four studies assessing physical function outcomes (two regarding functional independence and two regarding walking ability), aquatic exercise programs were found to have a positive impact. And in four studies assessing physical fitness, there were positive effects found with aquatic exercise.

One of the underlying RCTs in both systematic reviews, Jung et al (2014a), focused solely on the beneficial effect of aquatic exercise on pulmonary function in patients with an SCI. It concluded that aquatic exercise therapy was more effective than land exercise therapy for improving pulmonary function.

POPULATION	This study incorporated 20 persons with an SCI
STUDY DESIGN & QUALITY	RCT Regarding assessment of quality: • According to Palladino et al (2023) this study was of low quality, as assessed by the Cochrane risk of bias tool. • According to Li et al (2017), the study was of weak quality (score of 13), as assessed by the Downs and Black scale. (Ellapen et al, 2018 gave this study a 100% score using the modified Downs and Black scale)
INTERVENTION	The aquatic exercise intervention included a warm-up (ROM and breathing exercises), 40 mins of upper limb functional exercises (incorporating weight shift) and a cool down (ROM and breathing exercises) Dosage: • session duration - 60 minutes • frequency - 3 sessions per week • intervention period - 8 weeks
COMPARATOR	The comparator was the same intervention program of activities held on land Dosage: • session duration - 60 minutes • frequency - 3 sessions per week • intervention period - 8 weeks
RELEVANT RESULTS	• V LAND GROUP there were significant improvements in favour of the aquatic group in Forced Vital Capacity - FVC (p=0.031) and Forced Expiratory Volume at 1 second - FEV1 (p=0.038) • V BASELINE ➢ <u>Aquatic group</u> demonstrated significant improvements in all 4 measures –FVC (p=0.001), Forced Expiratory Flow Rate - FER (p=0.010), FEV1 (p=0.019), and FEV1/FVC (p=0.001). ➢ <u>Land group</u> –significant improvement was only found in FER (p=0.037).
SUMMARY	The authors concluded that, whilst land exercise therapy was effective, aquatic exercise therapy is more effective than land exercise therapy for improving pulmonary function.

Another underlying trial in Li et al's (2017) review, da Silva et al (2005), found that swimming had beneficial effects on the functional independence of individuals with an SCI.

POPULATION	This study incorporated 16 individuals with a traumatic spinal cord injury (classified as ASIA "A")
STUDY DESIGN & QUALITY	Controlled clinical trial According to Li et al (2017), the study was of fair quality (score of 14), as assessed by the Downs and Black scale.

INTERVENTION	The intervention was swimming PLUS conventional rehabilitation Dosage: • session duration - 45 minutes • frequency - 2 sessions per week • intervention period - 4 months
COMPARATOR	The comparator was conventional rehabilitation
RELEVANT RESULTS	FUNCTIONAL INDEPENDENCE MEASURE (FIM) • V conventional rehabilitation group – there were significant improvements in favour of the swimming group in: ➢ transference (bathroom, bathtub and shower) ➢ overall motor score ➢ overall score - although both presented significant gains, the experimental group presented higher gains (p = 0.01). • V baseline: Swimming group demonstrated significant gains in: ➢ transferences (including bed-chair-wheelchair, bathroom, bathtub- shower) ➢ body care (including taking a shower and dressing the lower body) ➢ overall motor score ➢ overall score Conventional rehabilitation group demonstrated significant gains in: ➢ body care (including using the bathroom) ➢ transferences ➢ overall motor score ➢ overall score
SUMMARY	"The swimming activity was effective in improving their physical condition, bringing motor benefits on the functional capacity of participants from the experimental group." "Both groups demonstrated noticeable gains related to body care, transference, overall and motor scores, even though the experimental group presented greater gains in transference, overall motor score and overall score."

A retrospective chart review (Recio et al,2020) has also produced interesting results. This study looked at the feasibility of aquatic exercise for SCI individuals with invasive appliances and also at the functional improvements possible from such an intervention. It documented an improvement in participants' functional abilities and also established that it was possible for SCI individuals with various invasive appliances to participate safely in aquatic therapy.

POPULATION	101 adults with chronic spinal cord injury and invasive appliances. In terms of invasive appliances, there were: • 47 patients with pressure injury dressings • 43 patients with suprapubic catheters • 18 with indwelling catheters • 7 with colostomy bags • 2 with tracheostomy tubes There were 3 subgroups of participants: • Group 1 – 49 subjects completed Spinal Cord Independence Measure (SCIM III) • Group 2 – 45 subjects completed ASIA Impairment Scale (AIS) • Group 3 – 9 subjects completed 6-minute walk test (6MWT)

STUDY DESIGN & QUALITY	Retrospective chart review No quality analysis of this review was undertaken
INTERVENTION	Aquatic therapy involved scheduled 1-hour sessions with a physiotherapist, who adapted and applied the aquatic methods most suitable for each patient. Sessions were held 1-2xweek for 3-6 weeks. Average number of sessions received was 6. INVASIVE APPLIANCE MANAGEMENT Policies and procedures in place required that: • "All wounds, peripheral lines, and deaccessed ports were covered in gauze dressings and sealed to the skin with Opsite, Duoderm, or adhesive membranes." • "Colostomy bags were emptied and covered with an Opsite dressing and securely frame- taped to surrounding skin." • "Urine collection bags were emptied and securely attached to the patients' legs with tape." • "Patients with tracheostomy tubes used flotation accessories, such as underarm and cervical floats, AquaJoggers, and closed foam noodles to safely keep their shoulders and tracheostomy tubes above the surface." • It should be noted that authors included "pressure injuries because the invasive appliances associated with hydrovac dressings through foam designs and conventional dressings span the space of normal skin surface to subcutaneous wounds. These bandage designs installed over and under the skin are invasive because they are within the body as it heals."
COMPARATOR	No comparator was used.
RELEVANT RESULTS	V BASELINE • SPINAL CORD INDEPENDENCE MEASURE (SCIM III). There were statistically significant improvements in: ➢ Total score (MD 1.43, $P \leq 0.021$). ➢ Self-care scores (MD 0.86, $p \leq 0.021$) ➢ mobility scores (MD 0.61, $p \leq 0.0386$) • ASIA IMPAIRMENT SCALE (AIS) There were statistically significant improvements in: ➢ Motor score (MD1.95, p 0.0028) ➢ Upper extremity score (MD1.29, p 0.0125) ➢ Lower extremity score (MD 0.71, p 0.04) • 6 MINUTE WALK TEST (6MWT) There was a statistically significant increase of 60.6 metres in the distance walked (text stating $p \leq 0.011$ but Table 2 suggesting p was 0.0265) ADVERSE EVENT "There was one unplanned bowel evacuation. Therapy was stopped, and the patient was removed from the pool. Solid stool was collected with a mesh net, and the water was treated with calcium hypochlorite to bring the bromine level up to 20 ppm. Government-regulated policies require that the type of bowel evacuation (loose or solid) determines the time the pools need to remain at a high bromine level. In this case, the solid bowel required 30 mins. Loose bowel evacuation requires 24 hrs. All towels and linens were placed in sanitary bags and discarded. Pool filters were cleaned and water quality assessed before reuse." This event did not prevent future therapy for this participant.
SUMMARY	"Based on this retrospective patient treatment analysis, we demonstrated that SCI patients' functional scores continued to improve during aquatic therapy and the presence of invasive devices was well tolerated." "Spinal cord injury patients with various invasive appliances can safely participate in specialized aquatic therapy without complications and seem to achieve clinically significant benefits. We recommend that

	spinal cord injury rehabilitation centers seek out and connect with opportunities for aquatic therapy within their institutions and communities."

In 2018, Ellapen et al published a narrative literature review in a peer-reviewed journal regarding the benefits of hydrotherapy for SCI persons. It incorporated fifteen studies of various types, including systematic reviews, RCTs and case studies. While acknowledging a paucity of RCTs in the field, the authors concluded that hydrotherapy improved underwater gait-kinematics; improved cardiorespiratory and thermoregulatory responses; and reduced spasticity.

The authors discuss that, as Zamparo and Pagliaro (1998) found the energy expenditure of those with SCIs is lower during underwater walking as compared to land-based walking at specific speeds, they recommend that those with SCIs engage in hydrotherapeutic walking before land walking. In this way, the SCI lower limb neuromuscular system will be conditioned, "preparing them for land walking and simultaneously increasing energy expenditure, lowering their cardiometabolic risk profile."

The authors also highlight that "exercising while submerged in warm water lowers the heart rate and enhances thermoregulatory responses" and this then prolongs the ability of a person with an SCI to exercise and thus can lead to an increase their aerobic capacity (using the findings of Gass & Gass 2001; Gass et al. 2002).

There are also two recent qualitative studies investigating the use of aquatic exercise for individuals with a spinal cord injury. Marinho-Buzelli et al (2022) found that "a wide range of benefits were reported by the respondents, from improved sensorimotor function to psychological well-being." Aquatic therapy was reported to offer persons with an SCI "an opportunity to gain function and independence in a way not possible on land" but that "pool accessibility and constraints around therapeutic pool use were mentioned as major barriers" to use of this therapy.

From the perspective of rehabilitation professionals, Marinho-Buzelli et al (2019) reported that aquatic therapy for those with an SCI was viewed as "a unique and versatile approach that benefits the multi-dimensional aspects of the health of individuals" and that they were able to successfully integrate aquatic therapy "into their clinical practice despite the barriers faced by professionals and clients."

Two other publications promote aquatic therapy for those with a spinal cord injury. Recio et al (2017) reviewed aquatic therapy "in order to demonstrate that it is a valuable therapeutic tool in patients with spinal cord injuries". Frye et al (2017) present an information page on aquatic exercise as an option for those with spinal cord injury.

Physiotherapy treatment, whether it takes place on land or in the water, must be informed by clinical reasoning. Higgs et al (2008) discuss clinical reasoning in physiotherapy as a process in which the developed goals and health management strategies are based not only on clinical data, professional knowledge and judgement but also on interaction with the client, care givers and other professionals and with consideration of the environment and particular situational elements.

Using this clinical reasoning process, consider a stroke client and the Australian Stroke Foundation's Clinical Guidelines for Stroke Management recommendations of:

a. repetitive task practice for sit to stand and walking (with or without body support) and
b. activities that challenge balance.

The physiotherapist may reason that performing these recommended activities in a pool may be appropriate for a particular client. Firstly, there is evidence to indicate that aquatic therapy may be even more effective than land therapy for improving balance and for functional independence (including sit to stand and gait) (Ghayour Najafabadi et al 2022; Giuriati et al 2021; Li et al 2021; Saquetto et al 2019).

Secondly, there may be advantages to the client working in the pool. Falls risk is lower and the buoyancy of the water can provide some body support and facilitate voluntary movement. These factors also provide the opportunity for safe implementation of challenging activities at the limit of balance.

The decision to provide therapy in the water may also be considered as an application of the guideline's recommendation to address specific barriers to physical activities. In this case, the barriers could be considered the falls risk and the manual handling risk, particularly if a therapist does not have access to a weight support system or allied health assistant.

In another application of clinical reasoning, a number of guidelines for neurological clients include a recommendation to improve or maintain cardiorespiratory fitness (Australian Stroke Foundation and Mead et al 2023 regarding the stroke population; Osborne et al 2022 with reference to those with Parkinson's disease). Given that many neurological clients may not be able to run or cycle or go to the gym, cardiovascular work in the pool may be a viable option. There is also evidence to suggest that exercising in the pool is more effective than land exercise in this regard (Faíl et al 2022 regarding the PD population; Saquetto et al 2019 regarding the stroke population).

One critical aspect of clinical reasoning to consider with regards to aquatic therapy is the wholistic view of the individual client, including co-morbidities and preferences. Whilst contraindications, precautions and other barriers must be considered, the aquatic environment may provide unique advantages for a particular client. A neurological client with obesity and severe osteoarthritis in both knees may find completing rehabilitation on land quite difficult and painful. This client may find themselves able to do more, with less pain, when working in the pool. Another client may love the water and prefer to work in the water and thus program adherence may be enhanced. Such were participant preferences in a trial involving stroke clients (Zhang et al 2016), that twenty prospective participants declined to participate when they were not randomly allocated to the aquatic therapy group.

Research limitations must also be taken into account. For example, many RCTs for aquatic therapy involving stroke participants exclude participants who are unable to walk ten metres independently (including Perez de la Cruz 2021 and Saleh et al 2019). The physiotherapist may still decide to work on balance and gait in the pool with clients who are unable to walk independently, based on previous clinical experience, clinical consensus or through extrapolation of research.

There are also neurological conditions for which there have been no high-quality research studies undertaken, nor any recommended rehabilitation protocols established. This does not mean that clients with these conditions are excluded from physiotherapy treatment (including aquatic physiotherapy). In fact, this would not be ethical. Therefore, the physiotherapist may consider applying research findings for a similar condition or refer to professional clinical consensus or rely on their own clinical experience. Critically, the physiotherapist would establish assessment baselines and reassess these measures to determine effectiveness of the therapy.

For the aquatic physiotherapist, knowledge of the safe and effective use of the medium of water is critical. Client screening and risk management is also essential. Literature is available to develop greater knowledge in these areas.

PHYSIOLOGY OF IMMERSION

Key to the safe management of clients in the water is a thorough understanding of the physiological effects of immersion. Two valuable resources outlining these effects are Hall et al (1990) and Becker et al (2009).

With regards to physiological effects particularly pertinent to neurological clients, there is emerging evidence to suggest that aquatic therapy may improve brain health.

Studies have found that both immersion at rest (Carter et al 2014) and exercising in the water (Parfitt et al 2017; Pugh et al 2015) increases blood flow to the brain, which may induce improvements in cerebrovascular health, via shear stress adaptation of the cerebrovasculature (Carter et al 2014; Parfitt et al 2017; Pugh et al 2015).

Kang et al (2020) found that aquatic exercise (in elderly women) significantly increased the levels of two neurotrophic factors, brain-derived neurotrophic factor (BNDF) and insulin-like growth factor-1. Bansi et al (2013) also found that an aquatic fitness cycling intervention in MS participants led to a significant increase in the level of BNDF. These results are important, as studies suggest that elevated levels of neurotrophic factors may lead to neurogenesis, neuroplasticity and perhaps the recovery of both motor and cognitive functions (Castellano et al 2008; Prakash et al 2010). A study by Shoemaker et al (2019) has already demonstrated that 20 minutes of moderate-intensity swimming improves visuo-motor (cognitive) performance in healthy subjects.

Thus, aquatic exercise may enhance cognitive function, neuroplasticity and overall brain health.

PHYSICS OF IMMERSION

Knowledge of the physics associated with immersion, including hydrostatic pressure, buoyancy and drag, is particularly important for effective treatment planning. For example, a therapist can make use of buoyancy to facilitate a movement or employ drag to provide resistance. A number of resources are available regarding the relevant physics of immersion, including Halliwick Association of Swimming Therapy (1992), Ruoti et al (1997) and Ward et al (2013).

BEST PRACTICE INFORMATION

The Australian Physiotherapy Guidelines for Physiotherapists working in and/or managing hydrotherapy pools (2nd edition, 2015) provides comprehensive guidelines on many aspects of aquatic physiotherapy, including safety; staff skills and responsibilities; client screening; management of specific conditions; infection control and hygiene; and water maintenance.

Regarding the screening of clients, Recio et al (2020) found that spinal cord injury clients safely participated in aquatic therapy with invasive appliances. The term "invasive appliances" referred to such items as pressure injury dressings, suprapubic catheters, indwelling catheters, colostomy bags and tracheostomy tubes. The management of these appliances was outlined in the study. These findings have the potential to open up aquatic therapy to other client types who may have invasive appliances, such as those with an acquired brain injury.

REFERENCES

Amedoro A, Berardi A, Conte A, Pelosin E, Valente D, Maggi G, Tofani M, Galeoto G (2020) The effect of aquatic physical therapy on patients with multiple sclerosis: A systematic review and meta-analysis. *Multiple Sclerosis and Related Disorders* Jun;41:102022. doi: 10.1016/j.msard.2020.102022. Epub 2020 Feb 22. PMID: 32114368.

Australian Physiotherapy Guidelines for Physiotherapists working in and/or managing hydrotherapy pools (2nd edition, 2015)

Australian Stroke Foundation's *Clinical Guidelines for Stroke Management* https://strokefoundation.org.au/what-we-do/for-health-professionals/living-stroke-guidelines

Ayan C, Cancela JM, Gutierrez-Santiago A, Prieto I (2014) Effects of two different exercise programs on gait parameters in individuals with Parkinson's disease: A pilot study. *Gait & Posture*, 39(1), 648–651. https://doi.org/10.1016/j.gaitpost.2013.08.019

Bansi J, Bloch W, Gamper U, Kesselring J (2013) Training in MS: influence of two different endurance training protocols (aquatic versus overland) on cytokine and neurotrophin concentrations during three week randomized controlled trial. *Multiple Sclerosis*. Apr;19(5):613-21. doi: 10.1177/1352458512458605. Epub 2012 Aug 30. PMID: 22936334.

Bayraktar D, Guclu-Gunduz A, Yazici G, Lambeck J, Batur-Caglayan HZ, Irkec C, Nazliel B (2013) Effects of Ai-Chi on balance, functional mobility, strength and fatigue in patients with multiple sclerosis: a pilot study. *NeuroRehabilitation* 33 (3), 431–437.

Becker, BE, Hildenbrand K, Whitcomb RK, Sanders JP (2009) Biophysiologic Effects of Warm Water Immersion *International Journal of Aquatic Research and Education* Vol. 3: No. 1, Article 4. DOI: https://doi.org/10.25035/ijare.03.01.04

Bei N, Long D, Bei Z, Chen Y, Chen Z, Xing Z (2023) Effect of Water Exercise Therapy on Lower Limb Function Rehabilitation in Hemiplegic Patients with the First Stroke. *Alternative Therapies in Health and Medicine.* Oct;29(7):429-433. PMID: 37573592. http://alternative-therapies.com/oa/index.html?fid=8228

Braz de Oliveira MP, Rigo Lima C, da Silva SLA, Firmino Vaz Figueira EC, Truax, BD & Smaili SM (2023) Effect of aquatic exercise programs according to the International Classification of functionality, disability and health domains in individuals with Parkinson's disease: a systematic review and meta-analysis with GRADE quality assessment *Disability and Rehabilitation* 1-14.

Carroll LM, Morris ME, O'Connor WT, Clifford AM (2020) Is Aquatic Therapy Optimally Prescribed for Parkinson's Disease? A Systematic Review and Meta-Analysis *Journal of Parkinsons Disease* 10(1):59-76. doi: 10.3233/JPD-191784. PMID: 31815701.

Carroll LM, Morris ME, O'Connor WT, Clifford AM (2022a). Community aquatic therapy for Parkinson's disease: an international qualitative study. *Disability and Rehabilitation*, 44(16): 4379-4388.

Carroll LM, Morris ME, O'Connor WT, Volpe D, Salsberg J, Clifford AM (2022b) Evidence-Based Aquatic Therapy Guidelines for Parkinson's Disease: An International Consensus Study. *Journal of Parkinson's Disease*, 1: 621-637.

Carroll, LM, Volpe D, Morris ME, Saunders J, Clifford AM (2017) Aquatic exercise therapy for people with Parkinson disease: a randomized controlled trial. *Archives of Physical Medicine and Rehabilitation* 98, 631e638

Carter HH, Spence AL, Pugh CJ, Ainslie P, Naylor LH, Green DJ (2014) Cardiovascular responses to water immersion in humans: impact on cerebral perfusion. *American Journal of Physiology - Regulatory Integrative and Comparative Physiology*; 306(9):R636-R640.

Castellano V and White L (2008) Serum brain-derived neurotrophic factor response to aerobic exercise in multiple sclerosis. *Journal of Neurological Sciences* 269: 85–91.

Castro-Sánchez AM, Matarán-Peñarrocha GA, Lara-Palomo I, Saavedra-Hernández M, Arroyo-Morales M, Moreno-Lorenzo C (2012) Hydrotherapy for the treatment of pain in people with multiple sclerosis: a randomized controlled trial. *Evidence-Based Complementary and Alternative Medicine* 2012:473963. doi: 10.1155/2012/473963. Epub 2011 Jul 14. PMID: 21785645; PMCID: PMC3138085.

Chae CS, Jun JH, Im S, Jang Y, Park GY. (2020) Effectiveness of hydrotherapy on balance and paretic knee strength in patients with stroke: a systematic review and meta-analysis of randomized controlled trials. *American Journal of Physical Medicine & Rehabilitation*, May;99(5):409-419. doi: 10.1097/PHM.0000000000001357.

Chan K, Phadke CP, Stremler D, Suter L, Pauley T, Ismail F, Boulias C (2017). The effect of water-based exercises on balance in persons post-stroke: A randomized controlled trial. *Topics in Stroke Rehabilitation*, 24(4), 228–235. https://doi.org/10.1080/10749357. 2016.1251742

Chard S (2017) Qualitative perspectives on aquatic exercise initiation and satisfaction among persons with multiple sclerosis *Disability and Rehabilitation*. Jun;39(13):1307-1312. doi: 10.1080/09638288.2016.1194897. Epub 2016 Jun 26. PMID: 27346481.

Chen MH, DeLuca J, Sandroff BM, Genova HM (2022) Aquatic exercise for persons with MS: Patient-reported preferences, obstacles and recommendations. *Multiple Sclerosis and Related Disorders* Apr;60:103701. Doi: 10.1016/j.msard.2022.103701. Epub 2022 Feb 20. PMID: 35235900.

Chu KS, Eng JJ, Dawson AS, Harris JE, Ozkaplan A, Gylfadóttir S (2004) Water-based exercise for cardiovascular fitness in people with chronic stroke: a randomized controlled trial. *Archives of Physical Medicine and Rehabilitation* 85: 870–874.

Corvillo I, Varela E, Armijo F, Alvarez-Badillo A, Armijo O, Maraver F (2017) Efficacy of aquatic therapy for multiple sclerosis: a systematic review. *European Journal of Physical and Rehabilitation Medicine* Dec;53(6):944-952. doi: 10.23736/S1973-9087.17.04570-1. Epub 2017 Feb 17. PMID: 28215060.

Curcio A, Temperoni G, Tramontano M, De Angelis S, Iosa M, Mommo F, Cochi G & Formisano R (2020) The effects of aquatic therapy during post-acute neurorehabilitation in patients with severe traumatic brain injury: a preliminary randomized controlled trial, *Brain Injury*, 34:12, 1630-1635, DOI: 10.1080/02699052.2020.1825809

da Silva MCR, de Oliveira RJ & Conceição MIG (2005) Effects of swimming on the functional independence of patients with spinal cord injury. *Revista Brasileira de Medicina do Esporte*; 11: 237e–241e

Dai S, Yuan H, Wang J, Yang Y, Wen S (2023) Effects of aquatic exercise on the improvement of lower-extremity motor function and quality of life in patients with Parkinson's disease: A meta-analysis. *Frontiers in Physiology* Feb 3;14:1066718. doi: 10.3389/fphys.2023.1066718. PMID: 36818451; PMCID: PMC9935607.

de Andrade CHS, da Silva BF, Corso SD. (2010) Effects of Hydrotherapy on the Balance of Individuals with Parkinson's Disease. *ConScientiae Saúde* Aug 10, 9(2):317-23. Available at: https://periodicos.uninove.br/saude/article/view/2108

Driver S, Ede A (2009) Impact of physical activity on mood after TBI. *Brain Injury* Mar;23(3):203-12. doi: 10.1080/02699050802695574. PMID: 19205956.

Driver S, O'Connor J, Lox C, Rees K (2004) Evaluation of an aquatics programme on fitness parameters of individuals with a brain injury. *Brain Injury* Sep;18(9):847-59. doi: 10.1080/02699050410001671856. PMID: 15223738.

Driver S, Rees K, O'Connor J, Lox C (2006) Aquatics, health-promoting self-care behaviours and adults with brain injuries. *Brain Injury* Feb;20(2):133-41. doi: 10.1080/02699050500443822. PMID: 16421061.

el Hayek M, Lobo Jofili Lopes JLM, LeLaurin JH, Gregory ME, Abi Nehme AM, McCall-Junkin P, Au KLK, Okun MS, Salloum RG (2023) Type, Timing, Frequency, and Durability of Outcome of Physical Therapy for Parkinson Disease: A Systematic Review and Meta-Analysis. *JAMA Network Open*. Jul 3;6(7):e2324860. doi: 10.1001/jamanetworkopen.2023.24860. PMID: 37477916; PMCID: PMC10362470.

Ellapen TJ, Hammill HV, Swanepoel M, Strydom GL (2018) The benefits of hydrotherapy to patients with spinal cord injuries. *African Journal of Disability* May 16;7(0):450. doi: 10.4102/ajod.v7i0.450. PMID: 29850439; PMCID: PMC5968875.

Ernst M, Folkerts A-K, Gollan R, Lieker E, Caro-Valenzuela J, Adams A, Cryns N, Monsef I, Dresen A, Roheger M, Eggers C, Skoetz N, Kalbe E (2023) Physical exercise for people with Parkinson's disease: a systematic review and network meta-analysis. *Cochrane Database of Systematic Reviews* Issue 1. Art. No.: CD013856. DOI: 10.1002/14651858.CD013856.pub2.

Eyvaz N, Dundar U, Yesil H (2018) Effects of water-based and land-based exercises on walking and balance functions of patients with hemiplegia. *NeuroRehabilitation* 43, 237e246.

Faíl LB, Marinho DA, Marques EA, Costa MJ, Santos CC, Marques MC, Izquierdo M, Neiva HP (2022) Benefits of aquatic exercise in adults with and without chronic disease - A systematic review with meta-analysis *Scandinavian Journal of Medicine & Science in Sports* Mar;32(3):465-486. doi: 10.1111/sms.14112. Epub 2021 Dec 24. PMID: 34913530.

Frye SK, Ogonowska-Slodownik A, Geigle PR (2017) Aquatic exercise for people with spinal cord injury. *Archives of Physical Medicine and Rehabilitation*. Jan;98(1):195-197. doi: 10.1016/j.apmr.2016.07.010. PMID: 28010781.

Furnari A, Calabrò RS, Gervasi G, La Fauci-Belponer F, Marzo A, Berbiglia F, Paladina G, De Cola MC, Bramanti P. (2014) Is hydrokinesitherapy effective on gait and balance in patients with stroke? A clinical and baropodometric investigation. *Brain Injury*, 28(8):1109-14. doi: 10.3109/02699052.2014.910700.

Gass EM, Gass GC (2001) Thermoregulatory response to repeated warm water immersion in subjects who are paraplegics, *Spinal Cord* 39(3), 149–155. https:// doi.org/10.1038/sj.sc.3101117

Gass EM, Gass GC, Pitetti K (2002) Thermoregulatory responses to exercise and warm water immersion in physically trained men with tetraplegia, *Spinal Cord* 40(9), 474–480. https://doi.org/10.1038/sj.sc.3101341

Ghayour Najafabadi M, Shariat A, Dommerholt J, Hakakzadeh A, Nakhostin-Ansari A, Selk-Ghaffari M, Ingle L, Cleland JA. (2022) Aquatic Therapy for improving Lower Limbs Function in Post-stroke Survivors: A Systematic Review with Meta-Analysis. *Topics in Stroke Rehabilitation*, Oct;29(7):473-489. doi: 10.1080/10749357.2021.1929011.

Giuriati S, Servadio A, Temperoni G, Curcio A, Valente D, Galeoto G. (2021) The effect of aquatic physical therapy in patients with stroke: A systematic review and meta-analysis. *Topics in Stroke Rehabilitation*, Jan28(1):19-32. doi: 10.1080/10749357.2020.1755816

Gomes NM, Pontes SS, Almeida LO, da Silva CM, da Conceição Sena C, Saquetto MB (2020) Effects of water-based exercise on functioning and quality of life in people with Parkinson's disease: a systematic review and meta-analysis. *Clinical Rehabilitation*. Dec;34(12):1425-1435. doi: 10.1177/0269215520943660. Epub 2020 Jul 27. PMID: 32715810.

Gu X, Zeng M, Cui Y, Fu J, Li Y, Yao Y, Shen F, Sun Y, Wang Z, Deng D (2023) Aquatic strength training improves postural stability and walking function in stroke patients. *Physiotherapy Theory and Practice* Aug 3;39(8):1626-1635. doi: 10.1080/09593985.2022.2049939. Epub 2022 Mar 14. PMID: 35285397.

Hall J, Bisson D, O'Hare P (1990) The Physiology of Immersion *Physiotherapy* Sept Vol 76 No9 p517-521

Halliwick Association of Swimming Therapy (1992) *Swimming for people with disabilities* (2nd Ed) A &C Black p48-66

Hao Z, Zhang X, Chen P (2022) Effects of Different Exercise Therapies on Balance Function and Functional Walking Ability in Multiple Sclerosis Disease Patients-A Network Meta-Analysis of Randomized Controlled Trials. *International Journal of Environmental Research and Public Health* Jun 11;19(12):7175. doi: 10.3390/ijerph19127175. PMID: 35742424; PMCID: PMC9222772.

Higgs J, Jones M, Loftus S, Christensen N (2008) *Clinical Reasoning in the Health Professions* 3rd Edition. Elsevier (Butterworth Heinemann) ISBN978-0-7506-8885-7.

Huang L, Huang H, Dang X, Wang Y (2024). Effect of body weight support training on lower extremity motor function in patients with spinal cord injury: a systematic review and meta-analysis. *American Journal of Physical Medicine & Rehabilitation*, 103 (2), 149-157. doi: 10.1097/PHM.0000000000002320.

Iliescu AM, McIntyre A, Wiener J, Iruthayarajah J, Lee A, Caughlin S, Teasell R. (2020) Evaluating the effectiveness of aquatic therapy on mobility, balance, and level of functional independence in stroke rehabilitation: a systematic review and meta-analysis. *Clinical Rehabilitation*, Jan,34(1):56-68. doi: 10.1177/0269215519880955

Jacobs M, Fasano J, Seyboth M, Johnson E, Marcoux B, Dupre AM (2012) The effect of an aquatic exercise program on balance in individuals with Parkinson disease. *Journal of Aquatic Physical Therapy* 19:4e15.

Jung J, Chung E, Kim K, Lee BH, Lee J (2014a) The effects of aquatic exercise on pulmonary function in patients with spinal cord injury. *Journal of Physical Therapy Science* May;26(5):707-9. doi: 10.1589/jpts.26.707. Epub 2014 May 29. PMID: 24926136; PMCID: PMC4047236.

Jung J, Lee J, Chung E, Kim K (2014b) The effect of obstacle training in water on static balance of chronic stroke patients. *Journal of Physical Therapy Science* 26:437e40.

Kang DW, Bressel E, Kim DY (2020) Effects of aquatic exercise on insulin-like growth factor-1, brain-derived neurotrophic factor, vascular endothelial growth factor, and cognitive function in elderly women. *Experimental Gerontology*. Apr;132:110842. doi: 10.1016/j.exger.2020.110842. Epub 2020 Jan 15. PMID: 31954186

Kargarfard M, Etemadifar M, Baker P, Mehrabi M, Hayatbakhsh R (2012) Effect of aquatic exercise training on fatigue and health-related quality of life in patients with multiple sclerosis. *Archives of Physical Medicine & Rehabilitation* 93, 1701e1708

Kurt EE, Buyukturan B, Buyukturan O, Erdem HR, Tuncay F (2018) Effects of Ai Chi on balance, quality of life, functional mobility, and motor impairment in patients with Parkinson's disease *Disability & Rehabilitation* 40, 791e797. Online 2017

Lee D, Ko T, Cho Y (2010) Effects on static and dynamic balance of task-oriented training for patients in water or on land. *Journal of Physical Therapy Science* 22:331e6

Li D, Chen P (2021) Effects of Aquatic Exercise and Land-Based Exercise on Cardiorespiratory Fitness, Motor Function, Balance, and Functional Independence in Stroke Patients-A Meta-Analysis of Randomized Controlled Trials. *Brain Sciences* Aug 20;11(8):1097. doi: 10.3390/brainsci11081097. PMID: 34439716; PMCID: PMC8394174.

Li C, Khoo S, Adnan A (2017) Effects of aquatic exercise on physical function and fitness among people with spinal cord injury: A systematic review. *Medicine* (Baltimore). Mar;96(11):e6328. doi: 10.1097/MD.0000000000006328. PMID: 28296754; PMCID: PMC5369909.

Liu Z, Huang M, Liao Y, Xie X, Zhu P, Liu Y, Tan C (2023) Long-term efficacy of hydrotherapy on balance function in patients with Parkinson's disease: a systematic review and meta-analysis. *Frontiers in Aging Neuroscience*. Dec 13;15:1320240. doi: 10.3389/fnagi.2023.1320240. PMID: 38152605; PMCID: PMC10751311.

Marandi SM, Nejad VS, Shanazari Z, Zolaktaf V (2013) A comparison of 12 weeks of pilates and aquatic training on the dynamic balance of women with multiple sclerosis. *International Journal of Preventative Medicine* 4:S110e7

Marinho-Buzelli AR, Bonnyman AM, Verrier MC (2015) The effects of aquatic therapy on mobility of individuals with neurological diseases: a systematic review. *Clinical Rehabilitation* 29(8):741-751. doi:10.1177/0269215514556297

Marinho-Buzelli AR, Gauthier C, Chan K, Bonnyman AM, Mansfield A, Musselman KE (2022) The state of aquatic therapy use for clients with spinal cord injury or disorder: Knowledge and current practice. *Journal of Spinal Cord Medicine*. Jan;45(1):82-90. doi: 10.1080/10790268.2021.1896274. Epub 2021 Apr 8. PMID: 33830895; PMCID: PMC8890513.

Marinho-Buzelli AR, Vijayakumar A, Linkewich E, Gareau C, Mawji H, Li Z &. Hitzig SL (2023) A qualitative pilot study exploring clients' and health-care professionals' experiences with aquatic therapy post-stroke in Ontario, Canada. *Topics in Stroke Rehabilitation* 1-11. DOI: 10.1080/10749357.2023.2195590

Marinho-Buzelli AR, Zaluski AJ, Mansfield A, Bonnyman AM, Musselman KE (2019) The use of aquatic therapy among rehabilitation professionals for individuals with spinal cord injury or disorder. *Journal of Spinal Cord Medicine* 2019 Oct;42(sup1):158-165. doi: 10.1080/10790268.2019.1647935. PMID: 31573458; PMCID: PMC6783731.

Mead GE, Sposato LA, Sampaio Silva G, Yperzeele L, Wu S, Kutlubaev M, Cheyne J, Wahab K, Urrutia VC, Sharma VK, Sylaja PN, Hill K, Steiner T, Liebeskind DS, Rabinstein AA (2023) A systematic review and synthesis of global stroke guidelines on behalf of the World Stroke Organization. *International Journal of Stroke*. Jun;18(5):499-531. doi: 10.1177/17474930231156753. Epub 2023 Mar 1. PMID: 36725717; PMCID: PMC10196933.

Mehrholz J, Kugler J, Pohl M (2011) Water-based exercises for improving activities of daily living after stroke *Cochrane Database of Systematic Reviews* Jan 19;2011(1):CD008186. doi: 10.1002/14651858.CD008186.pub2. PMID: 21249701; PMCID: PMC6464732.

Methajarunon P, Eitivipart C, Diver CJ, Foongchomcheay A (2016) Systematic review of published studies on aquatic exercise for balance in patients with multiple sclerosis, Parkinson's disease, and hemiplegia. *Hong Kong Physiotherapy Journal* July 7;35:12-20. doi: 10.1016/j.hkpj.2016.03.002. PMID: 30931029; PMCID: PMC6385144

Montagna JC, Santos BC, Battistuzzo CR, Loureiro AP (2014) Effects of aquatic physiotherapy on the improvement of balance and corporal symmetry in stroke survivors. *International journal of clinical & experimental medicine* Apr 15;7(4):1182-7. PMID: 24955206; PMCID: PMC4057885.

Moritz TA, Snowdon DA, Peiris CL (2020) Combining aquatic physiotherapy with usual care physiotherapy for people with neurological conditions: A systematic review. *Physiotherapy Research International* Jan;25(1):e1813. doi: 10.1002/pri.1813. Epub 2019 Oct 8. PMID: 31594035

Naeimi N, Rastkar M, Shahraki A, Abdi M, Ghajarzadeh M (2024) The Effects of Aquatic Therapy on Depression, Fatigue, and Balance in Patients with Multiple Sclerosis (MS): a Systematic Review and Meta-Analysis. *Maedica (Bucur)* Mar;19(1):86-93. doi: 10.26574/maedica.2021.19.1.86. PMID: 38736922; PMCID: PMC11079745.

Nascimento, Lucas Rodrigues & Flores, Louise & Menezes, Kênia & Teixeira-Salmela, Luci. (2019). Water-based exercises for improving walking speed, balance, and strength after stroke: a systematic review with meta-analyses of randomized trials. *Physiotherapy,* 107:100-110. Doi: 10.1016/j.physio.2019.10.002.

Nayak P, Mahmood A, Natarajan M, Hombali A, Prashanth CG, Solomon JM. (2020) Effect of aquatic therapy on balance and gait in stroke survivors: A systematic review and meta-analysis. *Complementary Therapies in Clinical Practice*, May;39:101110. doi: 10.1016/j.ctcp.2020.101110.

Noh DK, Lim JY, Shin HI, Paik NJ (2008) The effect of aquatic therapy on postural balance and muscle strength in stroke survivors-a randomized controlled pilot trial. *Clinical Rehabilitation* Oct-Nov;22(10-11):966-76. doi: 10.1177/0269215508091434. PMID: 18955428.

Oh S, Lee S (2021) Effect of aquatic exercise on physical function and QOL in individuals with neurological disorder: A systematic review and meta-analysis *Journal of Bodywork and Movement Therapies* July 27:67-76 doi: 10.1016/j.jbmt.2021.01.009

Osborne JA, Botkin R, Colon-Semenza C, DeAngelis TR, Gallardo OG, Kosakowski H, Martello J, Pradhan S, Rafferty M, Readinger JL, Whitt AL, Ellis TD (2022) Physical Therapist Management of Parkinson Disease: A Clinical Practice Guideline From the American Physical Therapy Association, *Physical Therapy*, Volume 102, Issue 4, April, pzab302, https://doi.org/10.1093/ptj/pzab302

Paizan NLM, Da Silva R, Borges MA (2009). Hidrotherapy: Coadjuvant treatment to kinesiotherapy in patients with sequels after stroke. *Revista Neurociencias*, 17(4), 314–318.

Palamara G, Gotti F, Maestri R, Bera R, Gargantini R, Bossio F, Zivi I, Volpe D, Ferrazzoli D, Frazzitta G. (2017) Land Plus Aquatic Therapy Versus Land-Based Rehabilitation Alone for the Treatment of Balance Dysfunction in Parkinson Disease: A Randomized Controlled Study With 6-Month Follow-Up. *Archives of Physical Medicine and Rehabilitation* Jun;98(6):1077-1085. doi: 10.1016/j.apmr.2017.01.025. Epub 2017 Feb 27. PMID: 28254636.

Palladino L, Ruotolo I, Berardi A, Carlizza A, Galeoto G (2023). Efficacy of aquatic therapy in people with spinal cord injury: a systematic review and meta-analysis. *Spinal Cord*. Jun;61(6):317-322. doi: 10.1038/s41393-023-00892-4. Epub 2023 Mar 25. PMID: 36966260

Parfitt R, Hensman MY, Lucas SJE (2017) Cerebral Blood Flow Responses to Aquatic Treadmill Exercise *Medicine & Science in Sports & Exercise* Jul;49(7):1305-1312

Park J, Lee D, Lee S, Lee C, Yoon J, Lee M, Lee J, Choi J, Roh, H. (2011). Comparison of the effects of exercise by chronic stroke patients in aquatic and land environments. *Journal of Physical Therapy Science*, 23(5), 821–824. https://doi.org/10.1589/jpts.23.821

Park J, Roh H (2011). Postural balance of stroke survivors in aquatic and land environments. *Journal of Physical Therapy Science* 23(6), 905–908. https://doi.org/10.1589/jpts.23.905

Pérez de la Cruz S (2017) Effectiveness of aquatic therapy for the control of pain and increased functionality in people with Parkinson's disease: A randomized clinical trial. *European Journal of Physical and Rehabilitation Medicine* 53, 825-832.

Pérez de la Cruz S (2018) A bicentric controlled study on the effects of aquatic Ai Chi in Parkinson disease. *Complementary Therapies in Medicine* 36, 147-153.

Pérez de la Cruz S (2021) Comparison between Three Therapeutic Options for the Treatment of Balance and Gait in Stroke: A Randomized Controlled Trial. *International Journal of Environmental Research and Public Health*, Jan 7;18(2):426. doi: 10.3390/ijerph18020426.

Physiotherapy Evidence Database *PEDro scale* https://pedro.org.au/english/resources/pedro-scale/

Prakash RS, Snook EM,Motl RW, Kramer AR (2010) Aerobic fitness is associated with gray matter volume and white matter integrity in multiple sclerosis. *Brain Research* 1341: 41–51. NIH Public Access

Pugh CJ, Sprung VS, Ono K, Spence AL, Thijssen DH, Carter HH, Green DJ (2015) The effect of water immersion during exercise on cerebral blood flow. *Medicine & Science in Sports & Exercise* Feb;47(2):299-306.

Qian Y, Fu X, Zhang H, Yang Y, Wang G (2023) Comparative efficacy of 24 exercise types on postural instability in adults with Parkinson's disease: a systematic review and network meta-analysis. *BMC Geriatrics* Aug 28;23(1):522. doi: 10.1186/s12877-023-04239-9. PMID: 37641007; PMCID: PMC10463698.

Recio AC, Kubrova E, Stiens SA (2020) Exercise in the aquatic environment for patients with chronic spinal cord injury and invasive appliances: successful integration and therapeutic interventions. *American Journal of Physical Medicine & Rehabilitation*. Feb;99(2):109-115. doi: 10.1097/PHM.0000000000001278. PMID: 31361621.

Recio AC, Stiens SA & Kubrova E (2017) Aquatic-Based Therapy in Spinal Cord Injury Rehabilitation: Effective Yet Underutilized. *Current Physical Medicine and Rehabilitation Report* 5, 108–112 https://doi.org/10.1007/s40141-017-0158-5

Rodríguez P, Cancela-Carral JM, Ayán C, Do Nascimento C, Seijo-Martínez M (2013) Effect of aquatic exercise on the kinematics of the gait pattern in patients with Parkinson's disease: a pilot study. *Revista de Neurologia* 56 (06):315-320 doi: 10.33588/rn.5606.2012572

Roehrs TG, Karst GM (2004) Effects of an aquatics exercise program on quality of life measures for individuals with progressive multiple sclerosis. *Journal of Neurologic Physical Therapy* 28, 63e71

Ruoti RG, Morris DM, Cole AJ (Eds) (1997) *Aquatic Rehabilitation* Lippincott, Williams and Wilkins –Chapter 2 Aquatic Physics by B Becker p15-23

Saleh MSM, Rehab NI, Aly SMA (2019) Effect of aquatic versus land motor dual task training on balance and gait of patients with chronic stroke: A randomized controlled trial. *NeuroRehabilitation*, 44(4):485-492. doi: 10.3233/NRE-182636.

Salem Y, Scott A, Belobravka V (2010) Effects of an aquatic exercise program on functional mobility in individuals with multiple sclerosis: a community-based study. *Journal of Aquatic Physical Therapy* 8: 22–32.

Salem Y, Scott AH, Karpatkin H, Concert G, Haller L, Kaminsky E, Weisbrot R, Spatz R (2011). Community-based group aquatic pro- gramme for individuals with multiple sclerosis: a pilot study. *Disability & Rehabilitation* 33:720e8.

Saquetto MB, da Silva CM, Martinez BP, Sena CDC, Pontes SS, da Paixão MTC, Gomes Neto M. (2019). Water-Based Exercise on Functioning and Quality of Life in Poststroke Persons: A Systematic Review and Meta-Analysis. Journal of Stroke & Cerebrovascular Diseases, Nov,28(11):104341. doi: 10.1016/j.jstrokecerebrovasdis.2019.104341.

Schoeneberg B, Arcadipane N, Bussa B, Haselwood E (2020) Effectiveness of aquatic therapy for individuals with multiple sclerosis: a systematic review. *Journal of Aquatic Physical Therapy* 28 (1), 5–12.

Shariat A, Ghayour Najafabadi M, Soroush Fard Z, Nakhostin-Ansari A, Shaw BS (2022) A systematic review with meta-analysis on balance, fatigue, and motor function following aquatic therapy in patients with multiple sclerosis. *Multiple Sclerosis and Related Disorders* Dec;68:104107. doi: 10.1016/j.msard.2022.104107. Epub 2022 Aug 13. PMID: 35988329.

Shoemaker LN, Wilson LC, Lucas SJE, Machado L, Thomas KN, Cotter JD (2019) Swimming-related effects on cerebrovascular and cognitive function. *Physiological Reports* 7(20):e14247.

Terrens AF, Soh S-E & Morgan PE (2021). Perceptions of aquatic physiotherapy and health-related quality of life among people with Parkinson's disease. *Health Expectations* 24:566-577

Useros-Olmo AI, Collado-Vázquez S (2010) Effects of a hydrotherapy program in the treatment of cervical dystonia. Pilot study. *Revista de Neurologia* 51 (11):669-676 doi: 10.33588/rn.5111.2010489

Veldema J, Jansen P. (2021) Aquatic therapy in stroke rehabilitation: systematic review and meta-analysis. *Acta Neurologica Scandinavica*, Mar,143(3):221-241. doi: 10.1111/ane.13371

Vivas J, Arias P, Cudeiro J (2011) Aquatic therapy versus conventional land-based therapy for Parkinson's disease: an open- label pilot study. *Archives of Physical Medicine & Rehabilitation* 92:1202e10.

Volpe D, Giantin MG, Maestri R, Frazzitta G (2014) Comparing the effects of hydrotherapy and land-based therapy on balance in patients with Parkinson's disease: A randomized controlled pilot study. *Clinical Rehabilitation* 28, 1210-1217.

Volpe D, Giantin MG, Manuela P, Filippetto C, Pelosin E, Abbruzzese G, Antonini A (2017) Water-based vs. non-water-based physiotherapy for rehabilitation of postural deformities in Parkinson's disease: a randomized controlled pilot study. *Clinical Rehabilitation* 31, 1107e1115

Ward A, Heywood S and Whitelock Bishop H (2013) *Aquatic Physiotherapy: Applied Physics* Australian Physiotherapy Association

Wheeler S, Acord-Vira A, Davis D (2016) Effectiveness of interventions to improve occupational performance for people with psychosocial, behavioral, and emotional impairments after brain injury: a systematic review. *American Journal of Occupational Therapy* May-Jun;70(3):7003180060p1-9. doi: 10.5014/ajot.115.020677. PMID: 27089290.

Xie G, Wang T, Jiang B, Su Y, Tang X, Guo Y, Liao J (2019) Effects of hydrokinesitherapy on balance and walking ability in stroke survivors: a systematic review and meta-analysis of randomized controlled studies. *European Review of Aging and Physical Activity* Nov 13;16:21. doi: 10.1186/s11556-019-0227-0. PMID: 31754406; PMCID: PMC6854709.

Xu GZ, Li YF, Wang MD, Cao DY (2017). Complementary and alternative interventions for fatigue management after traumatic brain injury: a systematic review. Therapeutic Advances in Neurological Disorders May;10(5):229-239. doi: 10.1177/1756285616682675. Epub 2017 Feb 1. PMID: 28529544; PMCID: PMC5426526.

Zamparo P, Pagliaro P (1998) The energy cost of level walking before and after hydro-kinesitherapy in patients with spastic paresis, *Scandinavian Journal of Medicine in Science and Sport* 8(4), 228–28. https://doi.org/ 10.1111/ j.1600- 0838.1998.tb00196.x

Zhang Y, Wang YZ, Huang LP, Bai B, Zhou S, Yin MM, Zhao H, Zhou XN, Wang HT. (2016) Aquatic Therapy Improves Outcomes for Subacute Stroke Patients by Enhancing Muscular Strength of Paretic Lower Limbs Without Increasing Spasticity: A Randomized Controlled Trial. American Journal of Physical Medicine & Rehabilitation, Nov;95(11):840-849. doi: 10.1097/PHM.0000000000000512. PMID: 27088480.

Zughbor N, Alwahshi A, Abdelrahman R, Elnekiti Z, Elkareish H, Gabor MG, Ramakrishnan S. (2021) The Effect of Water-Based Therapy Compared to Land-Based Therapy on Balance and Gait Parameters of Patients with Stroke: A Systematic Review. *European Neurology*, 84(6):409-417. doi: 10.1159/000517377.

APPENDIX 1: EDUCATION OF CLIENTS & HEALTH PROFESSIONALS

The findings of four qualitative studies, investigating aquatic therapy for four different neurological populations, suggest that both clients and health professionals would benefit from better education regarding the safety and effectiveness of this therapy.

NEUROLOGICAL CONDITION	QUALITATIVE STUDY	FINDINGS
PARKINSON'S DISEASE	Carroll et al (2022a)	• "Barriers to participation in aquatic therapy reported by some participants included a lack of credible information sources… Our study's participants recommended increasing awareness and knowledge of the benefits of aquatic therapy as one possible solution to improve uptake in people with Parkinson's disease" • "People with Parkinson's disease may benefit from timely information about the unique benefits, pre-requisites, and local aquatic therapy facilities to promote greater uptake of aquatic programs."
STROKE	Marinho-Buzelli et al (2023)	• "Lack of formal and informal education and communication as participants' transition from rehab to community were viewed as barriers to aquatic therapy use post-stroke. Developing education material and communication strategies may improve the uptake of aquatic therapy post-stroke." • "The present data indicated there is not only a lack of communication between care settings but also among health-care professionals" • "Overall, both group of participants of the present study reported that health-care professionals are possibly not aware of aquatic therapy benefits and approaches due to the limited academic curriculum and/or lack of specific guidelines for aquatic therapy post-stroke."
MULTIPLE SCLEROSIS	Chard (2017)	• "Despite regular visits, health care providers were not a common source of information regarding the feasibility of aquatic exercise." • "Communication regarding local aquatic opportunities is critical for ensuring aquatics engagement among persons with MS. Providers could play a stronger role in emphasizing the feasibility and benefits of aquatic programs."
SPINAL CORD INJURY	Marinho-Buzelli et al (2022)	"Certain barriers could be mitigated by educating healthcare professionals, clients and community stakeholders on the benefits of providing AT*. For instance, more in-depth and standardized AT education and training in school curricula could be implemented in the physiotherapy, kinesiology and physiotherapy assistant programs across Canada. There could be more robust AT knowledge dissemination for stakeholders on the value of AT, aimed at improving access to therapeutic pools in the community." *Aquatic Therapy

APPENDIX 2: PUBMED DATABASE SEARCH TERMS

Intervention search terms used were:

- Aquatic physiotherapy OR
- Aquatic therapy OR
- Aquatic exercise OR
- Water therapy OR
- Water exercise

This string was then linked (via AND) to EACH of the following condition search term combinations:

- Neurological
- Parkinson's disease OR PD
- Cerebrovascular accident OR CVA OR stroke
- Multiple sclerosis OR MS
- Acquired brain injury OR ABI OR traumatic brain injury OR TBI
- Spinal cord injury OR SCI

APPENDIX 3 – PEDRO QUALITY ASSESSMENTS

STUDY	SPECIFIED ELIGIBILITY CRITERIA	RANDOM ALLOCATION	CONCEALED ALLOCATION	GROUPS SIMILAR AT BASELINE	SUBJECT BLINDING	THERAPIST BLINDING	ASSESSOR BLINDING	<15% DROP OUT	INTENTION TO TREAT ANALYSIS	BETWEEN-GROUPS STATISTICAL COMPARISON	POINT & VARIABILITY DATA	TOTAL SCORE (SUM 2-10)	RATING
Bei et al 2023	y	y	n	y	n	n	n	y	y	y	y	6	good
Gu et al 2023	y	y	n	y	n	n	n	y	y	y	y	6	good
Curcio et al 2020	y	y	y	y	n	n	y	y	y	y	y	8	good
Driver et al 2004	y	y	n	y	n	n	n	y	y	n	y	5	fair
Driver et al 2006	y	y	n	y	n	n	n	y	y	n	y	5	fair
Driver 2009	y	y	n	y	n	n	n	y	y	y	y	6	good