Evidenced-based aquatic therapy guidelines for Parkinson's disease

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Evidenced-based Aquatic Therapy Guidelines for Parkinson's Disease.

By

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A thesis submitted to the University of Limerick in fulfilment of the requirements for the award Doctor of Philosophy at the University of Limerick

Supervisors:

Dr. Amanda M. Clifford, Professor William T. O'Connor, and Professor Meg E. Morris

Submitted to the University of Limerick September 2021

Abstract

AUTHOR: Louise Carroll

TITLE: Evidenced-based Aquatic Therapy Guidelines for Parkinson's Disease

BACKGROUND: Parkinson's disease (PD) is a progressive neurodegenerative disorder characterised by motor and non-motor symptoms, affecting movement, function, mental status, and social engagement. Aquatic therapy is gaining popularity as a form of structured physical activity. Implementing aquatic research evidence into clinical practice can be challenging due to a lack of patient and practice-based evidence and pragmatic aquatic therapy-specific guidelines.

AIMS: Firstly, to synthesise the literature on the effectiveness of aquatic therapy for PD and examine the optimum aquatic therapy prescription. Subsequently, to explore the values and preferences of people with PD. Finally, to establish international evidence-based aquatic therapy guidelines for people with PD.

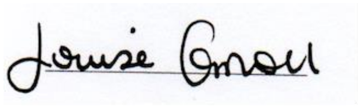
METHODS: A systematic review and meta-analysis was conducted to establish the research evidence base. Focus groups and interviews were conducted with people with PD in Ireland and Australia to identify factors influencing access to, participation in, and long-term adherence to community aquatic therapy. Information from both studies was used, along with stakeholder engagement, to obtain consensus using a 3-step modified Delphi process with over 45 international practice experts.

RESULTS: Aquatic therapy can have positive outcomes that are comparable to land-based interventions for improving mobility, balance, gait, disability, and quality of life. Patient-centred evidence highlighted the importance of access to community-based, individually tailored programs, group camaraderie, and socialisation, with aquatic therapy considered beneficial for health and wellbeing. The guidelines provide preliminary evidence for the optimal dosage, content, safety, and delivery of aquatic programs for people with mild to advanced PD.

DISCUSSION: The aquatic therapy guidelines presented in this thesis can be used to guide clinical decision-making and to help standardise aquatic therapy practice, increase safety and optimise outcomes for people with PD. It is anticipated that the guideline infographic will be shared widely to enhance the impact of this research.

Declaration

I, the undersigned, declare that the work contained in this thesis is my own work and was completed with the guidance of my supervisors Dr. Amanda Clifford, Professor William O'Connor, and Professor Meg Morris. This thesis has not been submitted for any other award or degree at another University or Higher Education Institute.

Signed: 

"If we knew what we were doing,

it wouldn't be called research!"

-Albert Einstein

'Mount Everest from a distance.' Taken by Louise Carroll © (2010)

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This Ph.D. journey has been like climbing my own 'Everest.' It has been a once-in-a-lifetime journey, full of highs and some bumps, but worth every step! There have been so many "pinch-me moments" during the past four years. For instance, I never thought that my first-time visiting Las Vegas would be to attend an international aquatic therapy conference and not to see the famous strip and lose some money at the casinos!

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eagerness to participate and share your knowledge and experiences with me. I dedicate this work to you all!

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List of Abbreviations

ACSM: American College of Sports Medicine

ADLs: Activities of daily living

FITT Framework: Frequency, Intensity, Time/Duration, Type

H&Y: Hoehn and Yahr

PD: Parkinson's disease

PPI: Public and Patient Involvement

PSP: Progressive Supranuclear Palsy

RCT(s): Randomised Controlled Clinical Trial(s)

YOPD: Young Onset Parkinson's disease

Glossary of Terms

Aerobic exercise: A subgroup of exercise, which entails sustained, recurrent movement of the body's bigger muscle groups for a defined time.[1]

Aquatic physiotherapy*:* A physiotherapy programme utilising the properties of water, designed by a suitably qualified physiotherapist. The programme should be specific for an individual to maximise function, which can be physical, physiological, or psychological. Treatments should be carried out by appropriately trained personnel, ideally in a purpose-built, and suitably heated aquatic physiotherapy pool.[2]

Buoyancy: The buoyancy effect of water is based on 'Archimedes Principle,' which states: "when a body is wholly or partially immersed in a fluid at rest, it experiences an upward thrust equal to the weight of the fluid displaced." Buoyancy is a force that can be used therapeutically to either support, assist, or resist movement performed in water.[3]

Density: The density of an object relative to the density of the same volume of pure water (1.0 kg/litre). The capacity of an object to float is reliant on its relative density. While the human body is largely made up of water, it has a relative density of 0.98 kg/litre when the lungs are filled with air. The ability of the body to float in water depends on the amount and distribution of the body's lean muscle mass (1.1 kg/litre) and fat mass (0.9kg/litre).[4]

Drag forces: This is the tendency for the body or an object to be pulled backwards in the water, into the wake. The wake is an area of decreased pressure in the water behind a moving body part or object. When the speed of a moving object or body part increases in water, the drag forces are increased, resulting in a greater resistance to movement.[3]

Exercise: A subset of physical activity where the aim is to increase physical fitness through planned, repetitive, and coordinated activities with a definite end goal.[1]

Hydrostatic pressure: The hydrostatic pressure effects associated with water immersion are based on 'Pascal's law,' which states: "At any given depth, the pressure from a liquid is equally exerted on all surfaces of the immersed object." An example of this is when a person is immersed in water to a depth of 1.2 meters, the pressure at their feet is four times higher than at the surface of the water.[3]

Hoehn and Yahr: A scale ranging from one to five used to classify the severity of Parkinson's disease. Both the original and the Modified Hoehn and Yahr staging scales can be used, with lower stages (1-2) signifying milder disease states where symptoms are predominantly unilateral, and moderate to advanced stages (3-5) signifying bilateral involvement with worsening functional, balance, and activity limitations.

Hydrotherapy: Traditional term used to describe water-based treatments occurring in warm water, heated therapy pools or spas, to enhance physical health and well-being.

Parkinsonism: An umbrella term used to describe a group of disorders that include Parkinson's-type symptoms, such as stiffness, tremors, bradykinesia, and postural instability.

Physical activity: Any body movement which expends calorific energy.[1]

Public and Patient Involvement (PPI): PPI is defined as "research being carried out 'with' or 'by' members of the public rather than 'to,' 'about' or 'for' them.[5]

Thermodynamics: Term used to describe the ability of water to be used therapeutically across a broad temperature range (e.g., 29°C-35.5°C). Water has a heat retention capacity 1000 times higher than the same air volume. Thus, the thermal conductive property of water makes it an extremely adaptable medium, which can maintain heat or cold temperatures, and transfer heat easily to the submerged body part(s).[4]

Turbulence: Is one of several fluid dynamics (including eddies, wakes and drag forces) associated with water immersion. When water achieves a critical velocity of flow, it causes water molecules to move in an erratic manner. This then triggers the rotational movement of molecules (eddies), resulting in turbulent water flow and further resistance to movement of the body part(s) submerged in water.[3]

Viscosity: The water's viscous properties, whereby water molecules stick together to create internal tension, creates resistance by attaching to the surface the skin or body part trying to move through the water. Higher forces of movement in water leads to increased viscous resistance, and ultimately higher exercise intensities. When the force generating movement stops, the resistance ceases almost immediately. [3,4]

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Research Outputs

List of Peer-Reviewed Journal Publications

Carroll, L.M., Morris, M.E., O’Connor, W.T., Volpe, D., Salsberg, J., and Clifford, A.M. (2021) ‘Evidence-based aquatic therapy guidelines for Parkinson's disease: an international consensus study,’ *Journal of Parkinson’s Disease*, 12, 621-637, available: http://dx.doi.org/10.3233/JPD-212881

Carroll, L.M., Morris, M.E., O'Connor, W.T. and Clifford, A.M. (2021) 'Community Aquatic Therapy for Parkinson's Disease: An International Qualitative Study', *Disability and Rehabilitation*, available: http://dx.doi.org/10.1080/09638288.2021.1906959.

Carroll, L.M., Morris, M.E., O'Connor, W.T. and Clifford, A.M. (2020) 'Is Aquatic Therapy Optimally Prescribed for Parkinson's Disease? A Systematic Review and Meta-Analysis', *Journal of Parkinson's Disease*, 10(2), 59-76, available: http://dx.doi.org/10.3233/JPD-191784.

International Prospective Register of Systematic Reviews

Carroll, L.M., Morris, M.E., O'Connor, W.T. and Clifford, A.M. (2018) ‘Evidence-based Analysis of Aquatic Therapy in Parkinson’s disease’, PROSPERO: International prospective register of systematic reviews, doi:10.15124/CRD42018085996, available from: https://www.crd.york.ac.uk/PROSPERO/display_record.php?RecordID=85996

International Conferences:

Invited Speaker

Carroll, L.M., Morris, M.E., O'Connor, W.T. and Clifford, A.M. (2021) 'Aquatic Therapy for Parkinson's Disease: What is the Evidence Telling Us?', UK Aquatic Therapy Conference, The Aquatic Therapy Association of Chartered Physiotherapists (ATACP), UK.

Oral Presentation

Carroll, L.M., Morris, M.E., Volpe, D., O'Connor, W.T., Saunders, J., Clifford, A.M., (2018) 'Aquatic Therapy for Parkinson's Disease', International Conference for Evidence Based Aquatic Therapy (ICEBAT), Las Vegas, USA.

National Conference: Oral presentation

Carroll, L.M., Morris, M.E., Volpe, Saunders, J., Clifford, A.M., (2017) 'Aquatic Exercise Therapy for People with Parkinson's disease: A Randomized Controlled Trial', The Irish Society of Chartered Physiotherapist Annual Conference, Galway.

International Research Seminar Presentation

Carroll, L.M., (2020) 'Aquatic Therapy for Parkinson's Disease: What is the Evidence Telling Us?', Pills on PD Rehabilitation Webinar [online], Fresco Parkinson's Institute, Italy.

Carroll, L.M., (2019) 'Aquatic Therapy for People with Parkinson's Disease', Science and Engineering Department, University of Padua, Italy.

Workshops and Presentations

Carroll, L.M., Conneely, M., O'Donoghue, M., O'Malley, N., O'Leary, N., and Roe, C., (2021 and 2020) 'Patient and Public Involvement in PhD Research', PPI Summer School, School of Medicine, University of Limerick.

Carroll, L.M., (2019) 'An Exploration of the Benefits of Aquatic Therapy for People with Parkinson's disease: A Multi-centre Study', Chartered Physiotherapists in Aquatic Therapy (CPAT) Annual General Meeting, Dublin, Ireland.

CHAPTER 1: Introduction

1.0 Prologue

This thesis explores the optimal prescription and delivery methods for aquatic therapy for people living with Parkinson's disease (PD). There has been a global surge in interest in aquatic therapy as a structured form of physical exercise for people with PD (Volpe *et al.* 2014; Carroll *et al.* 2017; da Silva and Israel 2019; Becker 2020; Terrens *et al.* 2020). However, gaps remain in the research evidence on how best to deliver this form of structured therapeutic exercise in clinical practice across the globe. In order to implement evidence-based aquatic therapy in practice (Sackett *et al.* 1996; Lennon and Bassile 2018, p.5), it is essential to understand the evidence for how aquatic therapy can benefit PD-specific impairments. It is also important to understand the optimal prescription, dosage, and mode of delivery of aquatic therapy for PD, along with patient preferences, clinical expertise, and contextual factors.

This thesis will address specific research gaps in international research using a mixed-methods approach. The over-arching objective is to develop evidence-based aquatic therapy guidelines for PD, to guide and inform healthcare practitioners working in this field.

This introduction chapter will present an overview of the research topic, research problem, rationale, aims, hypothesis, and theoretical framework, along with an outline of the ensuing chapters of the thesis.

1.1 Aquatic therapy

Background and definition

Aquatic therapy is a contemporary treatment method with deep historical roots (De Vierville 2010). Since prehistoric and medieval times, people worldwide have travelled to healing waters, hot springs, baths, pools, and spa therapy to cure and relieve their illnesses (Becker 2009; De Vierville 2010). In the early and mid-20th century, water-based treatment in warm water pools and spas became popularised for the treatment of conditions such as poliomyelitis, chronic arthritis, cerebral palsy, and paralysis (Lowman *et al.* 1937; Fletcher 1944; Becker 2009; Irion and Brody 2009, pp.8-9).

Today many different water-based activities exist and have been described and debated in the rehabilitation literature. Hydrotherapy and aquatic physiotherapy entail supervised therapeutic exercise performed in warm water (Eversden *et al.* 2007). Aqua aerobics involves strengthening and fitness exercises performed at a sustained tempo in the shallow end of swimming pools (Fisken *et al.* 2015). Aqua jogging focuses on deep water running with a buoyancy belt (Assis *et al.* 2006). For this thesis, the term aquatic therapy will be used. Aquatic therapy was coined in the late 20th-century to describe:

“A scientific theory, a medical rationale, and a set of clinical procedures using water immersion for the restoration of physical mobility and physiological activity, and, at times, for effecting psychological transformation” (De Vierville 2010, p.1).

Blue exercise

There has been a recent resurgence of interest in the potential public health benefits of being immersed in ‘green and blue spaces’ (e.g., natural water, lakes, rivers) and ‘blue exercise,' which includes physical exercise in and around natural aquatic environments (e.g., sea swimming) (Thompson and Wilkie 2021). Aside from the established physical and health benefits of swimming (Swimming and Health Commission 2017) and the abundance of anecdotal reports about these activities' physical and mental health benefits (Kelleher 2019; Garvey 2020), research exploring the specific benefits of 'blue exercise' is limited. Preliminary evidence does suggest, however, that 'blue exercise' can improve health and wellbeing, while the natural aquatic environment also enables people with disabilities to participate independently and more efficiently (Foley 2015; Gascon *et al.* 2017; Britton *et al.* 2020; Foley 2020; Thompson and Wilkie 2021).

1.2 Parkinson's disease

Parkinson's disease epidemiology

Parkinson's disease is an incurable, chronic progressive neurodegenerative disorder caused by degeneration of the neurons in an area of the brain called the striatum, located within the basal ganglia, which controls voluntary movements, learning, and behaviour (Jankovic 2008; Bloem and Munneke 2014). With no known cure, it is the fastest-growing neurological disease globally, and after Alzheimer's disease, it is the second most common neurodegenerative disorder (Elbaz *et al.* 2016; Dodel *et al.* 2021). The incidence of PD is rising and is estimated to affect about 1-2 per 1,000 (Tysnes and Storstein 2017), with more than 6 million people worldwide (Dorsey *et al.* 2018) and 12,000 people in Ireland (Stubbe *et al.* 2016) affected by the condition. A growing aging population is driving the epidemic of chronic diseases such as PD worldwide, with the prevalence of PD increasing from approximately 1% in adults over 60 years to 4% over the age of 85 (De Lau and Breteler 2006; Keus *et al.* 2014; Prince *et al.* 2015). Thus, the numbers of people diagnosed with idiopathic PD are expected to grow exponentially to more than 12 million people by 2040 (Dorsey and Bloem 2018; Dorsey *et al.* 2018; Bloem *et al.* 2020), resulting in rising healthcare demands and burden of costs associated with PD (Keus *et al.* 2014, p.20). In this regard, there is a strong need for all healthcare professionals to be accountable by ensuring effective, evidence-based treatment strategies to mitigate the long-term disease impacts associated with more and more people living with the condition (von Campenhausen *et al.* 2011; Hirsch *et al.* 2016; Bloem *et al.* 2020).

Parkinson's-type symptoms termed 'Parkinsonism' can present as different conditions such as idiopathic Parkinson's disease, Progressive Supranuclear Palsy, Dementia with Lewy Bodies, or Multiple Systems Atrophy. Idiopathic Parkinson's disease is estimated to account for 70% of Parkinsonism cases (Ramaswamy and Graziano 2018, p.227). Thus, the cause of this disorder, for the most part, is yet unknown. It is likely to be caused by an interplay between environmental, genetic, and age-associated risk factors (Baltazar *et al.* 2014; Elbaz *et al.* 2016). Environmental factors, such as long-term exposure to pesticides, herbicides, contaminated well water, are believed to affect the mitochondrial function of dopamine-producing cells located in the substania nigra region of the midbrain (Bellou *et al.* 2016). Genetic mutations of Parkinson's related proteins (alpha-synuclein), caused by inflammation, misfolding, or immunological responses, have been found to cause neuronal cells' loss in the dopamine-rich area of the brain, the substantia niagra (Ramaswamy and Graziano 2018, p.228; Dorsey *et al.* 2020, p.16). Considered a hallmark of Parkinson's disease, the build-up of misfolded proteins, called Lewy bodies, are deemed toxic to nerve cells (Gibb and Lees 1988). As the disease progresses, these protein clusters progressively build up and spread throughout the neocortical and cortical regions of the brain (Tysnes and Storstein 2017; Dorsey *et al.* 2020, p.25).

Motor impairments

Parkinson's disease is primarily considered a movement disorder, characterised by the cardinal motor impairments bradykinesia, coupled with a resting tremor and rigidity (Keus *et al.* 2014; Poewe *et al.* 2017; Ramaswamy and Graziano 2018, p.230). People with PD experience increasing motor deficits during the disease course, including postural instability, difficulties with balance, impaired walking ability, and reduced mobility. Postural instability and balance impairments are evident in the early disease stages (Modified H&Y 1.5-2) and steadily worsen as the disease develops (Mak *et al*. 2017). Abnormal postural reactions, comprising of decreased reactive stepping balance control, and reduced amplitude and velocity of anticipatory postural adjustments, can all negatively impact postural stability in individuals with PD when reaching, transitioning to standing from sitting, initiating gait, and maintaining upright stance in response to perturbation (Błaszczyk *et al.*, 2007; Kim *et al*., 2013; Mak *et al.*, 2017). Gait impairments commonly present in individuals with PD as abnormal walking patterns, characterised by short, shuffling steps, reduced gait speed, step length, trunk and pelvic rotation, increased stride variability and longer double-support phase (Morris *et al.*, 1994; Morris *et al.*, 1996; Hausdorff, 2005; Mak *et al*. 2017; Ni *et al*., 2018). Furthermore, people with PD can also experience episodic festination, termed freezing of gait, associated with gait initiating, negotiating obstacles, turning, and performing a concurrent task while walking (Morris *et al.* 2008; Perez-Lloret *et al.*, 2014).

These motor impairments combined lead to decreased functional independence and quality of life, impacting social and emotional well-being (Keus *et al.* 2007; Keus *et al.* 2014). Loss of functional independence also results in increased carers burden and reduced physical activity resulting in further muscle weakness, deconditioning, fear of falling, and reduced community participation (Benka Wallén *et al.* 2015). Subsequently, people with PD experience a high proportion of falls, with recent evidence to suggest that on average, about 60% fall at least once a year, while roughly 39% incur frequent falls (Allen *et al.* 2013; Fasano *et al.* 2017). With 33% estimated to result in fractures, people with PD are also more likely to be hospitalised, or admitted to nursing homes, with an increased mortality rate of about 10% among this cohort of fallers (Keus *et al.* 2014; Kalilani *et al.* 2016).

Non-motor impairments

Research has also shown that PD pathology extends beyond the nigrostriatal dopamine pathway (Braak *et al.* 2004; Sung and Nicholas 2013), resulting in numerous non-motor deficits, including depression, anxiety, cognitive impairments, disturbed sleep, fatigue, pain, autonomic dysfunction, psychotic and sensory symptoms (Chaudhuri *et al.* 2006; Schapira *et al.* 2017). These non-motor effects cause further disability and can have an additional detrimental impact on the health status and quality of life of people with PD (Martinez-Martin *et al.* 2011; Bloem *et al.* 2015, p.16; Dorsey *et al.* 2020). Evidence suggests that mild cognitive impairments may already be present in 25% of people in the initial stages of PD, with a decline in cognition another identified risk factor for falls (Mirelman *et al.* 2012; Stefanova *et al.* 2015; Pfeiffer 2016). In addition, people with PD who experience depression are at a higher risk of experiencing severe motor dysfunction and disability during the disease course (Pfeiffer 2016).

1.3 Parkinson's disease management

Pharmacological management

Current medical management of PD worldwide includes dopaminergic drug therapy and surgical intervention. Levodopa therapy and deep brain stimulation (DBS) are the mainstays of these treatments (Benabid 2003; Mercuri and Bernardi 2005; Deuschl *et al.* 2006). However, despite optimal medical management, people with PD continue to experience a deterioration in physical function, reduced independence and quality of life, and recurrent falls (Mak *et al.* 2017). Levodopa therapy is often associated with adverse side effects, including dyskinesia and motor fluctuations, which can impact sleep, cause anxiety due to reduced drug effects, difficulties performing functional activities, experiences of being immobilised, and pain (Tsugawa *et al.* 2015; Hackney *et al.* 2020). As the disease progresses, the efficacy of these PD-specific medications becomes diminished. In this regard, there is some promising emerging research evidence to indicate that exercise may increase dopamine efficacy (Fisher *et al.* 2013; Petzinger *et al.* 2015) and enhance levodopa absorption for some people with PD. As a result, this has led to organisations such as the Movement Disorder Society Evidence-Based Medicine Panel (Fox et al. 2011; Mak et al. 2017) and the European Physiotherapy Guidelines for Parkinson's disease (Keus et al. 2014) to recommend physiotherapy and exercise as effective treatment adjuncts to levodopa therapy.

Physiotherapy and exercise management

Physiotherapy for PD focuses on slowing down and limiting disease progression, maintaining and increasing physical fitness, enhancing independence and participation in functional tasks, work and leisure activities, fall prevention, and minimizing fall risk (Ellis 2021). Physiotherapists incorporate a range of evidence-based techniques (Tomlinson *et al.* 2012; Keus *et al.* 2014), such as physical exercise (Shen *et al.* 2016; Radder *et al.* 2020), cueing (Morris *et al.* 1996; Nieuwboer *et al.* 2007), and movement strategy training (Morris *et al.* 2017) to enhance aerobic capacity (Shulman *et al.* 2013), muscle strength (Corcos *et al.* 2013; Ni *et al.* 2016b), gait (Herman *et al.* 2007;

Mehrholz *et al.* 2015; Ni *et al.* 2018), balance (Conradsson *et al.* 2015; Shen and Mak 2015), posture (Mirelman *et al.* 2011a) functional mobility (van der Kolk and King 2013) and quality of life (Dereli and Yaliman 2010).

There is preliminary evidence that high-intensity aerobic exercise may play a role in slowing down disease progression through neuroprotective mechanisms (Petzinger *et al.* 2010; Johansson *et al.* 2020). Research findings from human and animal model investigations are promising, with increased dopamine release (Petzinger *et al.* 2010), reduced alpha-synuclein aggregation (Zhou *et al.* 2017), improved mitochondrial function (Kelly *et al.* 2014), and elevated levels of nigrostriatal neurotrophic factor (Lau *et al.* 2011), some of the key findings reported to date. Thus, including high-intensity exercise training, particularly in the earlier disease stages (Frazzitta *et al.* 2015; Schenkman *et al.* 2018), may positively affect various neuroplasticity markers.

In recent years, several complementary physiotherapy approaches have become popular for people with PD (da Rocha *et al.* 2015). These include group-based dance classes such as Argentine tango and Irish set dancing (Holmes and Hackney 2017; Shanahan *et al.* 2017b), Tai Chi (Li *et al.* 2012), boxing (Wilson 2018), Nordic walking (Cugusi *et al.* 2017), yoga (Ni *et al.* 2016a), as well as aquatic therapy (Vivas *et al.* 2011; Pérez and Cancela 2014). In addition to targeting movement disorder impairments, these alternative approaches have the potential to address emotional and cognitive challenges associated with PD (Bognar *et al.* 2017). Research indicates that these approaches can promote socialisation, enjoyment, well-being, and quality of life (Keus *et al.* 2014; Bloem *et al.* 2015; da Rocha *et al.* 2015; Mak *et al.* 2017), factors identified to be key motivators for increasing participation and long-term exercise adherence in people with PD (Crizzle and Newhouse 2012). Considering that people with PD are likely to be less physically active (Benka Wallén *et al.* 2015) and given the known benefits of regular exercise for people with PD (Oguh *et al.* 2014), facilitating access to these alternative structured exercise activities to promote sustained exercise adherence and participation is paramount. In this regard, aquatic therapy appears to be a promising approach as participation in a community-based aquatic program was found to be associated with high levels of adherence (Carroll *et al.* 2017).

1.4 Unique benefits of aquatic therapy for Parkinson’s disease

Physiological effects of water immersion in the healthy adult population

The unique application of the physical properties of water (e.g., buoyancy, viscosity, drag forces, thermodynamics, hydrostatic pressure) not only enables healthcare practitioners to justify using aquatic therapy over other land-based interventions but also has the potential to enhance exercise programs due to the capacity of water immersion to impact all body systems (Iron 2009, p.34). Many physiological benefits associated with water immersion, which have been extensively studied in healthy adults, may also be pertinent to Parkinson's disease (Gulick and Geigle 2009, pp.36-41; Becker 2010). Aquatic immersion has been found to improve cardiovascular (Arborelius *et al.* 1972) and respiratory muscle efficiency (Becker 2009), reduce sympathetic autonomic activity (Iellamo *et al.* 2018), increase muscle perfusion (Weston *et al.* 1987) and cerebral blood flow (Carter *et al.* 2014a), decrease anxiety (Watanabe *et al.* 2000), and offload painful or arthritic joints (Becker 2009; Gulick and Geigle 2009, p.42; Bartels *et al.* 2016) in people without PD. Previous research indicates that immersion in water to the clavicular level produces between a 10-15 % reduction in heart rate and a 30% increase in cardiac output (Arborelius *et al.* 1972; Becker 2009). Carter *et al.* (2014a) demonstrated that this rise in cardiac output, associated with head out of water immersion, resulted in a significant increase in brain blood flow velocity and carotid artery diameter in human subjects tested at rest (Becker 2020). Two further studies (Pugh *et al.* 2015; Parfitt *et al.* 2017) evaluating the effects of aquatic treadmill training observed significant increases in cerebral blood flow compared to over-land treadmill training. Of particular interest, Parfitt *et al.* (2017) observed a 21% increase in middle cerebral artery velocity following aquatic treadmill training compared to a 12% increase in land-matched treadmill training. Taken together, these results suggest that water immersion and water-based exercise could have greater brain and health benefits over similar land-based exercises (Becker 2020).

Application of the hydrodynamic principles for Parkinson's disease

Traditionally, aquatic therapy is delivered by skilled healthcare professionals, primarily physiotherapists, with specialist knowledge and understanding of the theory underpinning the hydrodynamic principles of water immersion (David M Morris and Paula R Geigle 2009, p.224). Table 1 has been designed by the author (LC) to provide a detailed description and outline of the fundamental hydrodynamic principles and how they might be applied in practice to target specific PD associated impairments based on information obtained from a number of literature sources (Becker 2009; Morris and Geigle 2009; Morris 2010). The water's versatile and exclusive properties, particularly the hydrostatic pressure and buoyancy support, could provide additional rehabilitative benefits for people with PD while minimising the risks of secondary complications (Morris 2010, p.193).

Table 1. Fundamental hydrodynamic principles and theoretical examples of their application for targeting specific Parkinson's disease impairments.

Parkinson's Impairments	FUNDAMENTAL HYDRODYNAMIC PRINCIPLES			
	Buoyancy	Hydrostatic pressure	Fluid dynamics of water (viscosity, turbulence & drag forces	Thermodynamics
Rigidity	• Decreased gravitational forces enable increased time to facilitate muscle activation throughout range of motion (ROM) • Assist increased ROM & muscle length.	• Facilitates muscle stimulation & contraction	• Use of turbulence to assist agonist/antagonist muscle activation and joint ROM (e.g., increased arm swing walking with arms submerged in water).	• Warm water (≥33.5°C) used to reduce muscle stiffness, tone, pain, and muscle spasms.
Bradykinesia	• Partially offset gravitational forces facilitates increased movement speed and amplitude.	• Increased sensory input (proprioceptive & joint mechanoreceptors). • Assists muscle contraction.	• Application of turbulence & drag forces to facilitate speed, movement amplitude, and quality of repeated movement.	• Cooler water (≤33.5°C) to stimulate or assist muscle activation. • Warmer water (≥33.5°C) to reduce muscle stiffness and tone.
Postural instability	• Enables trunk muscle activation & co-contraction to maintain upright posture in water. • Facilitate patient/client to assume and maintain a position in water.	• Uniform resistance in all movement planes to promote upright posture & reduce postural sway. • Stimulate proprioceptive input & muscle co-contraction.	• Challenge anticipatory postural adjustments by stimulating trunk muscle activation. • Facilitate proximal stability to enable patient/client to perform distal body movements (e.g., active assisted or resisted arm movements).	• Warmer water (≥33.5°C) enables patient/client to remain in water for longer periods to focus on movement quality and endurance.
Balance	• Increased reaction time to facilitate increased turn-speed and step width. • Enables patient/client to attain a stable body position in water (e.g., chair position). • Progress balance training from deeper to shallow water.	• Stimulate muscle activation & contraction. • Provide sensory input & stimulation.	• Challenge balance by applying turbulence (perturbation-based balance training) in a safe, controlled way.	• Warmer water (≥33.5°C) enables patient/client to remain in water for longer periods to focus on movement quality, and endurance.
Gait	• Longer reaction time to facilitate increased stride length and stance phase during the gait cycle. • Facilitate increased ROM, muscle strength & endurance. • Progress gait training from deeper to shallow water.	• Stimulate muscle activation & contraction. • Provide sensory input & stimulation.	• Challenge gait by facilitating increased step speed & step length. • Use of turbulence & drag forces to reduce or increase resistance to movement during arm & leg swing phase.	• Warmer water (≥33.5°C) to enhance quality of movement during gait training. • Cooler water (≤33.5°C) for targeting muscle strength, and aerobic fitness.

People with PD who may benefit most from engaging in aquatic therapy generally require the physical properties of water to enhance elements of their physical capacity and function (Irion and Brody 2009, p.10). One example is the application of water-based exercise to manage balance deficits and postural instability in people with PD (Table 1) (Bloem *et al.* 2015). Balance impairments in PD can manifest as abnormal postural sway and anticipatory postural adjustments, limited trunk rotation, reduced turn speed, reactive postural responses, and increased gait variability (Hausdorff 2005;

Zampieri *et al.* 2011; Mancini *et al.* 2012; Mak *et al.* 2017). According to Shumway-Cook and Woolacott's modified systems framework, it may be theorised that the physical properties of water can be used to stimulate sensory and musculoskeletal systems, neuromuscular strategies, and anticipatory mechanisms (Horak *et al.* 1997; Shumway-Cook and Woollacott 2007; Morris 2010, p.236). The water's buoyancy and hydrostatic pressure partially offset gravitational forces, facilitating increased reaction-time, proprioceptive input, and motor planning. In addition, drag forces and viscosity can be used to challenge or assist static and dynamic postural control, along with the targeted application of these resistive forces to increase muscle strength and endurance (Morris 2010, p.237). In this regard, there is some evidence suggesting that perturbation-based balance training in water may significantly improve outcomes in balance, postural control, and the quality of life for people with PD compared to land-based balance training (Volpe *et al.* 2014).

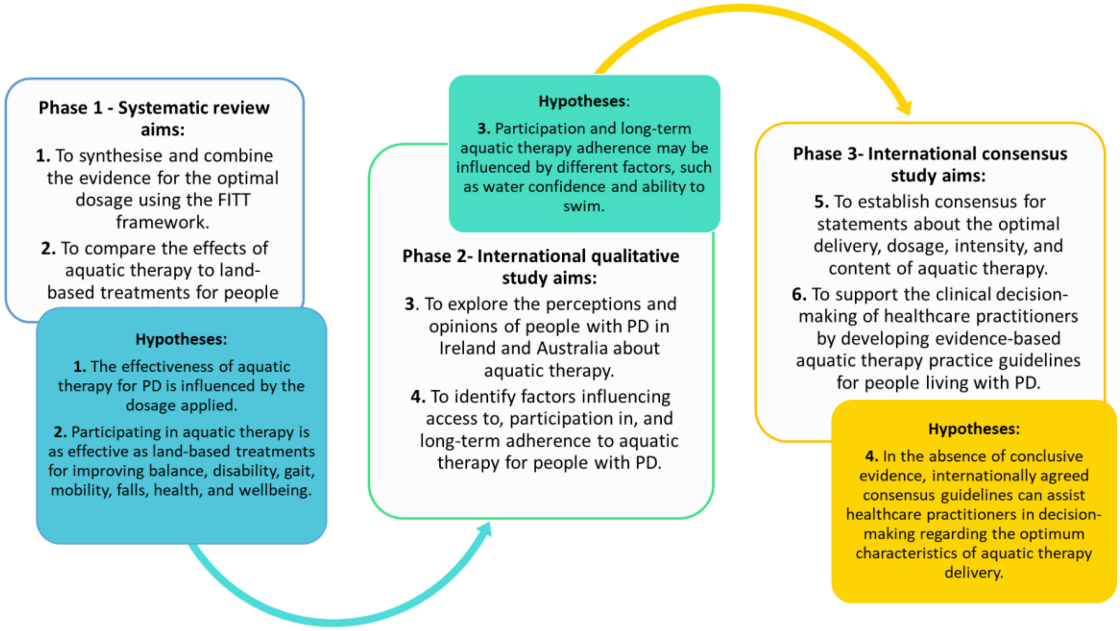
1.5 Research rationale, aims, and hypothesis

Aquatic therapy research evidence for Parkinson's disease

Aquatic therapy has been advocated as one form of structured exercise for people with PD (da Rocha *et al.* 2015; Carroll *et al.* 2017). Since 2011, the evidence exploring the effects of aquatic therapy for people with PD has slowly grown. However, before commencing this thesis project, no systematic review had been published, which compared the effectiveness of aquatic therapy to other land-based interventions. Findings from one systematic review and meta-analysis (Terrens *et al.* 2018) indicates that while the overall quality of the included studies (n=10) was low, improvements in motor performance, quality of life, mobility, and balance were observed in people with mild to moderate PD (H&Y 1-3) following 4-16 weeks of aquatic therapy. Previously published systematic reviews (Pérez and Cancela 2014; Marinho-Buzelli *et al.* 2015; Methajarunon *et al.* 2016) of primarily quasi-experimental studies also found some positive short-term evidence of aquatic therapy effectiveness for improving mobility, gait speed, motor symptoms, and quality of life. Results from randomised controlled trials (RCTs) have shown positive effects in people with mild to moderate PD following participation in aquatic therapy. Carroll *et al.* (2017) found small, non-clinically meaningful improvements in motor disability following community-based aquatic therapy compared to usual care. Findings from other trials suggest that in comparison to land-based exercise, aquatic therapy may improve postural alignment (Daniele Volpe *et al.* 2017a; D. Volpe *et al.* 2017), gait (Daniele Volpe *et al.* 2017b), and mobility (Vivas *et al.* 2011). Thus, given the increased number of recently published randomised controlled trials, phase one of the thesis project will involve synthesising research evidence from RCTs to evaluate the effects of aquatic therapy compared with other land-based approaches (Figure 1).

Additionally, in advance of conducting this project, there was a lack of information about the optimum characteristics of aquatic therapy, such as the frequency, intensity, time/duration, and type (FITT framework) required to confer benefits for people with PD (Ellis and Rochester 2018). To date, most of the aquatic therapy literature focused on the short-term effects, with considerable variations in frequency and the program characteristics described across studies (Terrens *et al.* 2018). The FITT principles offer a valuable framework for evaluating the effectiveness of aquatic therapy programs and can be used to establish guidelines regarding the optimal components and features of exercise programs (Power and Clifford 2013; Shanahan *et al.* 2015). Thus, phase one of the thesis will also aim to provide key information regarding aquatic therapy dosage and exercise prescription requirements for people with PD and inform the development of the phase three guidelines (Figure 1).

Figure 1. Research aims and hypotheses



Patient Informed aquatic therapy evidence

In contrast to the growing body of research evidence exploring the effectiveness of aquatic therapy, there was limited patient informed evidence, including qualitative literature, exploring the perceptions and potential challenges of aquatic therapy for people with PD from the perspective of people living with PD. Before conducting this project, only one qualitative study examined the opinions of people with PD and their carers about factors influencing exercise adherence following 6-weeks of aquatic therapy (Crizzle and Newhouse 2012). While the research identified supportive instructors, exercising as part of a group, and being able to see measurable physical improvements as key motivators for exercise adherence in people with PD, the research did not explore the opinions of people with PD about the unique features and perceived benefits and or challenges of aquatic therapy, and how they might impact participation and adherence. Furthermore, no studies have explored contextual factors or cultural influences, particularly perspectives of people with PD residing in different counties and their unique experiences of aquatic therapy.

Findings from a small-scale RCT exit questionnaire comparing 6-weeks of twice-weekly group-based aquatic therapy to usual care in Ireland (Carroll *et al.* 2017) indicate that aquatic therapy was perceived to be ‘enjoyable’ and ‘fun’ by some people with PD. Most of the participants (90%) expressed a strong interest in continuing the community-based classes. However, this study also identified challenges in recruiting people with PD to partake in the aquatic therapy intervention group, with 48% of eligible participants declining to take part (Carroll *et al.* 2017). Reasons for this non-participation were unclear. Thus, phase two of the thesis project will explore further barriers and factors that might influence people with PD to initially access aquatic therapy (Figure 1). Considering that PD is a chronic, progressive condition and that levels of physical activity in people with PD are low in comparison to their age-matched peers (Ellis *et al.* 2013; Lord *et al.* 2013), identifying factors influencing participation, and long-term adherence to aquatic therapy is another key aim of the phase two project (Figure 1).

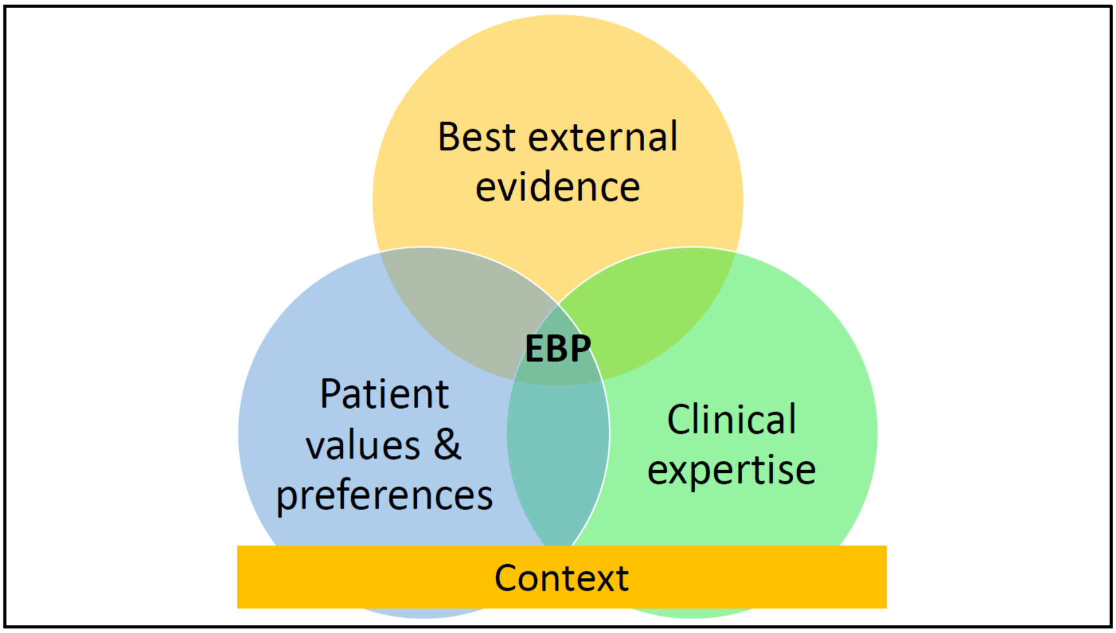
Clinical practice guidelines for Parkinson’s disease

The European Physiotherapy Guidelines for Parkinson’s disease (Keus *et al.* 2014) and the UK’s National Institute of Clinical Excellence (NICE 2017) recently developed evidence-based clinical practice guidelines for the optimal physiotherapy and medical management for people living with PD. While these guidelines provide a valuable resource for physiotherapists and other healthcare professionals working in clinical practice, there are currently no aquatic therapy guidelines to guide practitioners overseeing the delivery of aquatic therapy for people with PD. This presents a challenge for healthcare professionals regarding how best to facilitate and deliver aquatic therapy for people with PD throughout the disease course, which this thesis project aims to address (Figure 1).

Evidence-based practice: Theoretical framework

Evidence-based practice (EBP) is a key theoretical framework, described by Sackett *et al.* (1996) as the integration of three main pillars of evidence including 1. best available external evidence, 2. clinical expertise, and 3. patient preferences and values. Since its inception, it has become widely accepted and recognised as a prerequisite for guiding decision-making among healthcare professionals (Hecht *et al.* 2016; Nagtegaal *et al.* 2019). In recent years, the definition of EBP has been expanded to include contextual and pragmatic factors, reflecting practical considerations such as, resources and staff availability, local policies, and culture (Rycroft-Malone *et al.* 2004; McCurtin and Clifford 2015; Clifford *et al.* 2017). While following the principles of the EBP model is recommended, not least to ensure the safe delivery of high-quality care (Scurlock-Evans *et al.* 2014; Hecht *et al.* 2016), the predominant focus and potential over-reliance on efficacy research evidence have led to challenges implementing this framework in clinical practice. Although research evidence is essential, it does not represent the entirety of all evidence, and on its own, can be inadequate for facilitating patient-centred decision-making (Montori *et al.* 2013; Clifford *et al.* 2017). This thesis project aims to integrate research evidence from all four pillars to inform the development of evidence-based aquatic therapy guidelines for people with PD (Figure 2).

Figure 2. Four pillars of evidence-based practice



Thus, the first two phases of this research aim to address the three pillars of EBP, research evidence, patient values and preferences, and context to obtain expert opinion on the data obtained and the informational gaps from these phases of the project. Phase three of the thesis will aim to address this gap by developing pragmatic evidence-based guidelines to support decision-making and the delivery of aquatic therapy in practice (Figure 1).

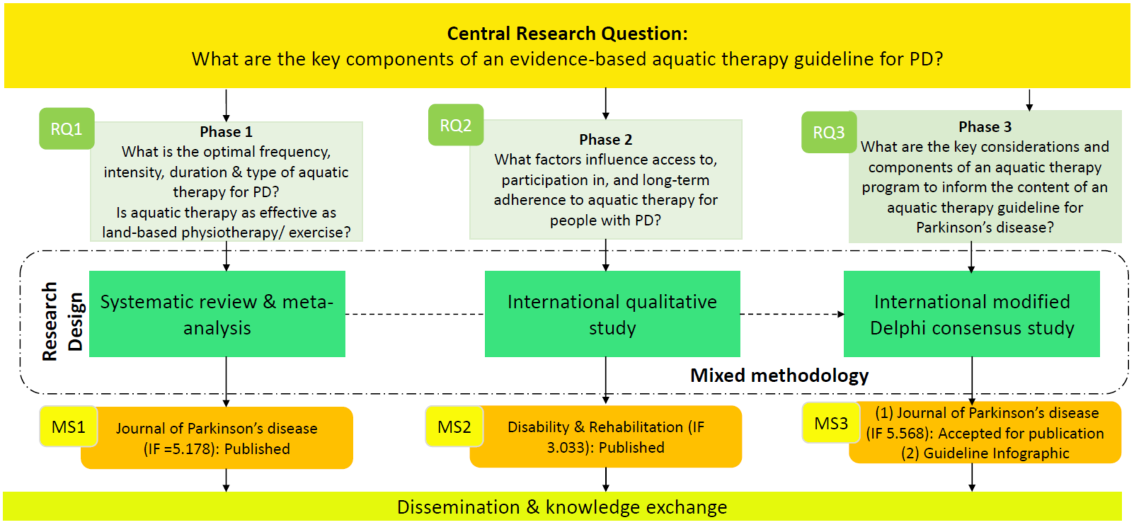
Safety features of aquatic therapy for Parkinson's disease

There is some contradictory evidence about the safety and feasibility of aquatic therapy for people with PD. A recent review (Terrens *et al.* 2018) found that the safety of aquatic physiotherapy for people with PD was underreported across trials, with all ten studies included in the review failing to record or report adverse events. In contrast, Carroll *et al.* (2017) found that community-based aquatic therapy was feasible and safe for an Irish sample (n=21) of people with mild to moderate PD. However, recent surveys conducted in Portugal and the UK have alerted healthcare practitioners to the potential difficulties incurred post-diagnosis by people with PD engaging in swimming-type activities (Neves *et al.* 2018). The survey results suggest that swimming could pose a safety risk for people with PD, with 49.1% (n=136) reporting near-drowning episodes related possibly to changes in their swimming performance, which were experienced by 87.7% (n=243) people post-onset. In addition, lower-limb function and coordination issues were highlighted as potential features, which could impede the safe execution of this complex activity in people with PD (Neves *et al.* 2018). Thus, considering the vulnerable nature of people with PD and the research recommendations by Terrens *et al.* (2018*)* for guidelines outlining safety measures, this thesis will also aim to establish key safety criteria in required for the sustained, safe participation of people with PD in aquatic therapy. To achieve this, chapter two will report on any adverse events reported across trials included in the systematic review; chapter three will explore barriers and facilitators in relation to the safe participation of people with PD who have previously engaged in aquatic therapy and with no previous experience of aquatic therapy; and phase 3 will aim to gain consensus for key safety features required to inform the development of aquatic therapy guidelines.

1.6 Research question(s) and methods

A logic model of the overarching research question and methods adopted to answer the individual research questions is presented in Figure 3.

Figure 3. Logic model outlining central research question, individual study's research question(s), research methodology and outputs.



Abbreviations: PD = Parkinson's disease; RQ1 = Research Question 1.; MS1 = Milestone 1.

1.7 Authors own standpoint and practice expertise

As this research project employs a mixed-methodology approach (Figure 3), it is important to provide a brief overview of my clinical expertise and prior experiences delivering aquatic therapy to people with Parkinson's disease, along with my views and beliefs, as it informed my initial decision to conduct this research. Similar to how objectivity is valued in quantitative research methods, subjectivity and reflexivity are key elements of the qualitative paradigm (Braun and Clarke 2013, p.26). Under the qualitative paradigm, it is widely acknowledged that researchers bring their values, histories, beliefs, and experiences to the research process (Ormston *et al.* 2013, p.22). Our subjectivity as researchers can often manifest in the research topics we choose to investigate (Braun and Clarke 2013, p.36). Thus, it is important to critically reflect on my role in generating and analysing the qualitative data (Braun and Clarke 2013, p.37; Ormston *et al.* 2013, pp.22-23) and the influences of my behaviours and prior views on the research process. As a qualitative researcher for phase two of the thesis project, my approach is mainly derived from an interpretative-constructivist epistemology approach (Bryman 1984; Braun and Clarke 2013), whereby I wanted to understand the preferences, opinions, and experiences of people with PD about aquatic therapy, which I also have extensive experience.

My clinical background comprises 13 years of experience working as a multidisciplinary team member, delivering physiotherapy to children (0-18 years) with complex neurological conditions attending a children's disability network team. In 2009, our service opened a state-of-the-art, purpose-built hydrotherapy pool on site. This was the beginning of my association with the Parkinson's Association of Ireland (PAI) local branch, delivering regular group-based aquatic therapy classes to people with mild to moderate Parkinson's disease within the local community. In Ireland, neurological services rely heavily on not-for-profit patient organisations, such as the PAI, to provide access to essential services and specialist support for people with PD in the community (Neurological Alliance of Ireland 2021). While it is widely acknowledged that neurorehabilitation services are critically under-developed in Ireland (Neurological Alliance of Ireland 2021), to the author's knowledge, people with PD do not have access to aquatic therapy services through the Health Services Executive (HSE).

I was often frustrated by the lack of aquatic therapy research evidence and clinical practice guidelines to support and inform my clinical practice through my work delivering aquatic therapy. Although anecdotal feedback from the class members and objective outcomes demonstrated the benefits of aquatic therapy, the research to support these findings was deficient. In addition, I was curious to understand why it was always the same group of people with PD who attended the classes, with few new members joining each year. Informal comments and feedback from class participants suggested that fear of water and an inability to swim were common barriers reported by their peers as some of the possible reasons for inhibiting new class members. This was surprising to me given the positive feedback from the class members and the large numbers of people with PD who received frequent updates on class timetables *via* post from the regional PD specialist nurse. Thus, these were some of the key reasons, which led me first to explore the effects of aquatic therapy on gait, disability, mobility, and quality of life for people with PD as part of my Masters' project (Carroll *et al.* 2017). A further reason was to continue my research journey, and to explore and develop evidence-based aquatic therapy guidelines.

1.8 Thesis Outline

This thesis is presented as a thesis by publication. There are five chapters, two of which have been published in peer-reviewed journals (Chapter 2 and 3), with a third paper (Chapter 4) accepted for publication. The structure of the thesis is summarised in Table 1 below.

Table 1. Thesis outline of chapters.

Chapter 2 **(Paper 1)**	Chapter 2, *"Is aquatic therapy optimally prescribed for Parkinson's disease: a systematic review and meta-analysis."* This review was undertaken to synthesise the literature and explore the optimal frequency, intensity, duration, and type of aquatic therapy for PD. The meta-analysis also examines the effectiveness of aquatic therapy in improving motor and non-

	motor PD symptoms. The findings helped to identify gaps in the research evidence, methodological limitation and provide future research recommendations. This review informs the design and development of the evidence-based aquatic therapy guidelines outlined in Chapter 4. This paper was published by the Journal of Parkinson's disease (IF 5.178) in 2020.
Chapter 3 **(Paper 2)**	Chapter 3, "*Community aquatic therapy for Parkinson's disease: an international qualitative study,"* explores aquatic therapy from the perspectives of people living with Parkinson's disease in Ireland and Australia to try to understand the perceived benefits of this treatment approach. The sample of participants included people with PD who had previously engaged in aquatic therapy and people with no prior experience of engaging in aquatic therapy. Using a combination of semi-structured interviews and focus groups, this qualitative study also explores and identifies potential motivating factors and barriers that might impact or prevent people with PD from starting and continuing aquatic therapy long-term. Study findings also inform the design and development of the evidence-based aquatic therapy guidelines outlined in chapter 4. This qualitative study was published in the journal Disability and Rehabilitation (IF 3.033) in April 2021.
Chapter 4	Chapter 4, "*Evidence-based aquatic therapy guidelines for Parkinson's disease: An international consensus study,"*

(Paper 3)	describes the process of designing and developing evidence-based aquatic therapy guidelines for PD. This chapter merges the information presented in the thesis thus far (research evidence, patient preferences and values). It incorporates stakeholder engagement to inform key statements used in developing the practice guidelines. International practice experts participated in a modified Delphi study to gain consensus for a list of statements. The consensus statements informed the evidence-based practice guidelines. The findings of this study, along with the presented guidelines, provide recommendations about key components of aquatic therapy delivery as a reference for practitioners to use in clinical practice. The paper was accepted for publication by the Journal of Parkinson's disease (IF 5.568) in September 2021.
Chapter 5 **Discussion and Conclusion**	This chapter, the discussion, and the conclusion bring together the key findings of this thesis. Clinical practice implications, research strengths and limitations, future research recommendations, and the impact of the project are also discussed.

CHAPTER 2:

Is Aquatic Therapy Optimally Prescribed for Parkinson's Disease? A Systematic Review and Meta-Analysis

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2.0 Prologue

This chapter presents findings from the systematic review and meta-analysis that investigated whether or not aquatic therapy is adequately prescribed for people with Parkinson's disease using the FITT framework (Power and Clifford 2013; Shanahan *et al.* 2015). This systematic review set out to synthesise and appraise existing research evidence from published randomized controlled trials and to provide an overview of key elements including dosage, and the effects of aquatic therapy for managing motor and non-motor symptoms in people with PD. The review also aimed to identify gaps in the existing body of evidence, which subsequently informed the 'research evidence' pillar of the evidence-based practice model, underpinning the design and development of the practice guidelines outlined in Chapter 5.

2.1 Publication and authorship

Carroll, L.M., Morris, M.E., O'Connor, W.T. and Clifford, A.M. (2020) 'Is Aquatic Therapy Optimally Prescribed for Parkinson's Disease? A Systematic Review and Meta-Analysis', *Journal of Parkinson's Disease*, 10(2), 59-76, available: http://dx.doi.org/10.3233/JPD-191784.

The author led the conception and development of the study design, search strategy and searches, data extraction, quality appraisal, data analysis and meta-analysis, interpretation, writing original draft, editing and the submission of the paper for publication. Dr. Amanda Clifford, as the primary supervisor, supported the conception and study design, and contributed to the data extraction, quality appraisal, interpretation, reviewing and editing of the paper. Professor Meg Morris, as co-secondary supervisor, supervised and contributed to the conception, study design, data extraction, quality appraisal, interpretation, reviewing and editing of the paper. Professor William

O'Connor, as co-secondary supervisor, supervised and contributed to the conception, study design, interpretation, reviewing and editing of the paper. All the authors agree with the findings and approved the final submission.

2.1 Abstract

BACKGROUND: Aquatic therapy offers an alternative physiotherapy approach to managing the motor and non-motor symptoms associated with Parkinson's disease (PD).

OBJECTIVES: This review examined exercise prescription for aquatic therapy in PD and evaluated if aquatic therapy is as effective as land-based physiotherapy for improving movement, disability and wellbeing in people living with PD.

METHODS: A systematic search of eight databases was conducted to identify suitable randomized controlled trials from inception until August 2019. Aquatic therapy prescription data and outcomes of interest included gait, balance, motor disability, mobility, falls, mood, cognitive function, and health related quality of life data was extracted and synthesised. A meta-analysis was performed where appropriate.

RESULTS: Fourteen studies involving 472 participants (Hoehn & Yahr scale I-IV) met the inclusion criteria. Eight were of modest quality, scoring 70-80% on the PEDro scale. Exercise prescription was highly variable and often insufficiently dosed. Similar gains were shown for aquatic therapy and land exercises for balance, motor disability or quality of life. A statistically significant difference was found for mobility as measured using the TUG (-1.5 seconds, 95 % CI -2.68 to -0.32; p= 0.01, I^2 =13%), in favour of aquatic therapy.

CONCLUSIONS: 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. Many trials appeared to be under-dosed and therapy duration was low, ranging from 3-11 weeks.

2.2 Introduction

Physiotherapy for people with Parkinson's disease (PD) aims to improve movement, physical capacity, quality of life, disability, and falls (Morris 2000; Keus *et al.* 2007; Keus *et al.* 2014). The content of a physiotherapy program varies according to individual needs (Morris 2000; Goodwin *et al.* 2008; Tomlinson *et al.* 2012; Paul *et al.* 2018) and can include interventions such as progressive resistance strength training (Dibble *et al.* 2006; Canning *et al.* 2015; Morris *et al.* 2015), cueing (Morris *et al.* 1996; Nieuwboer *et al.* 2007), falls prevention education (Ashburn *et al.* 2007; Morris *et al.* 2015; Morris *et al.* 2017), attention strategies (Morris *et al.* 1996; Morris *et al.* 2015; Morris *et al.* 2017), therapeutic dancing (Blandy *et al.* 2015; Shanahan *et al.* 2017a), cycling (Ridgel *et al.* 2012), upper limb training (Proud and Morris 2010), Tai Chi (Li *et al.* 2012), walking (Ni *et al.* 2018) and boxing (Combs *et al.* 2013). Despite movement disorders and falls being key features of PD, the optimal elements of physiotherapy for this chronic neurodegenerative condition are not completely clear. There have been several large, randomized trials of physiotherapy for people with PD (Nieuwboer *et al.* 2007; Goodwin *et al.* 2011; Canning *et al.* 2015; Conradsson *et al.* 2015; Morris *et al.* 2015), and the results have been mixed. For example, Seymour et al. (2019), Canning et al. (2015) and Morris et al. (2015) found some beneficial effects for resistance strength training, movement strategy training, and falls prevention education in people with idiopathic PD. Exercise training (Shen *et al.* 2016), gait training using virtual reality (Mirelman *et al.* 2011b), and motor-cognitive training interventions (Maidan *et al.* 2018) were also found to improve gait, balance and falls. Nieuwboer et al. (2007) examined different exercise approaches outside of the clinic and showed that cue training in the home and community could have positive effects on gait, freezing and balance.

Aquatic therapy is one approach for managing the motor and non-motor symptoms in early PD (da Rocha *et al.* 2015). Preliminary reports have shown favourable results for movement slowness, dystonia, balance, pain, quality of life and physical function (Volpe *et al.* 2014; Carroll *et al.* 2017; de la Cruz Pérez 2017; Palamara *et al.* 2017; D. Volpe *et al.* 2017; Daniele Volpe *et al.* 2017b). Immersion in water affords people with PD an alternative environment in which to exercise (da Rocha *et al.* 2015). Water's physical properties of buoyancy, hydrostatic pressure and drag forces provide sensory feedback that may help to regulate motor output (Morris and Geigle 2009, p.237). The physiological benefits of water immersion are well documented in healthy individuals (Hall *et al.* 1990; Becker 2009; Gulick and Geigle 2009). More recently, cytokine modulation was observed to facilitate immune responses in people living with PD, with short-term and long-term benefits observed following aquatic therapy (Pochmann *et al.* 2018).

Preliminary literature reviews of mainly non-randomized controlled trials (Pérez and Cancela 2014; Marinho-Buzelli *et al.* 2015; Terrens *et al.* 2018) reported that aquatic therapy may improve postural stability, motor function and gait in the early stages of PD. These reviews did not always report key elements such as the water temperature, water depth, accessibility of therapy, patient involvement in the treatment protocol design, location of pre-post assessments (in water or over-land), follow-up retention of aquatic therapy benefits, or the costs of aquatic therapy. Some recent trials have been reported, warranting a meta-analysis focusing exclusively on investigations using a randomized, experimental design. The primary aim of this review was to examine the therapeutic dosage and potential benefits of aquatic therapy for people living with Parkinsonism. The review sought to answer the following questions:

(1) What is the optimal frequency, intensity, duration, and type of aquatic exercise for people living with PD?

(2) Is aquatic therapy as effective as land-based physiotherapy/rehabilitation for improving gait, balance, motor disability, functional mobility, falls, health and wellbeing in people with idiopathic PD?

2.3 Methods

Identification and selection of studies

A systematic search of the literature was conducted for eight electronic databases (Embase, CINAHL complete, PubMed/Medline (Ovid), PsycINFO, Cochrane-CENTRAL, PEDro, Scopus, Web of Science) from inception to August 1st, 2019. A comprehensive search of the titles, abstracts and keywords of the databases was performed using a predefined search terms (see full search strategy in Appendix A).

Reference lists in the articles identified, along with other reviews and key rehabilitation journals were manually searched to find additional trials, which were not identified through rigorous database searches. Titles and abstracts of potentially eligible trials were screened using a predefined criterion (Box 1) and Rayyan software, by the primary author. All articles were read by two independent review authors and key information was obtained using a predetermined data extraction form by the primary author

(Higgins and Deeks 2008, pp.164-167). All data was cross checked for agreement by the independent review authors (AC and MM). Methodological quality was independently assessed for six randomly selected studies and the remaining were crosschecked, with any disagreements resolved through discussion.

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines were adhered to in this review. A review protocol was published on International Prospective Register of Systematic Reviews (PROSPERO ID CRD42018085996).

Box 1. Inclusion criteria

Design
- Randomized controlled trial (RCT), published in English and peer reviewed

Participants
- Adults > 18 years old
- Parkinsonism disorders (*e.g.* Idiopathic PD, Progressive Supranuclear Palsy (PSP) and Lewy Body Dementia) according to a confirmed diagnostic criterion
- Hoehn and Yahr Scale or Modified Hoehn and Yahr stages I-IV

Intervention
- Include aquatic therapy conducted in a community-based swimming pool (public), a clinic or rehabilitation setting, or a hospital-based hydrotherapy pool (private and public)

Outcome
- Primary outcomes: gait, balance, motor disability, functional mobility, mood, cognitive function and health related quality of life
- Secondary outcomes: economic assessment, participant's input into study design, treatment compliance and participant's safety

Comparisons
- Aquatic therapy versus land-based physiotherapy
- Aquatic therapy versus no therapy or usual care
- Aquatic therapy versus other aquatic therapy or water-based intervention
- Aquatic therapy as a co-intervention with land-based therapies versus land-based therapies

Assessments of characteristics of studies

Quality

The methodological quality of randomized controlled trials (RCTs) was assessed by two authors independently using the Downs and Black checklist (Downs and Black 1998) and the Physiotherapy Evidence Database (PEDro) Scale (Moseley *et al.* 2002). Both tools have reported reliability and validity and have been used to appraise RCTs in previous systematic reviews (Downs and Black 1998; Maher *et al.* 2003; de Morton 2009; Terrens *et al.* 2018).

Participants

Trials including participants with Parkinsonism disorders with all levels of disease severity (Hoehn and Yahr I-IV) were included. Age, gender, disease severity, Levodopa equivalent dose (LED) and diagnostic criteria were recorded to compare participants across trials.

Intervention

For the purpose of this review, aquatic therapy was operationally defined as physiotherapy occurring in a pool environment, supervised by a qualified healthcare professional. The experimental group could include varying aquatic therapy approaches (e.g., Ai Chi, Halliwick, Bad Ragaz Ring Method) (Morris and Geigle 2009) as long as it suitably targeted the outcomes of interest. Key information on the frequency, intensity, duration and type of aquatic therapy was extracted from each study.

Outcome measures

Primary outcomes of interest were gait measured using tools such as the Six-Minute Walk Test (Steffen and Seney 2008), freezing as measured by the Freezing of Gait Questionnaire (Shine *et al.* 2012), balance and postural instability assessed on the Berg Balance Scale (Berg *et al.* 1992), functional mobility measured using performance measures such as the Timed Up and Go (Podsiadlo and Richardson 1991; Morris *et al.* 2001), and motor disability evaluated using motor impairment measures such as the Unified Parkinson's Disease Rating Scale motor subsection III (Goetz *et al.* 2008).

Health related quality of life (Parkinson's Disease Questionnaire-39) (Marinus *et al.* 2002), falls (Falls Efficacy Scale, falls diary) (Yardley *et al.* 2005; Ashburn *et al.* 2008), depression (e.g., the Yesavage Geriatric Depression Scale) (Yesavage *et al.* 1982) and cognitive function (SCales for the Outcome of PArkinson's disease COGnition) (Marinus *et al.* 2003) were also recorded. Patient or public involvement in any stage of the research study, treatment compliance and participant' safety were also documented. The variables were further categorized based on a model of direct and indirect consequences of movement disorders (Rochester *et al.* 2013), their effects on important motor functions and recommended goals of therapy, and intervention approaches (Table 4).

Data analysis

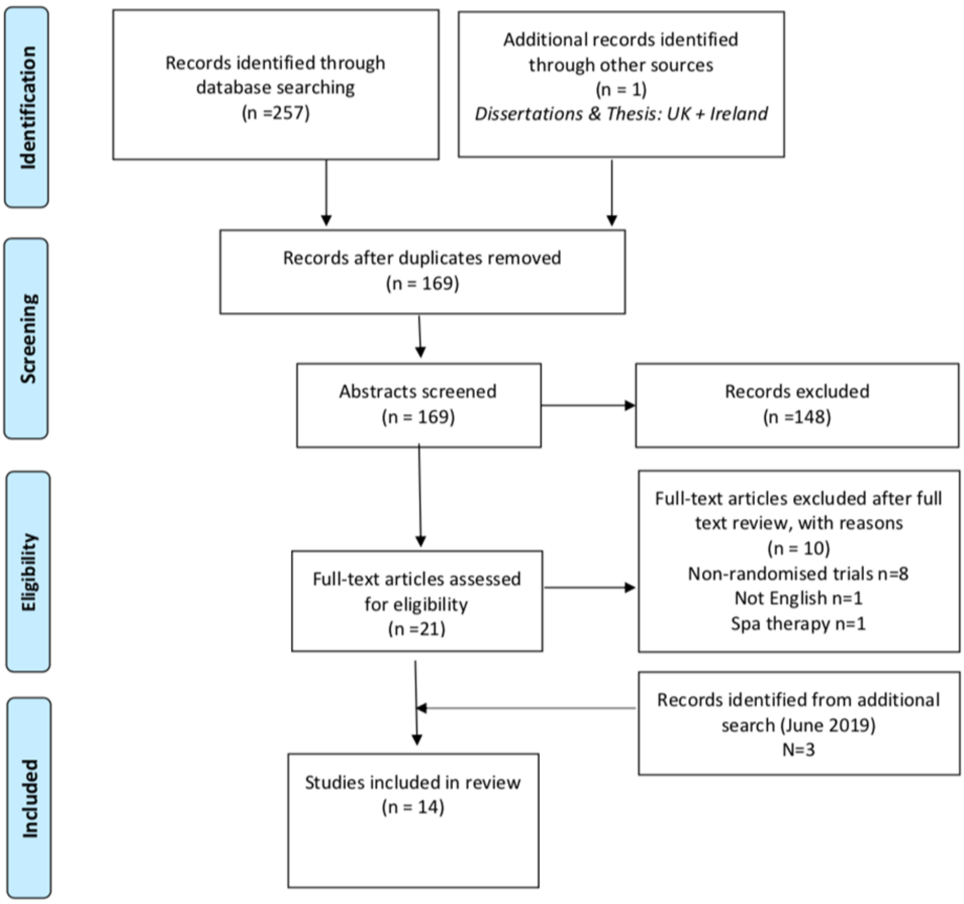
The results from each trial were combined to calculate the overall effects of aquatic therapy compared to a control intervention using standard meta-analysis methods, when two or more trials included the same outcome measures (Deeks *et al.* 2008, pp.244-249). All of the outcome variables were continuous variables therefore, the weighted mean difference method was applied by calculating the change in the mean and standard deviation from baseline to the first assessment post intervention (Kirkwood and Sterne 2003, pp.378-379). The mean difference (MD) was calculated for both the aquatic therapy and control groups for each trial and was combined using the random effects model of meta-analysis and inverse variance (RevMan 2014). The random effects model of meta-analysis was adopted as it assumes that the true treatment effects in the individual trials may be different from each other (Deeks *et al.* 2008, p.249). A statistical heterogeneity of $I^2 \geq 50\%$ was considered substantial heterogeneity (Shamseer *et al.* 2015).

2.4 Results

Flow of studies through the review

From a total electronic search yield of 258 possible studies, fourteen studies were deemed eligible for inclusion (Figure 1).

Figure 1. PRISMA flowchart



Characteristics of studies

Table 1 presents the characteristics of the studies included within the review. A total of 241 participants contributed to the aquatic therapy analysis, with sample sizes ranging from six (Vivas *et al.* 2011) to 34 people (Daniele Volpe *et al.* 2017b) with PD. Both males and female participants were included in all studies with the exception of one that excluded females (Shahmohammadi *et al.* 2017) due to cultural factors. Participants presented with mild to moderate disease symptoms (Hoehn and Yahr stage I-IV). Eight studies involved testing during the ‘ON’ medication phase (Volpe *et al.* 2014; Carroll *et al.* 2017; Palamara *et al.* 2017; Daniele Volpe *et al.* 2017a; Daniele Volpe *et al.* 2017b; Kurt *et al.* 2018; Zhu *et al.* 2018; Clerici *et al.* 2019; da Silva and Israel 2019) and five studies in the ‘OFF’ phase, with medication withheld between eight (Shahmohammadi *et al.* 2017) to 12 hours before assessments (Vivas *et al.* 2011; Pérez-de la Cruz 2017; Pérez-de la Cruz 2018; Pérez-de la Cruz 2019).

Methodological Quality

The methodological quality of the studies varied from low (Vivas *et al.* 2011) to high (Volpe *et al.* 2014) according to the Physiotherapy Evidence Database Scale (PEDro) and Downs and Black checklist (Table 1). The median score for methodological quality using the PEDro scale was seven out of ten (IQR 7,7). Eight of the 14 included studies scored between seven and eight implying moderate quality (Volpe *et al.* 2014; Carroll *et al.* 2017; Palamara *et al.* 2017; Pérez-de la Cruz 2017; Shahmohammadi *et al.* 2017; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Zhu *et al.* 2018), with a high risk of bias recorded for blinding of therapists and subjects, and intention to treat analysis (Table 2).

The Downs and Black checklist was also used to further guide and assess the methodological quality of the papers included, with a median score of 23.4 (IQR 22,24). Only one trial (Volpe *et al.* 2014) scored a maximum score of 27 indicative of a low risk of bias, with a priori sample size calculation and time period for recruitment of participants the foremost items recorded as high risk of bias (Table 3).

Table 1. Characteristics of studies included in review

Authors	Design	Country	Sample size (intervention: control group)	Dropouts (intervention: control group)	Age (Mean ± SD/Median, IQR)		Hoehn & Yahr (Mean ± SD/Median, IQR)		ON /OFF medication testing	Total number of AT sessions (min)	Quality measures	
					Aquatic therapy	*Control*	*Aquatic therapy*	*Control*			PEDro Score	Downs & Black
Carroll 2017 [29]	Single-blind RCT	Ireland	11:10	1:2	69.5 (67.75, 71.75)	64 (67, 77)	2.0 (1.5–2.25)	2.0 (1.63–2.88)	ON	12 (720)	6	24
Clerici 2019 [66]	Single- blind, parallel group, RCT	Italy	30:30	3:5	67 ± 8	67 ± 11	2.7 ± 0.4	2.7 ± 0.4	ON	12 (720)	7	24
da Silva 2019 [67]	Single blind RCT	Brazil	14:14	0:3	63.12 ± 13.61	64.23 ± 13.45	3 ± 1	3 ± 1	ON	20 (1200)	6	21
Kurt 2017 [63]	RCT	Turkey	20:20	0	62.41 ± 6.76	63.61 ± 7.18	Stage 2 *n* = 9 (45%) Stage 2.5 *n* = 7 (35%) Stage 3 *n* = 4 (20%)	Stage 2 *n* = 11 (55%) Stage 2.5 *n* = 5 (25%) Stage 3 *n* = 4 (20%)	ON	25 (1500)	7	23
Palamara 2017 [31]	RCT	Italy	17:17	0	70.8 ± 5.3	70.9 ± 5.7	3.1 ± 0.2	2.8 ± 0.5	ON	12 (720)	8	25
Pérez de la Cruz 2017 [30]	Single-blind RCT	Spain	15:15	0	66.80 ± 5.27	67.53 ± 9.89	2.82 ± 0.22	2.66 ± 1.02	OFF	20 (900)	7	22
Pérez-de la Cruz 2018 [69]	Pilot RCT	Spain	14:15	0	65.87 ± 7.09	66.44 ± 5.73	Not specified	Not specified	OFF	22 (990)	6	16
Pérez-de la Cruz 2019 [68]	Single-blind pilot RCT	Spain	15:15	0	64.40 ± 5.18	65.83 ± 8.92	2.81 ± 0.22	2.76 ± 1.02	OFF	20 (900)	7	24
Shahmo-hammadi 2017 [62]	RCT	Iran	11:11	1:1	60.5 ± 5.44	63.2 ± 4.94	Stage 2 (40%) Stage 3 (60%)	Stage 2 (40%) Stage 3 (60%)	OFF	24 (1320)	7	23
Vivas 2011 [60]	Pilot RCT	Spain	6:6	1:0	65.67 ± 3.67	68.33 ± 6.92	2.67 ± 0.58	2.4 ± 0.55	OFF	8 (360)	4	17
Volpe 2014 [28]	Single-blind RCT	Italy	17:17	0	68 ± 7	66 ± 8	2.88 ± 0.3	2.65 ± 0.49	ON	40 (2400)	8	27
Volpe 2017 [65]	Single-blind pilot RCT	Italy	15:15	2:4	70 ± 7.8 (59–84)	70 ± 7.8 (51–82)	2.6 ± 0.5	2.7 ± 0.5	ON	40 (2400)	7	22
Volpe 2017 [61]	Pilot RCT	Italy	36:20	0	PDS1-UW 76.7 ± 4.0 PDS1-LBW 78.4 ± 4.6 CS1 74.7 ± 4.9	PDS2 69.1 ± 5.8 CS2 65.5 ± 7.4	PDS1-UW 2.3 ± 0.5 PDS1-LBW 2.4 ± 0.5	PDS2 2.5 ± 0.5	Not specified	21 (840)	6	22
Zhu 2017 [64]	Single-blind RCT	China	23:23	0	65 ± 6	67 ± 5	2.37 ± 0.43	2.43 ± 0.41	ON	30 (900)	8	25

Abbreviations: SD, standard deviation; IQR, interquartile range; AT, aquatic therapy; PEDro, Physiotherapy Evidence Database.

Table 2. Methodological quality using the Physiotherapy Evidence Database (PEDro) scale

	Carroll 2017 [29]	Clerici 2019 [66]	da Silva 2019 [67]	Kurt 2017 [63]	Palamara 2017 [31]	Pérez de la Cruz 2017 [30]	Pérez-de la Cruz 2018 [69]	Pérez-de la Cruz 2019 [68]	Shahmo-hammadi 2017 [62]	Vivas 2011 [60]	Volpe 2014 [28]	Volpe 2017 [65]	Volpe 2017 [61]	Zhu 2017 [64]
Eligibility criteria	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
1. Random allocation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. Concealed allocation	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	N	Y
3. Baseline comparability	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
4. Blinded subjects	Y	N	N	N	N	N	N	N	N	N	N	N	N	N
5. Blinded therapist(s)	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
6. Blinded assessors	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y
7. Adequate follow-up	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Intention-to-treat	N	N	N	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y
9. Between group statistical comparison	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Point estimates & variability	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Total PEDro score	7	7	7	7	8	7	6	7	7	4	8	7	6	8

Total PEDro score ranges from 0-10 with a higher score indicative of better quality; Y, yes (=1); N, No (=0)

Table 3. Methodological quality using the Downs and Black checklist

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total Score
Carroll 2017 [29]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	24
Clerici 2019 [66]	Y	Y	Y	Y	Y	Y	Y	UTD	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	UTD	Y	24
da Silva 2019 [67]	Y	Y	Y	Y	Y	Y	Y	UTD	Y	Y	Y	UTD	UTD	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	UTD	N	Y	Y	21
Kurt 2017 [63]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	UTD	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	24
Palamara 2017 [31]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	25
Pérez de la Cruz 2017 [30]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	UTD	Y	N	Y	Y	Y	22
Pérez-de la Cruz 2018 [69]	Y	Y	Y	Y	UTD	Y	Y	UTD	Y	Y	UTD	UTD	Y	N	N	Y	Y	Y	UTD	Y	Y	UTD	Y	N	N	Y	N	16
Pérez-de la Cruz 2019 [68]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	UTD	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	UTD	Y	Y	Y	24
Shahmo-hammadi 2017 [62]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	23
Vivas 2011 [60]	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	UTD	N	Y	N	N	Y	Y	Y	Y	Y	Y	UTD	Y	N	N	N	N	17
Volpe 2014 [28]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	27
Volpe 2017 [65]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	UTD	Y	Y	N	N	N	22
Volpe 2017 [61]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	UTD	Y	Y	Y	Y	Y	Y	UTD	Y	UTD	Y	Y	N	22
Zhu 2017 [64]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	25

Note: Total Downs and Black score ranges from 0 to 27 with a higher score indicative of better quality; Y, yes (=1); N, no/unable to determine, UTD (=0).

Table 4. FITT Framework with targeted outcome variables and treatment components for the aquatic therapy interventions (n=14)

	Exercise prescription					Movement Disorder Impairments							Primary Conseq-uences						Secondary Conseq-uences			
	Frequency of AT		Intensity (rate of progression)		Type / main intervention component																	
Authors	Days per week	Number of weeks		Time (min)		Bradykinesia	Freezing	Dyskinesia	Dystonia	Postural control	Cognitive	Behavioral	Gait	Balance	Falls	Transfers	Upper-limb function	Pain	Strength	Endurance	Range of motion	Health Related Quality of Life
Carroll 2017 [29]	2	6	Borg RPE scale	60	Aquatic therapy	✓	✓	x	x	x	x	x	✓	x	x	x	x	x	x	x	x	✓
Clerici 2019 [66]	3	4	Not specified	60	Aquatic therapy plus land-based rehabilitation	✓	✓	x	x	✓	✓	x	✓	✓	✓	✓	x	x	x	x	x	x
da Silva 2019 [67]	2	10	Not specified ("gradual progression of difficulty")	60	Dual task aquatic exercise	✓	x	x	x	✓	✓	x	✓	✓	x	✓	✓	x	x	✓	✓	x
Kurt 2017 [63]	5	5	Not specified	60	Aquatic Ai Chi	✓	x	x	x	✓	x	x	x	✓	x	✓	x	x	x	x	✓	✓
Palamara 2017 [31]	3	4	Not specified ("shaping to progress complexity of exercises")	60	Aquatic therapy plus land-based rehabilitation	✓	x	x	x	x	x	x	x	✓	x	✓	x	x	x	x	x	x
Pérez de la Cruz 2017 [30]	2	5	Not specified ("gradual increase in difficulty")	45	Aquatic Ai Chi	✓	x	x	x	x	✓	✓	x	✓	x	✓	x	✓	x	x	✓	x
Pérez-de la Cruz 2018 [69]	2	11	Not specified ("sessions were designed with a gradual increase in difficulty")	45	Aquatic Ai Chi	✓	x	x	x	✓	✓	✓	x	✓	x	✓	x	✓	x	x	✓	✓
Pérez-de la Cruz 2019 [68]	2	10	Not specified ("progression of difficulty")	45	Aquatic Ai Chi	x	x	x	x	✓	x	✓	x	✓	x	x	✓	✓	x	x	✓	✓
Shahmo-hammadi 2017 [62]	3	8	Protocol progressed as per ACSM guidelines for physical exercise of the elderly with chronic conditions	55–60	Aquatic therapy	✓	x	x	x	✓	x	x	x	✓	x	x	x	x	x	x	x	✓
Vivas 2011 [60]	2	4	Not specified ("stated progression criteria")	45	Aquatic therapy	✓	x	x	x	x	✓	✓	✓	✓	x	✓	x	x	x	✓	x	x
Volpe 2014 [28]	5	8	Not specified	60	Aquatic therapy	✓	x	x	x	✓	x	x	x	✓	✓	✓	x	x	x	x	x	✓
Volpe 2017 [65]	5	8	Not specified ("Intensive training programme for posture")	60	Aquatic therapy	✓	x	x	✓	x	x	x	x	✓	✓	✓	x	x	x	x	x	✓
Volpe 2017 [61]	7	3	Walking at a self-selected speed	40	Under water gait training	✓	x	x	x	x	x	x	✓	✓	x	✓	x	x	x	✓	x	✓
Zhu 2017 [64]	5	6	Not specified	30	Obstacle aquatic therapy	x	✓	x	x	x	x	x	x	✓	x	✓	x	x	x	x	x	x

AT, aquatic therapy; RPE, rate of perceived exertion; HRR, heart rate reserve; ACSM, American College of Sports Medicine.

Frequency

Table 4 summarizes the frequency, intensity, time and type (FITT) of aquatic interventions implemented across all included trials. The frequency of intervention is described as the number of aquatic therapy sessions completed per week (Shanahan *et al.* 2015). The majority of studies provided either two sessions (Vivas *et al.* 2011; Carroll *et al.* 2017; Pérez-de la Cruz 2017; Pérez-de la Cruz 2018; da Silva and Israel 2019; Pérez-de la Cruz 2019) or five sessions per week (Volpe *et al.* 2014; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Zhu *et al.* 2018).

Intensity

The intensity of interventions were heterogeneous across the studies with eight failing to clearly define or objectively measure the intensity levels of participants (Volpe *et al.* 2014; Pérez-de la Cruz 2017; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Pérez-de la Cruz 2018; Zhu *et al.* 2018; da Silva and Israel 2019; Pérez-de la Cruz 2019). Studies varied from using the Borg Scale (Carroll *et al.* 2017), self-selecting pacing (Daniele Volpe *et al.* 2017b), or by increasing the number of repetitions (Shahmohammadi *et al.* 2017) as set out by the American College of Sports Medicine (ACSM) guidelines (Nelson *et al.* 2007) for older people with chronic conditions.

Time

The length of each session varied from 30 (Zhu *et al.* 2018) to 60 minutes (Volpe *et al.* 2014; Carroll *et al.* 2017; Palamara *et al.* 2017; Shahmohammadi *et al.* 2017; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Clerici *et al.* 2019; da Silva and Israel 2019) for the majority of interventions. The intervention period ranged from three (Daniele Volpe *et al.* 2017b) to 11 weeks (Pérez-de la Cruz 2018). The overall intervention time (Table 1) ranged from 360 (Vivas *et al.* 2011) to 2400 minutes (Volpe *et al.* 2014; Daniele Volpe *et al.* 2017a). Six studies included a follow-up assessment period varying from 17-days to six months (Palamara *et al.* 2017; Zhu *et al.* 2018).

Type

All studies included a five to 10 minute warm-up and cool-down period consisting of whole body stretching, cardiovascular or relaxation activities. The main neuromuscular training components consisting of Ai Chi movements (Pérez-de la Cruz 2017; Kurt *et al.* 2018; Pérez-de la Cruz 2018; Pérez-de la Cruz 2019), dual-task aquatic exercises (da Silva and Israel 2019), specific gait training exercises (Carroll *et al.* 2017; Daniele Volpe *et al.* 2017b), tailored aquatic therapy programs (Vivas *et al.* 2011; Shahmohammadi *et al.* 2017) and perturbation based balance exercises (Volpe *et al.* 2014) were compared to land-based physiotherapy or usual care (Carroll *et al.* 2017). Zhu et al. (2018) compared aquatic obstacle training to 'traditional' aquatic therapy consisting of balance training using the Halliwick method.

Environmental factors and treatment setting

Water temperatures differed from 30 degrees Celsius (°C) to 34 °C across studies. Pool depths, reported in all but six studies (Volpe *et al.* 2014; Palamara *et al.* 2017; Shahmohammadi *et al.* 2017; Daniele Volpe *et al.* 2017b; Clerici *et al.* 2019; da Silva and Israel 2019), varied from 0.6 to 1.5 meters. The level of immersion at which study participants exercised in water were waist depth (Shahmohammadi *et al.* 2017) or the mamillary line (Daniele Volpe *et al.* 2017a; Daniele Volpe *et al.* 2017b) in three trials. Four studies took place in a hydrotherapy pool in an outpatient rehabilitation setting (Vivas *et al.* 2011; Palamara *et al.* 2017; Kurt *et al.* 2018; Zhu *et al.* 2018). Four studies were in an inpatient rehabilitation setting (Volpe *et al.* 2014; Daniele Volpe *et al.* 2017a; Daniele Volpe *et al.* 2017b; Clerici *et al.* 2019), four in public swimming pools (Pérez-de la Cruz 2017; Shahmohammadi *et al.* 2017; Pérez-de la Cruz 2018; da Silva and Israel 2019) and one in a community hydrotherapy pool (Carroll *et al.* 2017).

Adverse events, participants involvement and economic evaluation

Eight investigations reported no adverse outcomes following participation in the aquatic interventions, although six studies did not specify whether or not adverse events were monitored or documented during the intervention period (Vivas *et al.* 2011; Shahmohammadi *et al.* 2017; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Pérez-de la Cruz 2018; da Silva and Israel 2019). No trials reported data for economic cost, and no studies reported patient or public involvement in any stage of the research study.

Effects of aquatic therapy compared to land-based physiotherapy

Of the 14 trials included in the review, seven studies were included in the meta-analysis (Vivas *et al.* 2011; Volpe *et al.* 2014; Palamara *et al.* 2017; Pérez-de la Cruz 2017; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Pérez-de la Cruz 2018). The effects of aquatic therapy versus conventional land-based physiotherapy for balance, mobility, motor disability and health related quality of life were included in the meta-analysis as they were the most common outcomes of interest. Carroll et al. (2017) could not be included in the meta-analysis as they published data as median and interquartile range values and the data were skewed. Zhu et al. (2018) compared aquatic obstacle course training to an aquatic therapy arm, which could not be included in meta-analysis comparing aquatic therapy to land-based physiotherapy. Volpe et al. (2017b) did not report data for the control groups and compared healthy subjects matched for age, body mass index and gender to the experimental group of people with PD.

Gait

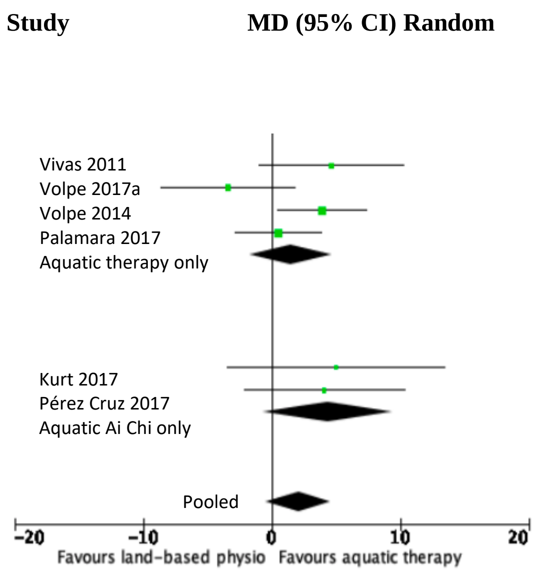
Five studies (Vivas *et al.* 2011; Volpe *et al.* 2014; Daniele Volpe *et al.* 2017b; Zhu *et al.* 2018; Clerici *et al.* 2019) reported outcomes relating to gait. Freezing of gait was assessed in three trials (Volpe *et al.* 2014; Zhu *et al.* 2018; Clerici *et al.* 2019) using the self-evaluating Freezing of Gait Questionnaire (FOGQ). Zhu et al. (2018) found significant improvements in both the aquatic obstacle therapy group and traditional aquatic therapy group ($p<0.001$). Carroll et al. (2017) and Clerici et al. (Clerici *et al.* 2019) observed no differences in the FOGQ between the aquatic therapy group and usual care control group or intensive motor-cognitive group respectively. Volpe et al. (2017b) found significant improvements in spatiotemporal parameters (stride length, stride period, stance period, speed, cadence) in participants with PD who received underwater gait training, with findings from 3D gait analysis demonstrating a significant improvement in hip, knee, ankle and shoulder ranges of motion ($p<0.05$). While two studies observed no significant improvements in gait variability (Vivas *et al.* 2011; Volpe *et al.* 2014), or step amplitude, turn time and cadence (Vivas *et al.* 2011) following four (Vivas *et al.* 2011) and six (Volpe *et al.* 2014) weeks of twice weekly aquatic therapy.

Balance

Six studies were included in the meta-analysis for the Berg Balance Scale (BBS) when comparing aquatic therapy and aquatic Ai Chi to land-based physical interventions (Vivas *et al.* 2011; Volpe *et al.* 2014; Palamara *et al.* 2017; Pérez-de la Cruz 2017;

Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018). (Refer to Figure 2, or for a more detailed forest plot see Chapter 2 Appendices: Appendix B, Figure 2). Small non-significant effects were observed for balance on the BBS in favor of the aquatic therapy and Ai Chi groups (2.08 points, 95 % CI -0.43 to 4.60; p= 0.10, I^2 = 37%), while Palamara et al (2017) found long term gains in BBS scores were maintained in more people with PD who received aquatic therapy in addition to intensive land-based rehabilitation. Kurt et al. (2018) found greater improvements in dynamic balance for the aquatic Ai Chi group when compared to land-based exercises, measured with the Biodex-3.1 (anteroposterior index p< 0.001, mediolateral index p< 0.001, overall balance index p< 0.001). Mean velocity of the center of pressure (COP) was better in the aquatic therapy group compared to land-based physiotherapy (p= 0.01; 95% CI -5.2, -0.66) (Shahmohammadi *et al.* 2017). Volpe *et al.* (2014) observed non-significant changes for COP sway with eyes closed in the aquatic therapy group in comparison to participants who underwent land-based physiotherapy (45.4 ±64.9 vs. 6.9±45.3, p= 0.05).

Figure 2. MD (95% CI) of effect of aquatic therapy immediately after 4 to 8 weeks of intervention on balance (Berg balance scale) compared to land-based physiotherapy. Data pooling for six studies (n=173).

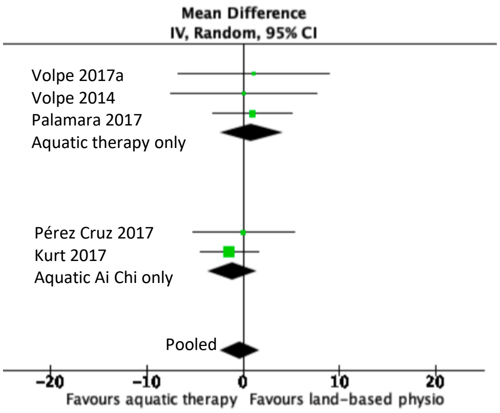


Motor Disability

Five trials with a total of 162 participants reported data for the Unified Parkinson's Disease Rating Scale motor subsection III (UPDRS III) with no difference between the aquatic therapy and aquatic Ai Chi groups compared to land-based interventions (-0.32 points, 95% CI -2.36 to 1.75; p= 0.75, I^2 = 0%). (Refer to Figure 3, or for a more detailed forest plot see Chapter 2 Appendices: Appendix B, Figure 3). Carroll et al. (2017) reported a significant improvement in UPDRS III scores in the aquatic therapy group (p< 0.01) in comparison with a control group who received medication alone. Small and non-significant effects were observed in favor of the aquatic Ai Chi groups compared to land-based rehabilitation (Pérez-de la Cruz 2017; Kurt *et al.* 2018). Two trials identified no significantly greater benefits when aquatic therapy was provided in addition to land-based movement rehabilitation (Palamara *et al.* 2017; Clerici *et al.* 2019).

Figure 3. MD (95% CI) of effect of aquatic therapy immediately after 5 to 8 weeks of intervention on motor disability (UPDRS III) compared to land-based physiotherapy. Data pooling for five studies (n=162).

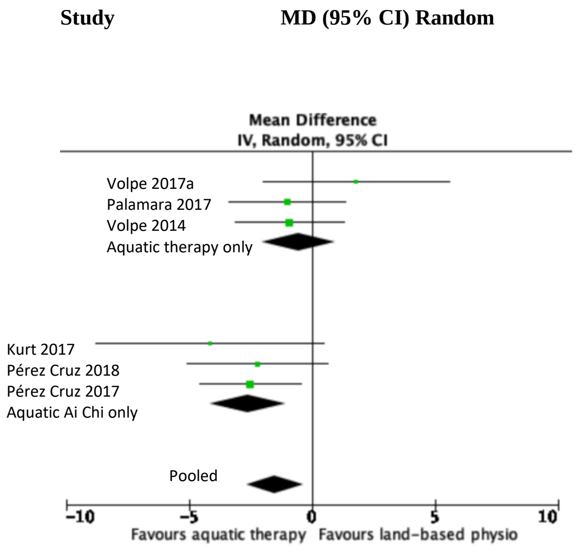
Study **MD (95% CI) Random**



Functional Mobility

Following short-term aquatic therapy, statistically significant improvements (-1.5 seconds, 95 % CI -2.68 to -0.32; p= 0.01, I^2 =13%) were seen for the Timed Up and Go (TUG) when the results were pooled for six of the 14 studies (Volpe *et al.* 2014; Palamara *et al.* 2017; Pérez-de la Cruz 2017; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018; Pérez-de la Cruz 2018). (Refer to Figure 4, or for a more detailed forest plot see Chapter 2 Appendices: Appendix B, Figure 4).

Figure 4. MD (95% CI) of effect of aquatic therapy immediately after 4 to 11 weeks of intervention on functional mobility (Timed Up and Go) compared to land-based physiotherapy. Data pooling for six studies (n=191).



Falls

Two studies evaluated the outcome of aquatic therapy on falls using the Falls Efficacy Scale (FES) (Volpe *et al.* 2014; Daniele Volpe *et al.* 2017a) and a falls diary (Volpe *et al.* 2014). Both reported a significant reduction in falls following aquatic therapy and Volpe et al. (2014) found significant differences on the FES (−5.9 SD 4.8 vs. −1.9 SD 1.4; p= 0.003) and falls diary (−2.4 SD 2.2 vs. −0.4 SD 0.5; *p*= 0.001) in favor of aquatic therapy**.**

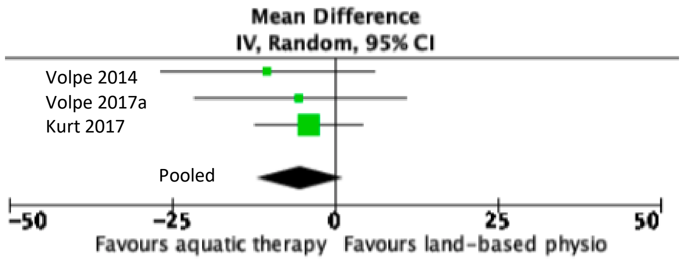
Health related quality of life

No significant differences between treatment groups (- 5.30 points, 95% CI -11.99 to 0.30; *p*= 0.12, I^2 = 0%) were observed for self-reported measures of quality of life on the PDQ-39 in three trials (Volpe *et al.* 2014; Daniele Volpe *et al.* 2017a; Kurt *et al.* 2018). (Refer to Figure 5, or for a more detailed forest plot see Chapter 2 Appendices: Appendix B, Figure 5). Total scores for the PDQ-39 were not available for one study

(Pérez-de la Cruz 2018) with no significant differences between aquatic therapy and land-based physiotherapy. Shahmohammadi et al. (2017) reported greater improvement in the aquatic therapy group compared to a land-based exercise group for quality of life using the Farsi version of the Parkinson's Disease Quality of Life (PDQL) questionnaire.

Figure 5. MD (95% CI) of effect of aquatic therapy immediately after 4 to 8 weeks of intervention on quality of life (Parkinson's disease questionnaire 39) compared to land-based physiotherapy. Data pooling for three studies (n=98).

Study **MD (95% CI) Random**



2.5 Discussion

The studies included in this review provided variable dosage, content and duration of aquatic interventions for people living with PD. Overall, the meta-analysis demonstrated that aquatic therapy had comparable positive outcomes to land-based physiotherapy for gait, balance, motor disability, falls and health related quality of life in the early to mid-stages of disease progression (stages I-III). Greater improvements were identified for functional mobility measured using the TUG (1.5 seconds). However, these improvements were less than the minimal detectable change (MDC) score of 3.5 seconds reported for the TUG in people with PD (Huang *et al.* 2011).

Arguably, a lack of targeted aquatic exercise interventions for specific movement disorders in PD may have limited the effects of aquatic therapy.

This meta-analysis adds to previous reports (Pérez and Cancela 2014; Marinho-Buzelli *et al.* 2015; Methajarunon *et al.* 2016; Terrens *et al.* 2018), with some new insights gained. A previous review by Methajarunon et al. (2016) was unable to draw firm conclusions as it only included two trials with small sample sizes. Another analysed within group effects only and included non-randomized trials (Terrens *et al.* 2018). Our analysis is based on raw data from seven randomized controlled trials and a total of 209 participants. A recent meta-analysis by Cugusi et al. (2019) had similar results for functional mobility. In contrast to our findings, that review (Cugusi *et al.* 2019) also reported small to moderate improvements following aquatic therapy for balance, fear of falling and health related quality of life when compared to land-based exercise. Whereas our review calculated the mean difference of pre and post-test values, Cugusi et al. (2019) included only mean values for post-test data.

Optimal frequency, intensity, duration and type of aquatic therapy?

Due to large variations in aquatic therapy interventions and outcome measures, we were unable to ascertain the optimum, intensity, time and type of aquatic therapy suitable for PD. It is likely that the content, dosage, duration, intensity and scheduling of aquatic therapy needs to be tailored to individual needs, considering the person's stage of disease progression, level of impairment, medications, activity limitations, co-morbidities and general fitness.

Frequency

Findings from high quality studies on people with mild to moderate PD that implemented between three (Palamara *et al.* 2017) and five sessions per week (Volpe *et al.* 2014; Kurt *et al.* 2018; Zhu *et al.* 2018) reported statistically greater improvements in balance (Volpe *et al.* 2014; Palamara *et al.* 2017; Kurt *et al.* 2018; Zhu *et al.* 2018), functional mobility, health related quality of life, motor disability (Kurt *et al.* 2018) and gait (Zhu *et al.* 2018) in the aquatic therapy group than land-based physiotherapy. This suggests that in order to gain clinically meaningful improvements in movement and wellbeing for PD, a minimum of three sessions per week ought to be conducted. However, participation in three to five sessions every week may not be feasible for all people living with PD. There can be challenges with access to aquatic therapy resources, trained health professionals and supervision in community settings, with a lack of time identified as a barrier to exercise in people with PD (Ellis *et al.* 2013). Thus, exploration of land-based strategies to augment the benefits gained and meet the frequency recommendations may be useful.

Duration

Variations in the length of time of each session (30 minutes to one hour) and duration of aquatic therapy interventions (three to 11 weeks) were noted. These variations require consideration and may have influenced outcomes. The mean aquatic therapy dose was 3.4 sessions of 51.8 minutes over 6.6 weeks. The European physiotherapy guidelines for exercise in Parkinson’s disease (Keus *et al.* 2014) recommends a minimum of three, 45-minute sessions per week over an eight-week period, which is a total of 24 sessions lasting 1080 minutes. Four of the studies included in this review achieved this dose with greater improvements noted in these moderate to high quality trials for balance (Volpe *et al.* 2014; Shahmohammadi *et al.* 2017; Kurt *et al.* 2018), trunk posture (Daniele Volpe *et al.* 2017a), and quality of life (Volpe *et al.* 2014; Shahmohammadi *et al.* 2017; Kurt *et al.* 2018) in the aquatic therapy groups compared to land-based physiotherapy. Thus, it is recommended that researchers use appropriate guidelines for frequency and intervention dosage in order to enable comparison and repeatability of aquatic therapy for Parkinson's disease.

Intensity

Most of the studies included omitted measuring intensity or the level of effort achieved during aquatic therapy. Trials did not always account for rest periods taken during aquatic exercise programmes affecting accuracy in reporting exercise intensity levels (Geigle 2018). The majority of interventions focused solely on the progression of neuromotor or task specific aquatic exercises and were not directed at achieving a high intensity rate, required to positively influence exercise enhanced neuroplasticity (Petzinger *et al.* 2013). The inclusion of intensity measurement tools to improve speed and load achieved during future trials for example, the Borg rating of perceived exertion scale (Borg 1982; Graef and Kruel 2006), an auditory metronome (Geigle *et al.* 2018), [80] or heart rate polar monitor (Fragala-Pinkham *et al.* 2014) using the formula HRmax in water = HRmax on land – ΔFC (where ΔFC = bradycardia resulting from water immersion) as described by Graef and Kruel (2006), are important in order to establish an optimum intensity target for people with PD exercising in water (Geigle 2018). To enable people with PD to perform past their self-perceived ability, future research could incorporate introduction sessions where participants are introduced to single-task exercises targeting specific impairments with an emphasis on movement quality (Conradsson *et al.* 2015; Shahmohammadi *et al.* 2017), and how buoyancy and drag can influence movement in water (Heywood *et al.* 2016). Higher intensity neuro-motor exercise training in water, if sufficiently prescribed, may lead to better outcomes over land-based exercise for people with PD.

The limited effectiveness of aquatic therapy over land-based exercise, with the majority of studies unable to achieve a sustained treatment effect, may be due a number of factors such as inadequate clinical application of buoyancy and drag forces during task specific activities in water (Heywood *et al.* 2017) and failure to educate patients on an optimal speed of movement in water (Heywood *et al.* 2016). Heywood et al (2016) identified that without precise guidance on speed of movement required for task-specific exercises, maximal speeds of movements in water will likely be less that on land, due to the impact of drag forces. Thus, in line with previous research findings on speed-amplitude relations in PD, it is recommended that clinician's focus on movement amplitude as one possible intervention strategy to improve speed-amplitude scaling for people with PD exercising in water (Farley and Koshland 2005).

Content of Physiotherapy Interventions

Our findings provide a preliminary comparison of various aquatic therapy approaches utilized by physiotherapists for people with PD. Variances in aquatic therapy outcomes could contribute to some of the equivocal findings of this review, which may be explained by the wide range of aquatic therapy exercise components adopted across trials. For example, aquatic therapy comprising of "perturbation-based balance training," (Volpe *et al.* 2014) might be beneficial for some people with PD experiencing loss of balance and falls by exposing them to drag forces and performing exercises against a turbulent flow of water (Morris and Geigle 2009), to stimulate enhanced balance reactions.

Ai Chi

Higher quality trials suggested that aquatic Ai Chi (Kurt *et al.* 2018) can be an effective approach to improving balance, disability, mobility and quality of life in PD. People with PD who participated in the Ai Chi intervention groups, performed a series of repeated exercises standing in shoulder deep water. The exercises progress in difficulty from static to dynamic, symmetrical to asymmetrical, and trunk rotational movements, with additional visual and non-visual challenges also included. It may be hypothesized that this type of aquatic exercise, focusing on amplitude and precision of movement could benefit impairments of bradykinesia and postural control. While the inclusion of conscious breath training along with the physiological benefits of water immersion, could help target non-motor impairments such as anxiety and depression, by regulating the autonomic nervous system (Sova 2009, p.102).

Aquatic Obstacle Course Training and Dual-Task Aquatic Exercises

Findings from high quality trials on aquatic obstacle course training (Zhu *et al.* 2018), involving multi-directional movements up, down, around and over changing obstacles could improve freezing impairments in some people with PD. The pathophysiology of freezing of gait in PD is not clearly understood but one could hypothesize that aquatic obstacle training, utilizing resistance forces in water may stimulate positive coupling of a normal postural preparation for step to the swing phase of a step, by directing attention to the acquisition of specific stepping skills in water (Jacobs *et al.* 2015). Moderate quality research on dual-task aquatic exercise training incorporated similar multidirectional activities in water and offers a promising aquatic approach for improved functional mobility, balance and gait in PD. It is recommended that for future trials, researchers provide a theory driven rationale for the development of interventions and clearly define the specific characteristics of aquatic therapy (Pérez-de la Cruz 2018), which are optimal for targeting varying movement disorders associated with Parkinson's disease (Table 4).

Study Designs

Involvement of key stakeholders in treatment design (Craig *et al.* 2008) as well as the inclusion of patient orientated outcomes and goals was only reported in two trials (Palamara *et al.* 2017; Clerici *et al.* 2019). Participant involvement in the research engages experiential evidence that includes the participant's perspective, functional difficulties and their preferred treatment needs (Cooper *et al.* 2014). The input of people with PD in a study's protocol design, taking account of their individual opinions on treatment acceptability, may also help to increase the cost effectiveness of trials by directing researchers towards interventions, which are likely to be beneficial and effective for future trials (O'Cathain *et al.* 2013; O'Cathain *et al.* 2014).

Recommendations for future research

Further, large scale randomized controlled trials with longer follow-up periods, specified intensity doses are required and would allow better comparisons of aquatic therapy with land-based physical interventions. The characteristics and mechanisms by which aquatic therapy can optimally contribute to impairments present in PD, and the extent to which these improvements may last over time await further investigations. The inclusion of outcome measurement tools evaluating underwater movements, such as 3D motion gait analysis (Daniele Volpe *et al.* 2017b) would help to strengthen our understanding of the specific features and benefits of aquatic therapy for PD.

This review included people with PD stages I-III with no adverse effects during aquatic therapy intervention found however, group aquatic therapy could be unsafe for people with advanced PD, Hoehn and Yahr stages IV-V and may warrant consensus among expert researchers and clinicians working in the field. Recent research suggests that Parkinson's disease can interfere with swimming and/or floating capacity and may pose a safety risk relating to asymmetric characteristics, poor coordination, and problems executing complex tasks (Neves *et al.* 2018).

None of the trials reviewed incorporated an economic assessment on the cost of implementing aquatic therapy, thus little is known about the economic value and cost effectiveness of aquatic therapy for PD. Given the increasing burden of cost associated with Parkinson's disease progression (Bohingamu Mudiyanselage *et al.* 2017), aquatic therapy services need to be deliverable within the financial limitations of modern healthcare systems. Due to a decline in hospital hydrotherapy services for the treatment of chronic conditions in some countries such as the UK (Martin *et al.* 2018a; Martin *et al.* 2018b), as well as increasing pool closures, the costs of implementing aquatic therapy for people living with PD needs to be taken into account when designing trials (Martin *et al.* 2018a; Martin *et al.* 2018b). A recent retrospective analysis of medical claims (Ypinga *et al.* 2018) provided preliminary evidence that specialized physiotherapy delivered through a community-based programme can reduce overall treatment costs and is associated with less disease related complications. The extent to which specialist aquatic therapy services may reduce costs and limit complications associated with PD related impairments needs to be investigated further.

Strengths and Limitations

All randomized controlled trials were comparable in focusing on the effectiveness of aquatic therapy in PD, with the seven studies and outcomes included for meta-analysis demonstrating minimal heterogeneity ($I^2 < 50\%$) however, there are some limitations of this meta-analysis. Firstly, reporting bias was identified in five studies that failed to indicate time periods over which participants were recruited (Vivas *et al.* 2011; Pérez-de la Cruz 2017; Daniele Volpe *et al.* 2017a; Daniele Volpe *et al.* 2017b; Pérez-de la Cruz 2018). Relevant data such as loss of patients to follow-up and the inclusion of intention-to-treat analysis was omitted in six trials (Vivas *et al.* 2011; Volpe *et al.* 2014; Shahmohammadi *et al.* 2017; Daniele Volpe *et al.* 2017a; Clerici *et al.* 2019; da Silva and Israel 2019) thus, outcome reporting bias in these studies may have founded misleading, positive results of the effectiveness of aquatic therapy. Trials included were small with only seven studies (Volpe *et al.* 2014; Palamara *et al.* 2017; Pérez-de la Cruz 2017; Shahmohammadi *et al.* 2017; Clerici *et al.* 2019; da Silva and Israel 2019; Pérez-de la Cruz 2019) including a power and sample size calculation, while five studies were documented pilot studies (Vivas *et al.* 2011; Daniele Volpe *et al.* 2017a; Daniele Volpe *et al.* 2017b; Pérez-de la Cruz 2018; Pérez-de la Cruz 2019).

The limited effects of aquatic therapy over land-based physiotherapy for gait variables such as gait variability, step amplitude, turn time and cadence may have been associated with an insufficiently powered trial (Vivas *et al.* 2011; Carroll *et al.* 2017). Only one low quality study (Vivas *et al.* 2011), which conducted testing during the “OFF” medication phase was suitable for inclusion in the meta-analysis making it difficult to establish if there was an overall difference in results when comparing to “ON” medication testing. Finally, the Berg Balance Scale was included in the meta-analysis as it was used in a number of studies (n=6). However, research has shown (Downs *et al.* 2013) that it has modest sensitivity and high ceiling effects and thus may not be the most appropriate measure to detect a change in balance during the early stages of PD. Other measures, such as the Mini-BESTest may have been more suitable to demonstrate differences especially where balance was targeted (King *et al.* 2012).

2.6 Conclusion

Aquatic therapy has comparable positive outcomes to land-based physiotherapy, showing benefits for gait, balance, motor disability, mobility, falls and quality of life in people in the early to middle stages of disease progression in PD. Aquatic therapy had superior outcomes for gait, balance and mobility for trials that delivered at least 3-5 sessions per week. The optimal frequency, intensity, duration, and type of aquatic exercise for people living with PD could not be confirmed from this review due to comparatively low dosages of therapy delivered and variations in therapy content. Group-based aquatic therapy is likely to be contra-indicated in those with advanced PD due to safety issues associated with severe movement disorders and co-morbidities

2.7 Epilogue

An updated search of all databases (see chapter 2 appendices, appendix A: search strategy) was conducted in July 2021. Remarkably, since the systematic review and meta-analysis was completed in August 2019, only one pilot RCT (Terrens et al. 2020) was published in the interim. However, this trial did not meet the inclusion criteria set out in the original review (Box 1) as the primary outcomes of interest included in the pilot study were safety, adherence, and attrition.

GRADE

This systematic review and meta-analysis successfully synthesised evidence from 14 randomised controlled trials, which are considered the highest level of empirical scientific evidence (Burns *et al.* 2011). In February 2022, the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) (Higgins *et al.* 2022) was completed to quantify the certainty of evidence for the outcomes included in the meta-analysis (see Chapter 2 Appendix F: GRADE). The findings suggest that there are low levels of evidence that aquatic therapy may yield small improvements in mobility over land-based physiotherapy, while there was very low to moderate quality research evidence indicating comparable effects to land-based interventions for balance, disability and quality of life following aquatic therapy for PD. Thus, the overall results of this systematic review and meta-analysis ought to be considered with some caution; with further large scale, high quality and well-designed randomised controlled trials required to determine the overall effectiveness of aquatic therapy for people with Parkinson's disease.

Results: Falls and Falls efficacy

Fear of falling was measured using the Falls Efficacy Scale (FES) in two trials (Volpe *et al.* 2014; Volpe *et al.* 2017a). Volpe *et al.* (2014) reported a significant reduction in FES scores (−5.9 SD 4.8 vs. −1.9 SD 1.4; p= 0.003) compared to the land-based group after two months. Volpe *et al.* (2017a) reported significant changes in both the aquatic therapy and land-based exercise groups following an 8-week intervention period (p=0.027). These results ought to be interpreted with caution, as due to the variable nature of falls, Lamb *et al.* (2005) suggest that a 12-month follow-up period should be included to determine any important effects, along with large sample sizes and data analysis utilising negative binomial regression (Robertson *et al*. 2005).

Falls were measured in one trial (Volpe et al. 2014) using a falls diary, with a significant reduction (−2.4 SD 2.2 vs. −0.4 SD 0.5; $p= 0.001$) reported in favor of aquatic therapy. However, owing to the inclusion of a small sample size and short intervention period of two months, this analysis should also be interpreted with caution.

Gaps in the research evidence in the context of the research project

However, owing to small numbers of studies with small sample sizes, and large variations in aquatic exercise prescription, many unanswered questions remain about how best healthcare professionals can apply this approach safely and effectively in clinical practice for people with PD. For example, how soon after diagnosis should people with PD start aquatic therapy? Considering the potential disease modifying effects of aerobic exercise, should high intensity aerobic exercises be included in aquatic therapy programs? Is aquatic therapy safe and feasible for people with advanced PD? Should people with PD have access to community-based aquatic therapy? What are the barriers and motivators for participating in aquatic therapy? While it could be argued that these questions would be best answered by conducting a randomised controlled trial (RCT), at the time of completing this systematic review we did not have the resources or finances to conduct a pilot study or definitive RCT. Furthermore, as PD is a heterogeneous condition combining motor, sensory and cognitive deficits, which is often accompanied by other medical conditions, it was thought that a ‘one size fits all’ approach to conducting research trials may limit our understanding of the optimal components of aquatic therapy and who might benefit most from different aquatic therapy approaches.

As previously discussed in Chapter 1, there was a dearth of qualitative and practice-based research evidence from the perspectives of people with PD and healthcare professionals delivering aquatic therapy to this client group. From my own clinically experience and background, I was acutely aware of the need for clinical practice guidelines to help guide and inform decision making in practice. Furthermore, as it was considered unlikely that larger, well designed, randomized controlled trials concerning some of these practice related issues would be published in the immediate future, upon completion of this phase of the project, it became apparent to the author and research supervisory team that while aquatic therapy is emerging as a promising approach for managing PD-specific impairments there were significant gaps in knowledge, which needed to be addressed in the form of evidence-based practice guidelines.

CHAPTER 3:

Community Aquatic Therapy for Parkinson's disease: An International Qualitative Study

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3.0 Prologue

As identified in chapter 2, there is growing evidence of the effectiveness of aquatic therapy for people with PD; however, the optimal content and dosage of aquatic therapy programs remain unclear (Carroll *et al.* 2020). While evidence of effectiveness is a key pillar of evidence-based practice (EBP), the literature review (Chapter 1) identified a significant lack of patient-informed aquatic therapy literature. Thus, based on gaps in the research evidence identified during phase one, along with findings from previous research (Carroll *et al.* 2017), this qualitative study aims to explore factors influencing access to, participation in, and long-term adherence to community-based aquatic therapy for people with PD. This chapter will also discuss key motivators and potential barriers to be considered in the development of the consensus statements and subsequent aquatic therapy guidelines outlined in Chapter 4.

Rationale for choice of methodological approach

Thematic analysis was adopted, as this accessible approach aims to generate a nuanced analysis, and to identify themes and patterns of meaning directly from the data, whilst also recognising that the analysis is shaped by the researchers own standpoint and clinical experiences (Braun and Clarke 2006; Braun and Clarke 2013 page 175; Braun *et al.* 2016). This approach was adopted as it best enabled us to explore in-depth the opinions of people with Parkinson's disease about aquatic therapy and to establish a rich thematic description about key factors influencing their engagement and long-term participation in aquatic therapy (Braun and Clarke 2006; Braun and Clarke 2013; Braun and Clarke 2014; Braun et al. 2016). During the conception stage of this study, other methods considered included Grounded Theory (Glaser and Strauss 1967), and Interpretative Phenomenological Analysis (Smith 1996), both of which are regarded as theoretically informed methodologies; however, as a novice qualitative researcher, Braun and Clarke’s (2006) 15-point checklist of criteria for good thematic analysis provided me with transparent steps that guided the quality and rigour of our thematic analysis practice to achieve methodological integrity throughout the entire research process.

3.1 Publication and authorship

Carroll, L.M., Morris, M.E., O'Connor, W.T. and Clifford, A.M. (2021) 'Community Aquatic Therapy for Parkinson's Disease: An International Qualitative Study', *Disability and Rehabilitation*, available: http://dx.doi.org/10.1080/09638288.2021.1906959.

The author led the conception and development of the study design of the Irish and Australian arms of the study, led the recruitment and data collection in Ireland, conducted all data analysis, interpretation, writing, editing and the submission of the paper for publication. Dr. Amanda Clifford, as the primary supervisor, supported the conception and study design, and contributed to the data analysis, interpretation and editing of the paper. Professor Meg Morris, as co-secondary supervisor, supervised and contributed to the conception, study design, led the recruitment and data collection in Australia, and contributed to the interpretation and editing of the paper. Professor William O’Connor, as co-secondary supervisor, supervised and contributed to the conception, study design, data analysis, interpretation and editing of the paper. All the authors agree with the findings and approved the final submission.

3.1 Abstract

PURPOSE: To explore the opinions of people living with Parkinson’s disease about access to and participation in community aquatic therapy.

METHODS: Focus groups and individual interviews were conducted with people living with Parkinson's disease in Ireland (n=24) and Australia (n=10). All discussions were audio-recorded, transcribed verbatim, and thematically analysed.

RESULTS: Four main themes were identified. Primarily, participants were optimistic about their reasons for choosing aquatic therapy and found it beneficial to their health and well-being. Optimal components of aquatic therapy identified were access to individually tailored aquatic programs, completed as a minimum once a week, at a moderate to high-intensity level, and guided by a credentialed instructor. Fear was a significant barrier for a small proportion of participants and was linked to water competence, past experiences, and fall risk associated with the aquatic environment. Participants identified a strong need for education and increased awareness about aquatic therapy benefits to promote greater engagement.

CONCLUSION: Aquatic therapy is a popular exercise choice for people with Parkinson's disease, especially in the early to middle disease stages. Considering the views of people living with Parkinson's disease can aid the design and implementation of interventions and future aquatic research internationally.

3.2 Introduction

Parkinson's disease is a leading cause of chronic disability and the fastest growing neurological condition globally (Dorsey *et al.* 2018). It is estimated to affect over 6 million people globally (Dorsey *et al.* 2018). It affects more than 12,000 people in Ireland (Stubbe *et al.* 2016) and 70,000 in Australia (Deloitte 2015). Throughout the disease course, people experience movement disorders such as bradykinesia, gait freezing, dyskinesia, dystonia, reduced postural control, cognitive decline, and changes in behaviour (Morris *et al.* 1994; Morris *et al.* 1996; Morris 2000). Symptomatic treatment of this complex condition includes medication together with targeted rehabilitation practices such as exercise and physiotherapy, incorporating disease-modifying strategies (Keus *et al.* 2014; Seymour *et al.* 2019).

There is a growing body of evidence on aquatic therapy's benefits as a physiotherapy approach for people with Parkinson’s disease (Cugusi *et al.* 2019; Carroll *et al.* 2020). Aquatic therapy utilises the principles of water immersion to enhance physical function and psychological well-being (De Vierville 2010, p.1). It has been increasingly advocated by Parkinson’s disease clinicians and researchers for disorders of gait (Daniele Volpe *et al.* 2017b), balance (Volpe *et al.* 2014), disability (Carroll *et al.* 2017), pain (Pérez-de-la-Cruz 2017), and health-related quality of life (Shahmohammadi *et al.* 2017). Clinically, water immersion may provide unique rehabilitation benefits associated with physiological changes such as increased cerebral blood flow (Parfitt *et al.* 2017), reduced sympathetic nervous system stimulation, and increased parasympathetic system activity (Hildenbrand *et al.* 2010; Becker 2020). Thus, aquatic physiotherapy may have additional non-pharmacological treatment effects on some of the symptoms of autonomic dysfunction commonly associated with Parkinson’s disease (Palma and Kaufmann 2018; Becker 2020).

Despite the increasing numbers of trials and systematic reviews evaluating the effectiveness of aquatic therapy (Palamara *et al.* 2017; Kurt *et al.* 2018; Terrens *et al.* 2018; Zhu *et al.* 2018; Pinto *et al.* 2019), there are currently no published studies reporting the views and experiences of aquatic therapy in people with Parkinson's disease. One finding reported by a recent systematic review and meta-analysis (Carroll *et al.* 2020) found insufficient patient-informed qualitative data, which are needed to gain a broader understanding of aquatic therapy from the perspectives of people living with the condition. In this regard, qualitative research can provide important insights into the complexities of recruitment to trials and inform the development of suitable interventions. (O'Cathain *et al.* 2013; Elliott *et al.* 2017). It is increasingly recommended that researchers work in partnership with people who have lived experience of health conditions to understand the key factors influencing recruitment and engagement, to reduce the knowledge-to-practice gap (Camden *et al.* 2015). A feasibility trial (Carroll *et al.* 2017) found recruitment of participants challenging, with 48% of the eligible adults with Parkinson's disease declining to partake in this community-based study. Conversely, the results from the trial's exit questionnaire found that aquatic therapy was enjoyable, with 90% of participants in the intervention group expressing a strong interest in continuing group classes. However, little is known about what factors might influence people with Parkinson's disease to take part in a community-based aquatic program.

This study's primary aim was to understand the opinions and beliefs of people living with Parkinson's disease on factors influencing access to, participation in, and long-term adherence to community-based aquatic therapy. A second aim was to compare the experiences and views of people living in different parts of the world, Ireland, and Australia, to understand how cultural differences may affect engagement and access to aquatic therapy.

3.3 Methods

Study design

This study adopted a qualitative design and interpretive approach to inform data collection and analysis (Ormston *et al.* 2013, p.22). Similar to previous research protocols, data were rigorously obtained using a combination of one-to-one interviews and focus groups (Lambert and Loiselle 2008; Taylor-Robinson *et al.* 2012). This form of data triangulation was initially adopted to ensure a broader spectrum of eligible participants were recruited (Lambert and Loiselle 2008). Where a participant was unable to attend a focus group, they were offered an individual interview (Carter *et al.* 2014b). In this regard, we completed in-depth interviews to build understanding and a high degree of trust with participants, thus improving the quality of the opinions and insights gained (Gill *et al.* 2008). Where possible, focus groups were conducted to generate a broad range of perspectives from dynamic peer interactions (Barbour and Kitzinger 1998; Barbour 2008). Data triangulation was considered useful to understand the different interpretations of aquatic therapy for people living with Parkinson's disease (Lambert and Loiselle 2008). The Consolidated Criteria for Reporting Qualitative Research Checklist (COREQ) was used to design and report this study (Tong *et al.* 2007) (See Chapter 3 Appendices: Appendix B, Table 3).

Participants

We recruited male and female adults residing in both rural and urban areas of Ireland and Australia. Inclusion criteria were adults ≥18 years with a confirmed diagnosis of Parkinson's disease who spoke English. We included people with Parkinson's disease who have previously engaged in aquatic therapy and those who have never participated in aquatic therapy. People with experience in community-based aquatic therapy were recruited using a purposive sampling strategy. A snowballing approach was adopted to recruit participants with no aquatic experience through local Parkinson's disease exercise and support groups.

Thirty-four participants (16 females, 18 males) took part in the focus groups and interviews across Ireland and Australia (Table 1). The aetiology of Parkinson's disease included idiopathic Parkinson's disease (n=29), Progressive Supranuclear Palsy (n=2), and Young Onset Parkinson's disease (n=3). Participants' median age was 70 years (range 63.5 -75), and the median disease duration was five years (range 3-9.3). Prior experience of partaking in aquatic therapy (n=16) ranged from more than five years (n=4) to having no experience (n=18). The Irish cohort (n=24) resided in the Midwest of Ireland, and the Australian cohort (n=10) lived in Victoria and Queensland.

Ethics

This research received full ethical approval from the Midwest Health Services Ethics Committee (Ref: 078/18) in Ireland and La Trobe University Human Research Ethics Committee (I.D. HEC19157) in Australia.

Data Collection

Data collection occurred between December 2018 and April 2020. All data collection took place at a location convenient for participants. Three interviews occurred by telephone in Australia due to Covid-19 restrictions. All interviews and focus groups were conducted with different participants in the English language. The focus groups and interview sessions lasted from 25 to 70 minutes. They followed a semi-structured interview guide (Table 2), designed to align with the research questions, based on observations and research findings (Carroll *et al.* 2017; Carroll *et al.* 2020). In both countries, experienced qualitative interviewers conducted all interviews and had no professional relationships with the participants. A second researcher acted as a note-taker for all focus groups to provide contextual information on the group discussion, participant's body language, and group dynamics (Barbour and Kitzinger 1998). Demographic information (Table 1) was collected at the beginning of each focus group and interview.

Table 1. Demographics. Characteristics of the focus group and interview participants.

	Number of participants	Gender		Age (years)		Years diagnosed with PD		Length of time in years doing aquatic therapy (number of participants)	Number of weeks doing aquatic therapy per year (number of participants)	Type of PD
		Male	Female	Median	IQR	Median	IQR			
Ireland										
FG 1	6	3	3	72	64.5-74.3	5	3.6-8.3	≤3 (4) ≤5 (2)	≤6 (1) ≤12 (5)	Idiopathic(n=5) PSP (n=1)
FG 2	7	3	4	70	67.5-70.5	10	5.5-12	≤3 (2) ≤5 (1) ≥5 (4)	≤12 (1) ≤20 (3) ≥20 (3)	Idiopathic (n=7)
FG 3	5	4	1	72	64-75	3	3-6	0 (5)	0 (5)	Idiopathic (n=5)
Interviews	6	3	3	68.7	66-74.5	3	2.3-4.5	0 (6)	0 (6)	Idiopathic (n=6)
Australia										
FG 4	7	3	4	76	71.5-79	4	4-6.5	0 (7)	0 (7)	Idiopathic (n=6) PSP (n=1)
Interviews	3	2	1	56	48.5-58	8	6.5-9.5	≤1 (2) ≤3 (1)	≤6 (3)	YOPD(N=3)
Total	**34**	**18**	**16**	**70**	**63.5-75**	**5**	**3-9.3**			

Abbreviations: FG= Focus group; IQR= Interquartile range; PD= Parkinson's disease; PSP= Progressive Supranuclear Palsy; YOPD= Young Onset Parkinson's disease.

Table 2. Methods. Interview guide including question route summary.

No aquatic therapy experience	Aquatic therapy experience
1. What do you know about exercising in water, or what does aquatic therapy mean to you?	1. Thinking back to when you first started aquatic therapy, why did you decide to take part in aquatic therapy?
2. What do you think might be the benefits of aquatic therapy?	2. What benefits do you feel you get from exercising in the water?
3. Do you have any concerns about exercising in the water?	3. Why do you keep going?
4. Considering your Parkinson's disease, what would make it easier for you to participate in aquatic therapy?	4. Did you encounter any difficulties in participating? How can these difficulties be overcome?
5. Because of your Parkinson's disease, what would make participating in aquatic therapy difficult?	5. Would you recommend aquatic therapy to other people with Parkinson's disease?
6. Suppose an introductory session to exercising in water was offered to help familiarise you with moving in water and address any issues you might have. Would you be interested in participating in this session?	6. If you were trying to get other people with Parkinson's disease involved, what would you do/recommend for us to do?
7. If you heard about an aquatic therapy group running for people with Parkinson's disease, would that interest you? If not, why?	7. What might prevent some people from participating? Is there anything we should put in place to encourage more people to take part?
8. If this poster was used to recruit people for an aquatic therapy trial, what would you think? Would it encourage you to participate in aquatic therapy?	8. Thinking about your Parkinson's disease, what types of exercise do you find most beneficial, and are there ones you think we should include? (e.g., balance, walking, aerobic exercises, strength training)
9. Would you prefer to exercise in the water with a group or a one-to-one setting with a physiotherapist?	9. Thinking about the current aquatic therapy group you attend, what are the key things that you think should stay the same, and are there any changes you would like to make to the program?
10. Thinking about your Parkinson's disease, what types of exercise would you like to see included in an aquatic exercise program.	10. Where would you recommend, we advertise the sessions? We have designed recruitment posters, what is your opinion of them?

Data Analysis

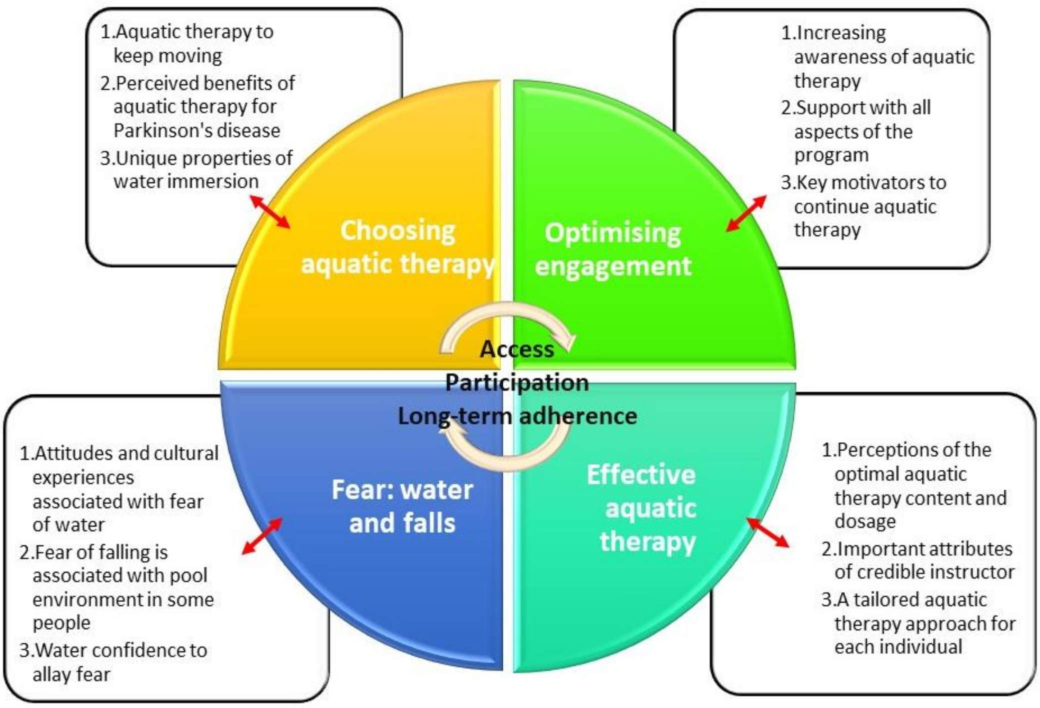
The audio recordings from the interviews and focus groups were transcribed verbatim with any identifying features replaced with anonymous pseudonyms. All audio recordings and transcripts were re-checked for accuracy. The data management software NVivo 12 was used during the analysis.

Inductive thematic analysis was used to analyse the data (Braun and Clarke 2006; Braun and Clarke 2014; Terry *et al.* 2017) using a 15-point checklist of criteria for conducting robust thematic analysis (Braun and Clarke 2006). As part of the familiarisation phase, transcripts were re-read many times by the primary author (LC). Open coding was conducted independently by three researchers (LC, AC, WO'C) on nine transcripts to ensure critical data were not omitted and to offer alternative views of the data (Gale *et al.* 2013; Saldaña 2015, p.55). To increase the trustworthiness of our findings, data generated from focus groups were interpreted from an associational and conversational context. In contrast, data generated from the interviews were analysed from an individual data context (Lambert and Loiselle 2008). The researchers considered each method's contribution to the overall understanding of the phenomenon when performing open coding (Lambert and Loiselle 2008; Carter *et al.* 2014b). A coding index was agreed upon following two face-to-face meetings and used to code all transcripts by LC (Smith and Firth 2011). The process of constructing, revising, and defining themes was conducted at length by the primary author (LC). Final themes and subthemes were discussed and agreed upon by all authors via telephone and video conferencing (Braun and Clarke 2006).

3.4 Results

Four higher-order themes were identified from the data, with 12 subthemes (Figure 1). Some quotes were edited for ease of reading and are connected to the data by either focus group or interview codes (Focus group [FG], Interview [Int]), the country (Ireland [Ire], Australia [Aus]), the focus group participant number (Participant [P]), number of years diagnosed with Parkinson's disease (PD), and level of aquatic therapy experience (years).

Figure 1. Results. Thematic map of emergent four higher-order themes and twelve subthemes.



Theme 1: Choosing aquatic therapy

This theme encompasses why the participants decided to partake in aquatic therapy, including the perceived benefits of aquatic therapy and water's physical properties, making it a unique therapeutic intervention for people living with this condition. (See Chapter 3 Appendices: Appendix C, Box 1).

Subtheme 1: Aquatic therapy to keep moving

All Irish participants with experience of aquatic therapy expressed positive attitudes towards partaking in aquatic therapy sessions. Many participants referred to the reasons for joining an aquatic therapy group as "something to keep us moving." Some participants were encouraged to keep moving by their peers, and aquatic therapy was seen to be enjoyable and something different to try.

Most Irish informants with no aquatic experience expressed interest in trying out aquatic therapy and saw it as another type of exercise to help "push the disease back." Some Australian participants with no experience suggested that starting aquatic therapy early, at the time of diagnosis is essential "to keep your body going," as one participant stated:

> The fitter and stronger you are, the better the resistance to the disease. (FG4, Aus, P7, PD diagnosis ≥4 years, no aquatic therapy).

Subtheme 2: Perceived benefits of aquatic therapy for Parkinson's disease

All participants with aquatic therapy experience in both countries reported positive motor and non-motor benefits from engaging in aquatic therapy. There were many comments on the physical benefits of aquatic exercise relating to freedom of movement, feeling looser, reduced muscle soreness post-exercise, pain relief, reduced joint loading, enhanced well-being, and being able to "move better" in a pool. One Australian interviewee described the physical benefits of swimming compared to other land-based activities as:

> I definitely feel looser, less - I've forgotten the correct term, but less rigidity in my muscles after I swim. That's the main thing. I just feel less tight, less tense, for a period of time afterward. (Int8, Aus, PD diagnosis ≥5 years, aquatic therapy ≤1 year)

Subtheme 3: Unique properties of water immersion

Participants described the unique hydrostatic properties such as buoyancy, viscosity, drag forces, and hydrostatic pressure in various terms as beneficial in facilitating better movement and physical functioning. For instance:

> It's much easier to move your arms or your legs, all your limbs, there is no problem with movement while you are in water. (FG3, Ire, P1, PD diagnosis ≥5 years, no aquatic therapy)

Participants in one focus group agreed that the buoyancy effects of water enable them to succeed at doing "more complicated things" or physical activities, which are more challenging to do on land:

> I wouldn't be able to do the jumping jacks outside, I tried, but I didn't get anywhere. (FG1, Ire, P5, PD diagnosis ≥4 years, aquatic therapy ≤3 years)

Experienced participants discussed how warm water and the effects of buoyancy could reduce muscle tightness and aid relaxation, as one informant stated:

> And then when I'm really tired, and I'm finished exercising, I can just float, and that just relaxes me. (Int7, Aus, PD diagnosis ≥11 years, aquatic therapy ≤3 years)

Some participants with no aquatic experience across countries envisaged that the water’s resistance might be beneficial for Parkinson’s disease:

> I would imagine in water with that resistance, with that flow, with that stimulation of your muscles, it would be an awful benefit to me. I can see the benefit. (Int1, Ire, PD diagnosis ≥2 years, no aquatic therapy)

Theme 2: Fear: water and falls

Fear was an emotion intensely described by some participants with and without the experience of aquatic therapy. It was described in relation to a phobia of water stemming from life experiences or a perceived threat of falling associated with the aquatic environment. This theme addresses participants' attitudes and past cultural experiences in cultivating a fear of water or falling connected with the pool environment. It also encompasses people with Parkinson’s disease's opinions about participating in water confidence sessions to familiarise them with the aquatic therapy environment, thus addressing potential intrinsic and extrinsic barriers. (See Chapter 3 Appendices: Appendix C, Box 2).

Subtheme 4: Attitudes and cultural experiences associated with fear of water

Three Irish participants with no previous aquatic experience openly described a fear of water, which "you grow up with" resulting from one participant witnessing a drowning in their youth or from their parent's perceptions of water:

> It comes from your parents, am, they didn't like water, so I didn't. (Int6, Ire, PD diagnosis ≥22 years, no aquatic therapy)

Two Irish participants with aquatic experience described overcoming a lifelong fear of water when they joined a community-based aquatic group for Parkinson’s disease:

> I was afraid of water, afraid of going in there like, I was scared stiff, and I think I broke that. I wouldn't have come again, only for the two (group members). (FG1, Ire, P1, PD diagnosis ≥4 years, aquatic therapy ≤3 years)

A few participants discussed the fear associated with being out of one's depth in the pool and not being able to swim as possible barriers, which might negatively influence aquatic therapy participation:

> The biggest problem is with people that can't swim; they think they are going to drown (FG2, Ire, P4, PD diagnosis ≥10 years, aquatic therapy ≥5 years)

Subtheme 5: Fear of falling is associated with the pool environment in some people

Some participants associated environmental features such as wet tiles, transfers, and water immersion with an increased risk of falling or slipping. This may have implications for people with Parkinson’s disease, who may already have a fear of falling on land associated with movement disorder symptoms, such as postural instability and gait freezing. For instance:

> I'm not steady on my feet anyway, so I have a little bit of worry that I would fall (FG3, Ire, P4, PD diagnosis ≥3 years, no aquatic therapy)

Several Irish participants questioned why some adults with Parkinson’s disease dropped out of their aquatic therapy group. One participant, who ceased aquatic therapy after attending just one session, suggested a fear of falling and limited water confidence as possible reasons for this non-attendance:

> When I went in first, I had to hold on, and I think I took a few steps without holding on to anything, and am, panic sets inside in me. (Int4, Ire, PD diagnosis ≥3 years)

Physical supports and stringent safety measures when walking on the tiles outside the pool; access to a chair lift and support aids in the pool, were discussed to alleviate fall risks. While remaining within a comfortable water depth was highlighted by many Irish participants to increase participant's confidence.

Subtheme 6: Water confidence to allay fear

While fear of water was discussed across both countries, finding out if participants "have got a fear of water" was suggested as crucial information for healthcare professionals to obtain when screening patients. Participants with no aquatic experience (n=18) discussed if introduction sessions with a healthcare professional, either one-to-one or in a small group, would ease potential fears or anxieties associated with water immersion. Overall, Irish participants agreed that participating in these sessions would help "get information and the correct procedures" from the outset. Furthermore, participants suggested that these sessions could help people with Parkinson's disease to feel safe and more confident before joining an already established aquatic therapy group:

> Even if it's a group of four people, and we are all starting as equals, I think that's a very good idea (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy).

Some participants with aquatic experience agreed that it could help to decrease "fear of the unknown":

> Ya, give people an idea of what they might be doing because ah, the fear would go out of it then if they knew. (FG2, Ire, P6, PD diagnosis ≥13 years, aquatic therapy ≥5 years)

In contrast, the Australian focus group participants expressed that "it would depend on the program" provided. Some Australian participants were not keen to attend sessions for reasons non-related to fear of water or fall risk.

Theme 3: Effective aquatic therapy

This theme encompasses participant's perceptions around the optimal features of an aquatic therapy program, key attributes of the aquatic therapy instructor in implementing the program and their role in targeting specific Parkinson's impairments, and the grouping of classes by the level of disease severity. (See Chapter 3 Appendices: Appendix C, Box 3).

Subtheme 7: Optimal aquatic therapy content and dosage

Some participants who had previously engaged in aquatic therapy suggested more than one session per week as an optimal frequency.

> I found once a week wasn't enough; that's why I went to (public pool), so I could get maybe a session Monday or Friday, to top up. (FG2, Ire, P1, PD diagnosis ≥3 years, aquatic therapy ≤3 years)

In contrast, a few participants suggested that a lack of time might inhibit people from attending more than one session per week. Participants suggested performing aquatic therapy at a "reasonably vigorous" or challenging intensity level to reap the aquatic program's full benefits. Where pool access is not readily available, healthcare professionals may need to provide other options for adults with Parkinson’s disease to carry out additional land-based exercises, as one Irish participant suggested:

> You would need to be doing something in between. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy)

Almost all participants across both countries agreed that "a good variety" was favourable, with "the more activities, the better." Participants recommended structured activities such as walking, aerobic conditioning, resistance, balance, and stretching exercises be included in the program. Irish participants with aquatic experience spoke positively about doing fun and varied exercise tasks, as one participant described a dual-task activity:

> They (balls) are different textures and weights, you know, and once you get in, you lose the focus on yourself or what I am not able to do, and your focus is on the ball. (FG2, Ire, P3, PD diagnosis ≥3 years, aquatic therapy ≤3 years)

Some participants expressed a preference for or an interest in doing swimming as part of the aquatic program:

> Because every part of your body is moving then. (FG3, Ire, P2, PD diagnosis ≥9 years, no aquatic therapy)

Subtheme 8: Important attributes of a credible instructor

All participants agreed that a qualified healthcare professional should deliver aquatic therapy to ensure they were “doing the right exercise” for their movement disorder impairments and was a “big attraction” for joining and continuing aquatic sessions. Some participants discussed the importance of an instructor who can easily integrate new participants and adapt the exercises to everyone’s level. A confident heath care professional who "imparts that confidence to us" with Parkinson’s disease experience were other key attributes described to motivate and engage participants in aquatic therapy. For instance:

> They (physiotherapists) can pick out certain things, different things that would bother me, my balance. I find balance difficult, and it is fabulous what they can do with the buoyancy of the water, but like, they will notice people who maybe need to do more of this or that, they'll pick it out. (FG2, Ire, P3, PD diagnosis ≥3 years, aquatic therapy ≤3 years)

Subtheme 9: A tailored aquatic therapy approach for each individual

Most participants agreed that aquatic therapy programs should be personalised according to the individual's different motor impairments. For instance, one participant with Young Onset Parkinson’s disease described how swimming could help reduce symptoms of stiffness:

> Everyone seems to have such different symptoms. If they said, "I feel tight and sore and stiff," I'd say, "Maybe try some hydrotherapy pool, go for a swim in that." (Int8, Aus, PD diagnosis ≥5 years, aquatic therapy ≤1 year)

A few participants with no prior aquatic therapy experience discussed categorising people according to their level of physical function and ability, for example:

> I think you want to try and get people with similar disabilities to form one group so that they get an exercise program that would be way better for that group. (FG4, Aus, P6, PD diagnosis ≥1 year, no aquatic therapy)

Participants expressed mixed opinions around this. One Australian interviewee described their reluctance to join an aquatic group, as they associate it with an older demographic of people with Parkinson’s disease. In contrast, one Irish participant stressed that a mixed abilities group would be "encouraging," especially being able to "talk to" people with more advanced Parkinson’s disease. While smaller size groups or one-to-one sessions with a qualified therapist were suggested for people with advanced Parkinson’s disease:

> You’d feel more comfortable having someone there to support you, it’s not a big class, and you’re not getting lost in it. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)

Theme 4: Optimising engagement

Ways to promote engagement in aquatic therapy for people with Parkinson’s disease were identified and are discussed under the subthemes: information to raise awareness of aquatic treatment, support with all aspects of the program, and key motivators to continue aquatic therapy. (See Chapter 3 Appendices: Appendix C, Box 4).

Subtheme 10: Increasing awareness of aquatic therapy

Irish informants with aquatic experience discussed lack of information as one reason for the limited uptake of aquatic therapy among their local Parkinson’s disease population:

> Because sometimes people would just refuse it and say no, we wouldn't be interested, because they don't know what's involved. (FG2, Ire, P5, PD diagnosis ≥12 years, aquatic therapy ≥5 years)

Many Irish participants with no aquatic experience admitted knowing "nothing" or "very little" about what it entails for the Parkinson’s disease population. Some participants associated it with swimming, aqua aerobics for weight loss, or as a means of easing back pain.

Educating people around benefits, safety, cost, prior ability level, and keeping group numbers low were highlighted to consider when developing aquatic programs for people with Parkinson's disease. Participants recommended that this information be accessible through Parkinson's disease support groups, websites, newsletters, and "word of mouth" amongst peers suggested as most useful. Doctors, healthcare professionals, and Parkinson's disease specialist nurses were also indicated as essential sources of information to:

> Sell the concept that there is an exercise benefit for Parkinson's patients. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy).

Subtheme 11: Support with all aspects of the program

Support around flexible class times, the timing of medication, transport, and pool access, to limit reliance on carers were other extrinsic factors discussed, which may need to be considered by service providers. Financial support from the National Disability Insurance Scheme (NDIS) was another critical concern for most Australian participants accessing local aquatic sessions free of charge.

Many participants agreed that for "only one or two people with severe Parkinson's," that showering, and dressing could be "troublesome." Having to rely on a carer or peers for showering and dressing support was suggested as one potential barrier to long-term participation. However, most participants thought they could do this activity reasonably well. Similarly, a small number of participants with no aquatic experience described showering and dressing as an "inconvenience," particularly "getting wet and getting cold, and getting dressed."

Subtheme 12: Key motivators to continue aquatic therapy

Most participants discussed the group element and the importance of peer support as a fundamental reason for continuing aquatic therapy. Almost all participants emphasised the importance of group camaraderie and meeting other people with Parkinson's disease to share their personal experiences:

> But the social side of it, you know when you meet people. Even in the dressing room or changing room inside, you know, you'll hear the next person's story, and you kind of say well hello now I'm not altogether that bad, you know. (FG2, Ire, P5, PD diagnosis ≥12 years, aquatic therapy ≥5 years)

Some Irish participants recommended having more time before or after the aquatic session to socialise among the group members. A young Australian participant who swims weekly discussed how the social camaraderie of chatting to another swimmer in the pool is as important as how many laps they achieve:

> We may not do as many laps, but that's not a big deal (Int8, Aus, PD diagnosis ≥5 years, aquatic therapy ≤1 year)

Seeing physical improvements in other group members was suggested to be incredibly motivating for continuing the aquatic program. Furthermore, the structured and organised elements of aquatic therapy sessions, described as being "laid on a plate for you," was another essential motivating factor:

> I just think it would help - it is an organised activity for stretching in a group environment, so more motivation to do it than by yourself. I mean, we all know we should stretch. But if you partake in an organised group activity, I believe the likelihood of you performing the activities is much higher. (Int8, Aus, PD diagnosis ≥5 years, aquatic therapy ≤1 year)

3.5 Discussion

This qualitative study provides greater clarity and insight into factors influencing community aquatic therapy's access and participation for people living with Parkinson's disease. Most participants reported "wanting to keep moving" as an important influencing factor for uptake in aquatic therapy, matching findings from earlier literature (Pentecost and Taket 2011; Chard 2017). All participants who had aquatic therapy experience-reported holistic benefits such as enhanced well-being, feeling looser, less stiffness, and moving more freely. Participants often associated these benefits with warm water or the hydrostatic effects of water immersion. However, these meaningful benefits are not always captured nor reported in the quantitative literature (Mulligan *et al.* 2018; Carroll *et al.* 2020). It is recommended that future research further capture and quantifies the extent to which the unique properties of water immersion can benefit this population by using suitable standardised outcome measures and including qualitative interviews (Claesson *et al.* 2020).

Fear was a recurrent theme reported by a small sample of participants. Some participants reported fear of falling in the pool environment as a perceived risk associated with aquatic therapy. This finding reflects Elsworth et al. (2009), which highlighted safety issues relating to wet tiles and pool hoist availability as sources of fear and worry for people with neurological conditions, including Parkinson's disease, engaged in swimming as physical activity. Another source of anxiety reported was childhood experiences, family influences, and witnessing a traumatic event. Fear of water has a prevalence rate of 2.3% across the lifespan (Wardenaar *et al.* 2017) and is commonly associated with negative past experiences (Misimi *et al.* 2020) and parental influences (Pharr *et al.* 2014). However, alternative research findings suggest that water fear may develop organically in the absence of predisposing factors or adverse incidents (Menzies and Clarke 1993; Graham and Gaffan 1997). Some of our participants reported not being able to swim or stay within a comfortable water depth during water immersion as another potential fear source. Irwin et al. (2015) found that fear of drowning is a strong predictor of limited or no swimming ability in children and adolescents, with subsequent water avoidance continuing into adulthood (Pharr *et al.* 2018; Misimi *et al.* 2020). Clinically, water immersion is thought to offer a safe therapeutic environment for targeted interventions, such as balance training in people with chronic neurological conditions, due to a reduced injury and falls risk (Gresswell and Maes 2000; Becker 2020). A recent Parkinson's disease feasibility trial by Terrens et al. (2020) found aquatic physiotherapy in a group setting was safe, with no adverse events or falls reported in either aquatic intervention group. Most of our study's participants agreed that there might be a benefit for conducting water confidence sessions in a one-to-one or a small group setting, prior to participating in aquatic therapy programs, to help overcome possible fears. Exposure-based interventions are considered the gold standard for treating particular phobias (Sherman 1972; Weiss *et al.* 1998; Wolitzky-Taylor *et al.* 2008). A recent one-session fear of flying trial demonstrated that the participants responded positively to support and positive reinforcement from other group members (Wannemueller *et al.* 2020). Future research and clinical practice may draw from aspects of the Halliwick Concept, which incorporates mental adjustment as one approach to facilitate water competence (Gresswell and Maes 2000).

Similar to other Parkinson's disease literature findings (Elsworth *et al.* 2009), participants stressed that slowing the disease progression was an important consideration when designing an aquatic program. Many participants supported early access to regular aquatic therapy sessions (one or more sessions per week), performed at a reasonably vigorous intensity, and with the inclusion of a variety of aquatic approaches described as preferable. These findings are in accordance with some of the key exercise principles described by Fox et al. (2006) to promote neuroplasticity in Parkinson's disease (Petzinger *et al.* 2013; Conradsson *et al.* 2015; Hirsch *et al.* 2018). According to Frazzita *et al*. (2013) and Morris *et al.* (2017), positive rehabilitation outcomes are related to the frequency, duration, level of complexity, and number of exercise repetitions performed. In the absence of robust trials confirming the optimal aquatic therapy dosages (Carroll *et al.* 2020), including the preferences and needs of people with Parkinson's disease may promote greater long-term adherence to aquatic therapy.

All participants agreed that tailoring aquatic interventions to their individual needs is essential to ensure long-term adherence. The literature is consistent in recommending that rehabilitation programs aim to target each person's specific goals and impairments to improve treatment outcomes (Abbruzzese *et al.* 2016). Interestingly, there were mixed opinions among our study's participants about separating aquatic therapy groups according to disability levels. Rocha et al. (2017) reported that grouping, according to disability levels, may be viewed as discriminatory, particularly by people with more advanced symptoms. Adapting aquatic exercises to target specific Parkinson's disease impairments, along with the integration of new participants into a group of mixed levels, were also found to be important motivators for continued exercise adherence in previous dance related studies (Rocha *et al.* 2017; Zaman *et al.* 2019).

Many participants highlighted the importance of attending aquatic therapy with a suitably qualified professional who has a sound theoretical understanding of Parkinson-related impairments and is in line with previous research findings (Lindqvist and Gard 2013; Cleary *et al*. 2020). Elsworth et al. (2009) found that people with neurological conditions feel more confident doing physical activity with a physiotherapist's support. Similar to our findings, ongoing support and reassurance from credible exercise leaders were reported to be central for ensuring people with Parkinson's disease continue to exercise long-term (Elsworth *et al.* 2009; Crizzle and Newhouse 2012). Providing reassurance and clarification around issues such as safety, group size, and prior swimming ability were suggested by participants, to enhance aquatic therapy uptake amongst the Parkinson's disease population.

Barriers to participation in aquatic therapy reported by some participants included a lack of credible information sources, transport, and cost. These are similar barriers to exercise participation in other Parkinson's disease literature (Slade *et al.* 2020; Tan *et al.* 2020). A recent feasibility study reported low levels of uptake in aquatic physiotherapy amongst people with Parkinson's disease, with transport issues, a primary reason for declining to partake in the trial (Terrens *et al.* 2018). 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. Likewise, Pentecost and Taket (2011) demonstrated that the perceived benefits of exercise and exercise compliance were found to be closely linked in people with non-neurological chronic conditions. Other barriers identified in this study relating to dressing and showering care needs, factors unique to swimming and aquatic therapy, which will need to be addressed by service providers when designing and implementing aquatic programs.

Social support and group cohesion were strong motivators for long-term adherence to aquatic therapy. Consistent with recent qualitative literature (Pentecost and Taket 2011; Cleary and Rossi 2020), group socialisation was key to addressing disease-related social isolation and positively influencing people's willingness to continue to exercise (Pentecost and Taket 2011; Zaman *et al.* 2019). Claesson et al. (2020) suggest that taking part in a group-based community exercise program empowered people in the early disease stages to develop positive coping strategies derived from peer support. Our findings reflect those of Claesson et al. (2020), who found that peer socialisation was as crucial as the physical gains achieved from group exercise in some people with Parkinson's disease. Finally, some participants reported a need for a separate space to meet and socialise with their peers after completing the aquatic therapy program, which agrees with findings from dance and exercise literature (Eriksson *et al.* 2013; Rocha *et al.* 2017).

Strengths and Limitations

Although this study is novel and sought people's opinions with Parkinson's disease from two jurisdictions, including almost equal representation across both genders (Ellis *et al.* 2011), there were some limitations. The median number of years diagnosed with Parkinson's disease for our sample was five (IQR, 3-9.3). Thus, the views of adults with early or advanced stages of disability were not reported. This study focused solely on aquatic therapy accessed within community settings. It has become increasingly advocated that people with Parkinson's disease have access to specialist services delivered close to home (Bloem *et al.* 2020). Therefore, our findings may not characterise all opinions of people partaking in hospitals or inpatient aquatic therapy programs.

Despite efforts to ensure rigorous triangulation by integrating both focus groups and one-to-one interviews (Lambert and Loiselle 2008), there may be limitations relating to this method. While all focus group moderators endeavoured to include each participant's viewpoints, not all participants contributed equally to the group discussion. For face-to-face and telephone interviews, where participants were not personally invested in this topic, this may have impacted our ability to gain in-depth information (Braun and Clarke 2013, p.80). Although there were differences between methods, comparison of data sets found similar and complementary findings, which added a more nuanced and richer understanding of factors influencing aquatic therapy participation in people with PD (Carter *et al.* 2014b; Lambert and Loiselle 2008). Therefore, both data sets were equally informative, confirmed by the inclusion of a wide range of perspectives from a large sample of participants across different continents (Lambert and Loiselle 2008). Finally, while we sought cultural perspectives from two countries, the findings may not be generalisable to countries globally beyond Ireland and Australia.

3.6 Conclusion

Aquatic physiotherapy is one choice of exercise for people in the early and mid-stages of Parkinson’s disease. People living with this condition found the unique properties of water help target disease-related impairments. Better access to evidence-based information, qualified instructors, peer support, and a tailored aquatic program were argued to increase access and long-term participation. Future therapies and research trials need to address the fear of water and fall risk expressed by some people with Parkinson’s disease.

3.7 Implications for Rehabilitation

- Aquatic therapy is emerging as an effective physiotherapy approach for managing motor and non-motor symptoms in Parkinson's disease.
- Little is known regarding community-based aquatic therapy programs from the perspectives of people living with Parkinson's disease internationally.
- People with Parkinson's disease may benefit from timely information about the unique benefits, prerequisites, and local aquatic therapy facilities to promote greater uptake of aquatic programs.
- Tailored aquatic therapy interventions delivered within a group setting by a credentialed healthcare professional may increase long-term adherence.

Acknowledgments

The authors would like to acknowledge all the participants in this study and the input of Dr. Joanne Shanahan and Nevin Kazantzi.

3.8 Epilogue

This chapter achieved its aim of identifying factors that might influence people with PD in Ireland and Australia to access and participate in aquatic therapy long-term. This study is novel, as it's the first qualitative study to explore the opinions and preferences of people with PD across two countries, who had previous experience of engaging in community-based aquatic therapy outside of a research trial. Another unique strength of this study is the inclusion of people with no previous experience of engaging in aquatic therapy for PD.

Adherence to physiotherapy interventions and exercise poses a significant challenge for healthcare professionals and researchers as it can limit the effects of exercise, therapy programs, and research trials (Amateis *et al.* 2019). This study enabled us to identify barriers and motivating factors, which if addressed, may promote increased long-term adherence to aquatic therapy for people with PD (Schootemeijer *et al.* 2020). Barriers to starting or engaging in aquatic therapy for people with no prior experience of aquatic therapy included fear of water and or falling relating to the pool environment; while people with experience of aquatic therapy identified a lack of information around the benefits of aquatic therapy, transport, cost, dressing, and showering requirements as other possible barriers. Recently, Terrens *et al.* (2021) conducted focus groups with people with mild to moderate PD following a 12-week aquatic physiotherapy intervention in Australia to explore the attitudes and perceptions concerning this treatment. Similar to our findings, they found that safety concerns around dressing and transport were barriers, while fatigue was also highlighted (Terrens *et al.* 2021). Notably, fatigue was not commonly reported among the participants in our study.

Motivators to engaging in aquatic therapy identified in this study included: classes led by a knowledgeable healthcare professional and instructor, social support and group camaraderie, health and wellbeing benefits associated with water immersion (e.g., warm water, relaxation), and individually tailored programs designed to target PD-specific impairments. Comparably, Terrens *et al*. (2021) found group socialisation and equality, improved motor function, less falls, and feelings of being safe in the water were enablers for engaging in aquatic physiotherapy.

Thus, these barriers and motivating factors will also be considered when developing the consensus statements to inform the aquatic therapy guidelines (chapter 4).

CHAPTER 4:

Evidence-based aquatic therapy guidelines for Parkinson's disease: An international consensus study

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4.0 Prologue

Chapter 3 described the qualitative study, which was an essential part of the thesis project as it enabled us to identify key influencing factors for participation and long-term adherence in aquatic therapy among people with PD. During this research phase, the importance of engaging with people with PD and their value to the research project was evident. Thus, the qualitative study phase enabled me to create confidence among the participants and build relationships, leading to establishing a patient and public involvement panel to inform key aspects of the development of the aquatic therapy guidelines discussed in this chapter. There are growing calls for public and patient involvement (PPI) in research studies, particularly in health and social care research, to enhance research studies' design, development, quality, relevance, and implementation (Crocker *et al.* 2018; Tomlinson *et al.* 2019; Conneely *et al.* 2020). The operational definition 'targeted consultation' was used to describe the level of public involvement in this phase of the thesis, whereby the role of the PPI panel was focused on specific requests and tasks (Hughes and Duffy 2018), such as commenting on the consensus statements and the readability of guideline document. In this chapter, the term stakeholder is used interchangeably with Parkinson's patient and public involvement panel and the Parkinson's panel.

This final study aims to establish expert consensus for statements about the optimum features of aquatic therapy delivery, dosage, intensity, and content. This study also aims to support the clinical decision-making of healthcare practitioners by creating evidence-based aquatic therapy practice guidelines for people living with PD. The guidelines outlined in this chapter were developed based on current research evidence (phase 1), patient values and perspectives (phase 2), and international practice expertise resulting from the Delphi consensus methods adopted in this study.

4.1 Publication and Authorship

Carroll, L.M., Morris, M.E., O'Connor, W.T., Volpe, D., Salsberg, J., and Clifford, A.M. (2021) 'Evidence-based aquatic therapy guidelines for Parkinson's disease: An international consensus study,' *Journal of Parkinson's disease,* 12, 621-637, available: http://dx.doi.org/10.3233/JPD-212881

The author led the conception and development of the research concept, study design, recruitment of the international experts, and established the PPI panel. Louise Carroll also conducted all data collection, analysis, interpretation, prepared and drafted the original manuscript, edited, and submitted the paper for publication. As the primary supervisor, Dr. Amanda Clifford supervised, and contributed to the research concept, study design, data interpretation, reviewed each draft, contributed to and approved the final manuscript draft. Professor Meg Morris, as co-secondary supervisor, supervised and contributed to the research concept, study design, data interpretation, reviewed each draft, contributed to and approved the final manuscript draft. Professor William O'Connor, as co-secondary supervisor, supervised and contributed to the research concept, study design, data interpretation, reviewed each draft, contributed to, and approved the final manuscript draft. All the authors agree with the findings and approved the final submission. Dr. Daniele Volpe contributed to the data interpretation, reviewed each draft, contributed to and approved the final manuscript draft. Dr. Jon Salsberg contributed to the research design and development, reviewed, contributed to, and approved the final manuscript draft. All the authors agree with the findings and approved the final submission.

4.1 Abstract

BACKGROUND: Aquatic therapy is one therapy option for people living with Parkinson's disease (PD). However, optimal prescription, dosage, and delivery remain unclear.

OBJECTIVES: i) To generate consensus statements, ii) to establish evidence-based clinical practice aquatic therapy guidelines for PD.

METHODS: Seventy-three international experts were invited to participate in a 3-step modified Delphi study. Gaps in the aquatic therapy evidence, patient preferences, and stakeholder engagement were considered when developing the initial list of 43-statements identified by the research development group. Practice experts rated each statement on an 11-point Likert scale. Consensus for inclusion was set at a priori of ≥70% of respondents scoring an item ≥7. Two rounds of Delphi questionnaires were completed online, and the expert comments were analysed using content analysis. An online consensus meeting with an expert subgroup (n=10) then advised on the guideline's acceptability and debated items until consensus for inclusion was reached.

RESULTS: Fifty experts participated in the Delphi round one (83% response rate) and 45 in round two (90% response rate), representing 15 countries. In round one, 35 statements met the criteria for consensus. Content analysis informed the revised statements in round two, where 12 of the remaining 16 statements met consensus. The final agreed aquatic therapy guidelines include key information about dosage, content, safety, contraindications, and the optimal aquatic therapy delivery throughout the disease course.

CONCLUSION: Stakeholders, including international practice experts, informed a rigorous evidence-based approach to integrate the best available evidence, patient preferences, and practice expertise to inform these guidelines.

Keywords: Aquatic therapy; hydrotherapy; guidelines; Parkinson's disease; rehabilitation; physical therapy.

4.2 Introduction

Aquatic therapy is rapidly gaining global popularity for people living with Parkinson's disease (PD) (Daniele Volpe *et al.* 2017a; Zhu *et al.* 2018; da Silva and Israel 2019; Becker 2020; Radder *et al.* 2020; Terrens *et al.* 2021). Aquatic therapy is a term used to describe the use of water as an exercise or rehabilitation medium to optimize physical function and participation for people presenting with varying needs and therapeutic goals. (Becker 2009; Irion and Brody 2009; Carroll *et al.* 2017). Based on the hydrodynamic principles of water immersion, including hydrostatic pressure, buoyancy, viscosity, and thermodynamics, aquatic therapy is often used in the management of PD-specific motor and non-motor impairments (Cugusi *et al.* 2019; Carroll *et al.* 2021).

When targeting balance-specific impairments associated with PD such as postural instability, the unique hydrostatic pressure and buoyancy effects of water enhance sensory and proprioceptive input to increase muscle activation (Morris and Geigle 2009), while the therapist's application of turbulence can further challenge postural control (Morris and Geigle 2009; Volpe *et al.* 2014). In addition, engaging in aquatic therapy may yield added therapy benefits over land-based rehabilitation, such as the reduced risk of falls-related injuries and improved brain health (Becker 2020). There is emerging evidence to suggest that aquatic immersion enhances cerebral blood flow (Carter *et al.* 2014a; Pugh *et al.* 2015; Becker 2020), with a recent study demonstrating significant increases in cerebral blood flow following aquatic treadmill training compared to over-land treadmill training in healthy adults (Parfitt *et al.* 2017). In addition, participation in community-based aquatic therapy appears to be well accepted by people with Parkinson's disease (Carroll *et al.* 2021; Terrens *et al.* 2021). It is associated with high levels of adherence (Belza *et al.* 2002; Carroll *et al.* 2017), which is important considering the challenges associated with engaging people with PD in exercise long-term.

There is growing evidence that aquatic therapy is feasible and safe for people with mild to moderate PD (Carroll *et al.* 2017; Terrens *et al.* 2020). Recent meta-analyses showed that aquatic therapy can be as effective as land-based exercise for improving mobility on the Timed Up and Go (MD -1.5 s, 95% CI -2.68 TO -0.32)(Carroll *et al.* 2020), balance on the Berg Balance Scale (MD 3.1, 95% CI 1.2 to 5.0) (Gomes Neto *et al.* 2020), quality of life on the Parkinson's Disease Quality of Life Scale-39 (MD -5.5, 95% CI -11 to -0.7) (Gomes Neto *et al.* 2020), reducing disability on the Unified Parkinson's Disease Rating Scale motor (MD -4.6, 95% CI -7.5 TO 1.7) (Cugusi *et al.* 2019) and fear of falling measured using the Falls Efficacy Scale-I (SMD 0.72, 95% CI 0.19 TO 1.26) (Radder *et al.* 2020). Heterogeneity exists across previous studies, with the results yet to be confirmed by large multi-centred trials (Becker 2020; Carroll *et al.* 2020). Variations in protocols and aquatic approaches, a lack of uniform intensity-level measures, and limited patient follow-up make it challenging for healthcare practitioners to bridge research-to-practice gaps and meet the requirements of evidence-based practice (Sackett *et al.* 1996; Becker 2020). While research showed positive cost-benefits for pain and physical function in people with lower-limb osteoarthritis who participated in a group-based aquatic program (Cochrane *et al.* 2007); no trials have included an economic analysis to compare the cost-benefits of aquatic therapy in comparison with other land-based therapies for people with PD.

Since the research evidence underpinning the application of aquatic therapy in the management of PD is underdeveloped, no consensus exists for key components such as the optimal content, dosage, and delivery of aquatic therapy for people living with PD (Carroll *et al.* 2020). While the European Physiotherapy Guideline for PD (Keus *et al.* 2014) provides high-quality physiotherapy guidance, there are currently no internationally endorsed aquatic therapy guidelines for practitioners overseeing the delivery of aquatic therapy for people with PD. Clinical guidelines can help to facilitate evidence-based practice while also enabling practitioners to use their professional judgment based on the individual client's needs and preferences (Rosenfeld and Shiffman 2009; Veerbeek *et al.* 2014). The development of PD-orientated practice guidelines informed by an evidence-based practice framework (Kent 2019) and complemented by consensus statements can provide healthcare professionals with practical recommendations for safe and effective aquatic therapy delivery (Keus *et al.* 2014; Jünger *et al.* 2017). Furthermore, research has shown that using consensus guidelines to provide evidence-based best practice care can improve the overall quality of healthcare (Eubank *et al.* 2016).

The aims of this study were twofold. First, to establish consensus for statements about the optimal delivery, dosage, intensity, and content of aquatic therapy. Secondly, to support the clinical decision-making of healthcare practitioners by developing evidence-based aquatic therapy practice guidelines for people living with PD. These guidelines were developed based on current research evidence, patient values and perspectives, and international practice expertise resulting from the Delphi process. The overarching research question was:

> What are the key considerations and components of an aquatic therapy program to inform the content of an aquatic therapy guideline for Parkinson’s disease?

4.3 Methods

Similar to previous research, we employed a modified Delphi method to obtain expert opinion and gain international consensus to inform the practice-led component of the aquatic therapy guidelines (Figure 1) (Slade *et al.* 2014; Eubank *et al.* 2016; Hanson *et al.* 2020). The Delphi technique adhered to specifications in "Conducting and Reporting of Delphi Studies" (CREDES) (Jünger *et al.* 2017) and previous publications (Diamond *et al.* 2014). This was to ensure a high measure of scientific rigor, credibility, and accuracy of the research outcomes (Sandrey and Bulger 2008). The Delphi technique was chosen as it does not require face-to-face contact, thus reducing selection bias by facilitating international experts to participate (Trevelyan *et al.* 2015). The ease of access to the online Delphi questionnaires, and anonymity between experts, enables practice experts with divergent backgrounds to share their clinical knowledge and expertise without judgment (Black *et al.* 1999; Trevelyan *et al.* 2015). The Delphi technique is widely used as a process for making the best use of available information (Sandrey and Bulger 2008) particularly when the existing research evidence is conflicting or inconclusive, which was the case in this study (Black *et al.* 1999; Trevelyan *et al.* 2015; Carroll *et al.* 2020). The Reporting Items for practice Guidelines in HealThcare (RIGHT) checklist was utilized to further ensure the correct development and reporting of the guidelines (Chen *et al.* 2017).

Ethics

This research received ethical approval from the University's Faculty Research Ethics Committee (Ref: 2020_02_17_EHS). All stakeholders and experts named in the acknowledgments provided their written consent.

Research development group

The project was led by an experienced research team (the six listed authors) with extensive clinical practice and research proficiency in PD. They represented several disciplines (physiotherapy, neuroscience, implementation science, and medicine) from Ireland, Australia, and Italy. Four stakeholders representing people living with PD, residing in Ireland, and who had previous aquatic therapy experience (n=2) formed our Parkinson's patient and public involvement panel (here forward referred to as the Parkinson's panel). As part of the Delphi process, we asked the recruited experts to score aspects specific to clinical practice arising from gaps in the research evidence. As this was considered beyond the scope of lay participants, the Parkinson's panel engaged in online consultation meetings during the entire research process. The panel also provided feedback to develop and refine the final guidelines.

Recruitment of international experts

In the context of this study, the term expert was defined as "healthcare professional, researcher, or academic with expertise in the treatment, service provision, research or analysis of aquatic therapy for people with Parkinson's disease." The inclusion and exclusion criteria were determined in line with this definition. Similar to previous research (Hanson *et al.* 2020), snowballing and non-random purposive sampling were used to recruit a sample of more than 25 participants. This allowed for an anticipated dropout rate of 5%, in line with earlier research that recommends a minimum of 20 participants as an optimal sample size (Okoli and Pawlowski 2004).

From May to July 2020, experts were given study information by email and social media platforms (Figure 1). We also advertised by email through national and international special interest groups (such as the Aquatic Therapy Association of Chartered Physiotherapists, Australian Physiotherapy Parkinson's Community of Practice, Irish Society of Chartered Physiotherapists, International Aquatic Therapy Faculty, International Organization of Aquatic Physiotherapists). Prospective participants contacted the lead researcher (LC) and were assessed for eligibility. We intended to achieve a balance of international experts (male and female) from different geographical locations. In this regard, additional efforts were made to recruit experts from the USA and Canada to participate in the consensus meeting process and review the final guidelines. Endeavours to contact researchers and clinicians through appropriate organizations *via* email and social media platforms were unsuccessful.

Guideline scope

The population targeted by the guidelines

These guidelines are appropriate for adults with mild to advanced levels of disability (Hoehn Yahr stages 1-4) resulting from a diagnosis of Parkinson's disease, including idiopathic Parkinson's disease, Progressive Supranuclear Palsy, and Young Onset Parkinson's disease. The guidelines may also be appropriate for some people presenting with co-morbidities. However, it is advised that these individuals be screened by a qualified healthcare professional before commencing aquatic therapy.

Potential users of the guidelines

These guidelines were principally developed for physiotherapists treating people with Parkinson's disease in an aquatic therapy setting. Other potential users could include suitably qualified health care professionals (e.g., occupational therapists), exercise scientists, medical doctors, physical medicine, and rehabilitation physicians, along with people living with Parkinson’s disease, their families, and carers.

Evidence-based approach

Using the Delphi method, we employed a rigorous evidence-based practice (EBP) approach to integrate the best available evidence, patient values, clinical and research expertise to inform the guidelines (Michie *et al.* 2005; Rosenfeld and Shiffman 2009; Kent 2019). For the EBP pillar, 'best external evidence,' a recent systematic review and meta-analysis (Carroll *et al.* 2020) of 14 randomized controlled trials (RCTs) exploring the optimal aquatic therapy dosage by applying the frequency, intensity, duration, type (FITT framework), was used to identify research gaps and inform the consensus statements. The systematic review, which was conducted by some of the authors (LC, MM, WO’C, AC), explored the effects of aquatic therapy on gait, balance, motor disability, functional mobility, falls, health, and wellbeing outcomes in people with idiopathic Parkinson's disease (Carroll *et al.* 2020). The quality of the RCTs was evaluated using the PEDro rating scale (de Morton 2009). Secondly, the EBP pillar, 'Patient values and perspectives,' was incorporated through the Parkinson's panel, along with a recent qualitative study (Carroll *et al.* 2021). This qualitative analysis (Carroll *et al.* 2021) was also conducted by some of the authors (LC, MM, WO’C, AC) and explored the preferences and opinions of people with PD about factors such as access to, participation in, and long-term adherence to aquatic therapy. The systematic review (Carroll *et al.* 2020) and qualitative research findings (Carroll *et al.* 2021) were synthesized, with gaps in the research identified and used to inform the content of the original statement list. In consultation with the Parkinson's panel, the research team converted the list of statements into the Delphi questionnaire format under the headings: aquatic therapy delivery, location and pool environment, safety and supports, tailored aquatic program, dosage (frequency, intensity, duration), and elements of aquatic therapy. For the final EBP pillars, we sought to incorporate the 'clinical expertise' of the internationally recruited experts within the 'context' of the modified Delphi process, to inform and agree on the final aquatic therapy practice guidelines.

The Delphi process

The process of consensus-building and exploring the optimal aquatic therapy features for people with PD consisted of two rounds of online Delphi questionnaires (Figure 1) using Qualtrics v2020 software (Provo, UT, USA) and an international consensus meeting. Only participants who completed round one were invited to complete round two. Follow-up email reminders were sent to non-responders 14-days after the original email invitation.

The round-one questionnaire was piloted with six qualified healthcare professionals independent of the study, with their feedback used to refine the format and readability of certain statements and questions. No statements were added or deleted following the piloting phase. In Delphi round one, an opening question asked participants to consider if aquatic therapy guidelines are needed (yes; no; maybe). Participants were instructed to score each of the 43 statements on an 11-point Likert scale (0= unimportant, do not include in the guidelines; 10= very important, must be included in the guidelines) and invited to add comments explaining their clinical reasoning. Participants were informed that a score of seven or above signified agreement (Slade *et al.* 2016; Hanson *et al.*

2020). In addition, four single-choice questions and one multiple-choice question were included to explore opinions around dosage and types of aquatic therapy approaches adopted within clinical practice.

In Delphi round two, those statements not meeting the criteria for consensus, including the single and multiple-choice questions, were refined based on the participant's collective scores and their qualitative feedback. Any changes made to the statements for round two were done via an online discussion by the research development group and the Parkinson's panel. An anonymized summary of the participants' responses and their round one scores were then disseminated along with the round two questionnaire.

Data analysis

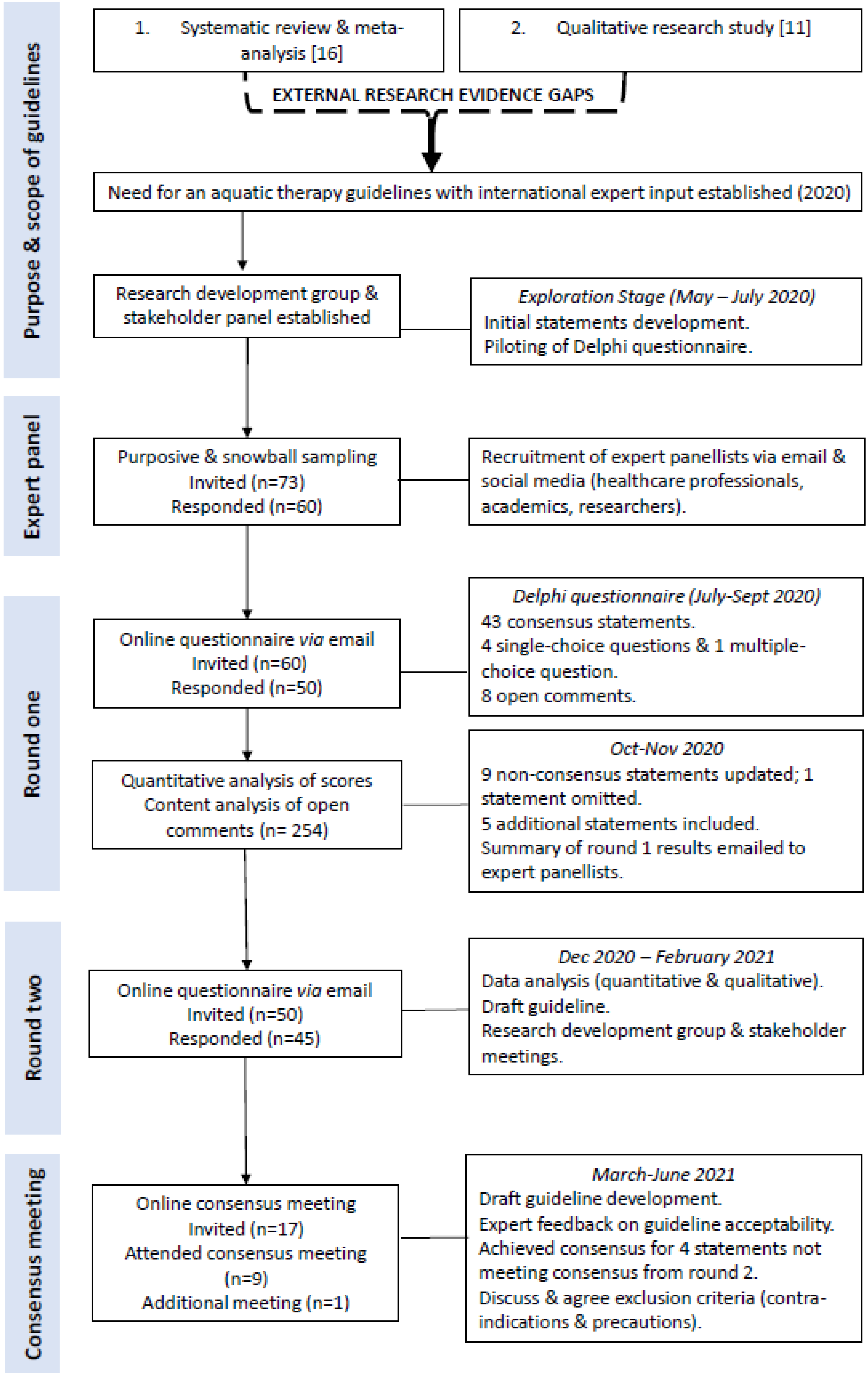
Quantitative data analysis for all Delphi questionnaire rounds were analysed by the first author in consultation with a senior biostatistician, using SPSSv26 (IBM, NY, USA). Consensus was defined as an a priori median score of ≥7, rated by 70% or more of the experts' (Slade *et al.* 2016). The median and interquartile ranges were applied as they are considered more robust to outlier influences (Trevelyan *et al.* 2015). A combination of descriptive statistics and frequency distributions was conducted to analyse all quantitative data.

The first author, who was experienced in qualitative analysis, collated all open comments for analysis (Keeney *et al.* 2011; Hanson *et al.* 2020). A conventional content analysis approach was used to analyse all qualitative data, ensuring that the knowledge generated was grounded in the data, and captured the participant's knowledge, expertise, and clinical reasoning process (Hsieh and Shannon 2005; Keeney *et al.* 2011). Following round one, the anonymized qualitative data were coded separately by two reviewers (the first author and an experienced post-doctoral researcher) to establish and agree on an initial coding scheme (Keeney *et al.* 2011, p.73). The first author completed the rigorous process of grouping and categorizing the data from both Delphi rounds (Elo and Kyngäs 2008).

Consensus meeting

A consensus meeting was convened online *via* Zoom (Zoom Video Communications Inc., 2021) to review a draft version of the guidelines. A subgroup of panellists (n=17) who completed both Delphi rounds were invited to partake in the consensus meeting. Potential panellists were asked based on their level of aquatic therapy expertise (≥ 6 years) and experience treating people with PD (Table 1). A draft of the guidelines presented as a two-page infographic, a preamble, and a list of all statements was shared with the expert subgroup two days before the meeting for them to review. During this meeting, experts were requested to discuss and comment on the guideline's acceptability and establish if they represented current best practices. Four polls were completed amongst the experts for the four statements not meeting consensus from the Delphi round two questionnaire (Table 2). A checklist for screening those with PD before partaking in aquatic therapy, including risk factors and precautions, was reviewed and debated by the subgroup. The first author chaired the meeting with other research team members in attendance (MM, AC) and lasted approximately one hour. Due to different time zones, an additional meeting occurred with an expert from the USA (n=1). This meeting followed a similar format to the consensus meeting, with a summary of key discussion points from the first meeting provided where further context was required.

Figure 1. Guideline development process



4.4 Results

Forty-five experts (female n=37; male n=8) representing 15 countries completed both rounds of the Delphi questionnaire (Table 1). Most (n=38, 84%) were qualified physiotherapists. Eight participants were involved in or had previously completed aquatic therapy research in the field of Parkinson's disease.

Round one

Fifty experts completed round one's questionnaire (83%). The majority (88%, n=44) of respondents agreed that aquatic therapy guidelines for people with Parkinson's disease were required, with 12% (n=6) answering 'maybe.' Twelve of the forty-three statements included in round one did not meet consensus (see Chapter 4 Appendices: Appendix B, Table 3). The research team excluded one statement after round one because it scored ≤1, with only 14.1% of the panellists scoring it seven or more (Table 2). Data gathered from the single and multiple-choice questions are presented in chart format within the supplementary material (see Chapter 4 Appendices: Appendix B, Figures 4-8). The six open comments generated a total of 253 comments, an average of five per expert. The inductive content analysis yielded five main categories and 17 generic categories (see Chapter 4 Appendices: Appendix B, Table 4).

Round two

Forty-five experts completed round two (90% response rate). Consensus for inclusion was attained for 12 of the 16 Likert statements (consensus range 72.7 -97.7%) (see Chapter 4 Appendices: Appendix B, Table 5). Agreement was achieved for the four statements (Md ≥7) without reaching consensus (53.3-66.7%) (Table 2). The open comments generated 121 comments, an average of 2.6 comments per expert. Content analysis of all available comments yielded no other categories.

Consensus meeting

Overall, there was consensus among the panel of experts (n=10) from eight countries that the guidelines were acceptable and representative of clinical practice. Consensus was also achieved for the four statements not reaching agreement from round two (Table 2; see Chapter 4 Appendices: Appendix B, Table 6), where ≥ 70% of participants scored the poll ‘yes’ to include the statements in the guideline recommendations. Before poll voting, the statements were refined according to expert feedback (see Chapter 4 Appendices: Appendix B, Table 6 and 7) along with the expert's recommendations for amendments to the guideline infographic (see Chapter 4 Appendices: Appendix B, guideline infographic).

Table 1. Gender, professional expertise, academic profile, and demographic breakdown of the internationally recruited expert group.

	Delphi Online Questionnaire		Consensus meeting
	Round 1	Round 2	
Expert sample size (n)	50	45	10
Gender (female: male)	42:8	37:8	9:1
	% (n)	**% (n)**	**% (n)**
Healthcare profession (some listed more than one)			
Physiotherapist /Physical therapist	86 (43)	84.4 (38)	90 (9)
Exercise scientist	4 (2)	-	-
Kinesiologist	2 (1)	4.4 (2)	-
Medical doctor	6 (3)	4.4 (2)	10 (1)
Aquatic therapist	2 (1)	-	-
PD nurse specialist	2 (1)	2.2 (1)	-
Other	2 (1)	4.4 (2)	-
Highest academic qualification (some listed more than one)			
Undergraduate diploma	4 (2)	2.2 (1)	-
B.Sc.	50 (25)	51.1 (23)	50 (5)
M.Sc.	18 (9)	20 (9)	20 (2)
PhD	24 (12)	26.7 (12)	20 (2)
M.D.	6 (3)	4.4 (2)	10 (1)
Aquatic therapy experience	90 (45)	97.7 (42)	100 (10)
0-5 years	30 (15)	33.3 (15)	-
6-15 years	28 (14)	31.1 (14)	30 (3)
16+ years	32 (16)	28.9 (13)	70 (7)
Current Parkinson's disease caseload			
All of the time	24 (12)	22.2 (10)	20 (2)
Frequently	36 (18)	40 (18)	60 (6)
Sometimes	32 (16)	31.1 (14)	20 (2)
Rarely	8 (4)	6.7 (3)	-
Research experience: Parkinson's disease & aquatic therapy	16 (8)	17.8 (8)	30 (3)
Country			
Argentina	2 (1)	2.2 (1)	-
Australia	28 (14)	28.9 (13)	30 (3)
Brazil	6 (3)	4.4 (2)	-
Ireland	4 (2)	4.4 (2)	-
Israel	2 (1)	2.2 (1)	10 (1)
Italy	14 (7)	15.6 (7)	10 (1)
Netherlands	2 (1)	2.2 (1)	10 (1)
Portugal	4 (2)	4.4 (2)	10 (1)
Singapore	2 (1)	2.2 (1)	-
South Africa	2 (1)	2.2 (1)	-
Spain	6 (3)	6.7 (3)	-
Thailand	6 (3)	4.4 (2)	-
Turkey	2 (1)	2.2 (1)	10 (1)
United Kingdom	16 (8)	13.3 (6)	10 (1)
USA	4 (2)	4.4 (2)	10 (1)

Table 2. Delphi round one and Delphi round two statements meeting international expert consensus, those not meeting consensus, and those omitted with weighting and scores

		Statements	Md	IQR	% Score
1. Aquatic therapy delivery	1	It is important that people with Parkinson's disease begin aquatic therapy as early as possible/ immediately after receiving their diagnosis.	7	4	70
	2	It is important that a suitably qualified therapist (e.g., physiotherapist or aquatic physiotherapist) prescribes individualized exercises as part of the aquatic therapy program.	9	2	90.9
	3	Depending on individual needs, some people with Parkinson's disease should receive one-to-one aquatic therapy session(s) with an aquatic physiotherapist prior to joining group-based aquatic therapy.	9	2	95.5
	4	It is important that people with Parkinson's disease become confident exercising in water before beginning targeted aquatic exercises for their impairment.	8	4	72
	5	It is important that all aquatic therapy activity undertaken by people with Parkinson's disease is supervised by a healthcare professional or suitably qualified people (e.g., therapy assistants).	9	5	72
	6	It is important to have a checklist for identifying the exclusion criteria for aquatic therapy participation in Parkinson's disease.	10	1	96
	7	People with Parkinson's disease admitted to inpatient services (e.g., hospital, rehabilitation centers), can benefit from access to aquatic therapy services.	9	2	93.2
2. Location & pool environment	8	For safety, it is important that people with Parkinson's disease with balance and mobility impairments only attend pools, which are fully accessible (e.g., chair lift, hoist, underfloor heating, graded pool depth).	9	3	84.1
	9	Where possible, it is important that people with Parkinson's disease access a thermoneutral pool (33.5°C -35.5°C).	8	3	72.7
	10	It is important that the level of immersion is recorded and reported when performing aquatic exercises.	8	3	88
	11	It is important that people with Parkinson's disease have access to aquatic therapy services in their local community (e.g., swimming pool, hydrotherapy pool).	10	2	90
3. Safety & supports	12	It is important that healthcare professionals support people with Parkinson's disease to transition towards participating in community-based aquatic groups with a suitably trained instructor.	10	3	80
	13	It is important to specify the qualifications (e.g., level of training and expertise) of the aquatic therapy instructor.	8	2	80
	14	It is important that aqua aerobics instructors, lifeguards and patient support workers receive basic training on aquatic therapy for people with Parkinson's disease from healthcare professionals to empower self-management in the local community.	9	3	84.1
	15	It is important to provide support for people with Parkinson's disease who may require assistance with dressing and showering.	10	2	92
	16	It is important to identify people with Parkinson's disease with a fear of falling, as it may deter them from engaging in aquatic therapy.	9	4	75
	17	It is important that people with Parkinson's disease who have a fear of water are identified and supported by healthcare professionals to access and participate in aquatic therapy.	10	2	91.7
	18	It is important to provide clear information and address any safety concerns of people with Parkinson's disease in preparing for the first aquatic therapy session.	10	0	87.9

	19	For safety, it is important that people with Parkinson's disease do not enter the poolside without trained personnel (e.g., lifeguard, pool manager) or an aquatic therapy instructor present.	10	2	85.4
	20	It is important that safe, non-slip footwear is worn by people with Parkinson's disease when accessing the pool and/or exercising in the pool.	10	2	90.9
	21	It is important to document and report any incidents or adverse events that occur during an aquatic therapy session.	10	0	97.9
	22	For safety (and in accordance with the ATACP space recommendation of $2m^2$ per bather), it important to have no more than 6-8 people with Parkinson's disease per aquatic therapist in a pool.	9	3	85.1
	24	It is important that people with advanced Parkinson's disease (Hoehn & Yahr stages 4-5) only participate in one-to-one aquatic therapy with a trained healthcare professional.	10	2	81.2
	25	It is important that aquatic therapists regularly assess people with Parkinson's disease for changes in their ability.	10	1	97.7
4. Tailored aquatic program	26	It is important that each individual's personal goals and preferences are identified and evaluated.	10	1	97.9
	27	It is important that group aquatic exercises are tailored to each individual's impairment(s) and symptoms.	10	2	93.7
	28	It is important that people with Parkinson's disease have access to aquatic therapy groups specifically targeting their disease severity level (e.g., Hoehn & Yahr level 1, level 2, level 3-4).	9	3	81.2
	29	It is important to report whether the planned aquatic program and individual performance of the program matched.	9	3	89.6
5. Dosage: Frequency of aquatic therapy	31	For maximal therapeutic effect and as part of their regular exercise routine, it is important for people with Parkinson's disease to attend community-based aquatic therapy twice weekly.	8	2	77.3
	32	In a community-based setting, if people with Parkinson's disease can only participate in aquatic therapy once a week, it is important to provide them with a specified home exercise program.	10	2	94
6. Dosage: Intensity of aquatic therapy	34	It is important that the level of aquatic exercise intensity is measured and recorded (e.g., heart rate monitor, rating of perceived exertion).	8	4	75.5
	35	When safe and able, it is important that people in the early stages of Parkinson's disease perform vigorous and sustained exercises within a pre-determined heart rate zone to enhance cardiovascular exercise effects.	8	2	90.9
	36	It is important that aquatic exercises for people with Parkinson's disease are progressed as per the American College of Sports Medicine (ACSM) guidelines for physical exercise.	8	3	70.8
	37	It is important that the number of sets and repetitions of each aquatic exercise performed is reported and recorded.	9	3	83.7
	38	It is important to describe in detail the criteria for determining when to progress aquatic exercises.	8	2	87.8
	39	During one-to-one aquatic therapy, it is important to accurately report and record every rest period between exercise sets and repetitions to enable the progression of the aquatic program.	8	3	72.7
7. Dosage: Duration of aquatic therapy	40	For a maximal therapeutic effect, it is important for people with Parkinson's disease to engage in aquatic therapy sessions for 30 to 60 minutes.	9	2	93.2

	41	For people with Parkinson's disease, it is important to include a variety of exercise components targeting movement disorder impairments in the aquatic therapy program.	10	1	89.8
8. Aquatic therapy elements	44	It is important to specify how adherence to aquatic therapy will be measured (e.g., exercise diary, goal attainment scale, motivational app) and reported.	8	3	77.6
	45	It is important to specify details of motivation strategies applied during aquatic therapy sessions (e.g., goal setting, rewards, motivational app, positive reinforcement, auditory and visual cueing).	8	2	83.7
	46	It is important to provide a detailed description of individual aquatic exercises to replicate aquatic programs (e.g., picture handout, photographs, videos).	9	2	85.7
	47	It is important that all people with Parkinson's disease participating in aquatic therapy are provided with a specified home exercise program.	9	3	83.7
9. Statements not gaining consensus (Delphi round 2)	30	For a maximal therapeutic effect, it is important for people with Parkinson's disease to attend aquatic therapy for a minimum of 12-weeks. [5. Dosage: Frequency of aquatic therapy]	7	2	66.7
	33	In an inpatient rehabilitation setting, it is optimal for people with Parkinson's disease to attend aquatic therapy between 3-5 times weekly as part of a multidisciplinary rehabilitation program. [5. Dosage: Frequency of aquatic therapy]	7	3	53.3
	43	It is important to include swimming training as a component of the aquatic therapy program for some people with Parkinson's disease to improve confidence and water safety. [8. Aquatic therapy components]	8	4	64.4
	48	Where applicable, it is important to describe non-exercise components of the aquatic therapy intervention (e.g., cognitive training). [8. Aquatic therapy components]	8	3	62.2
11. Statement omitted (Round 1)	23	For reasons of safety, it is important that people with advanced Parkinson's disease (Hoehn & Yahr stages 4-5) do not participate in aquatic therapy. [3. Safety and supports]	1	5	14.6

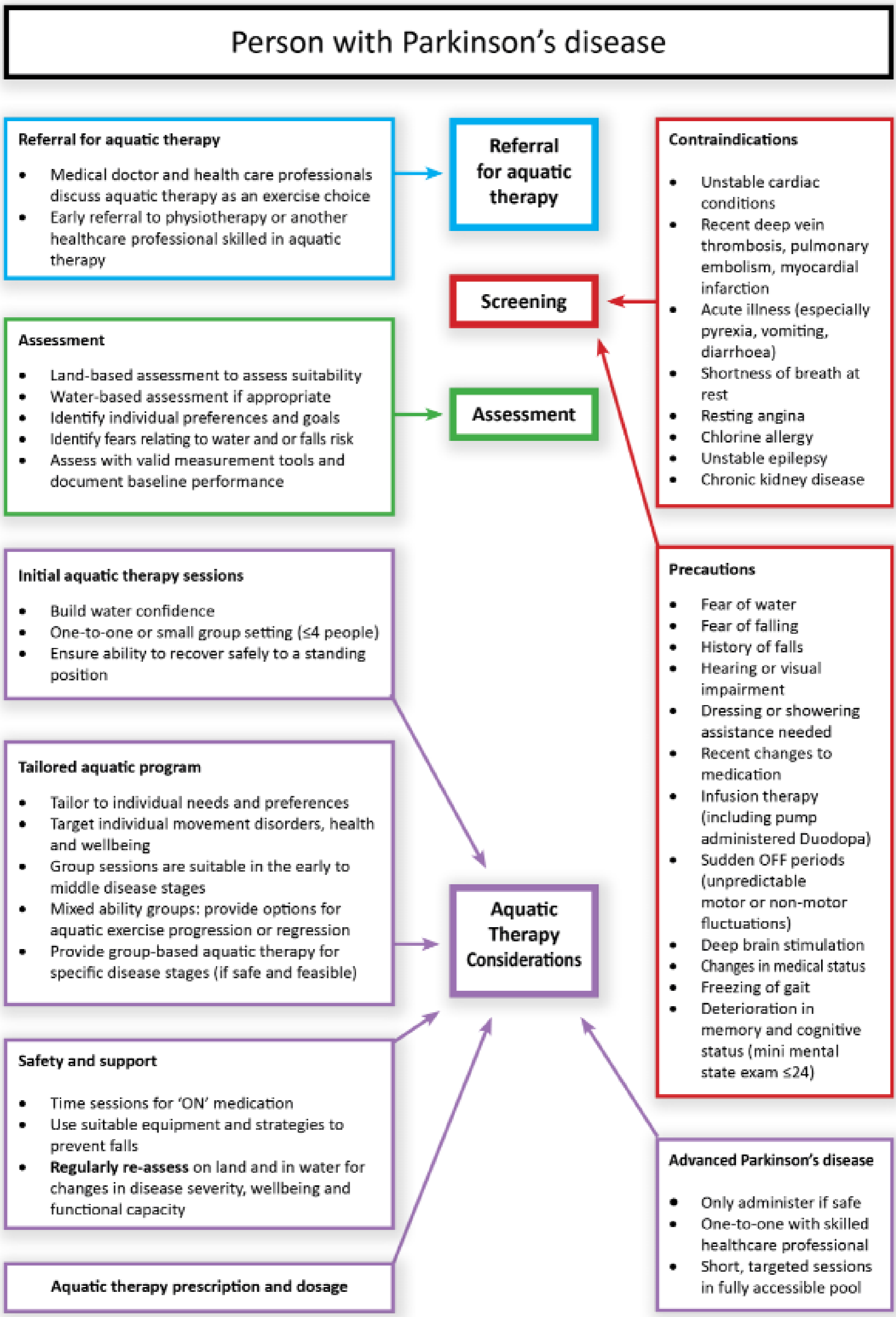
Abbreviations: PD= Parkinson's disease; Md=Median; IQR=Interquartile range; % Score = Percentage of experts scoring the statement ≥7 (Median score).

Evidence-based aquatic therapy guidelines: Expert recommendations

(1) Aquatic therapy delivery

Expert consensus was gained for all seven statements about aspects of aquatic therapy delivery, such as how soon after diagnosis, people with PD are referred for aquatic therapy and how aquatic therapy services should be provided and adapted during the disease course (Table 2). The findings are presented in a flow diagram to provide practical signposting for healthcare practitioners when referring, screening, assessing, and delivering aquatic therapy programs for people with Parkinson's disease (Figure 2; see Chapter 4 Appendices: Appendix B, guideline infographic).

Figure 2. Flow diagram of processes and considerations



(2) Location and pool environment

Experts agreed that access to aquatic therapy within the community setting is beneficial for people with PD. Most experts agreed that a fully accessible, heated pool is preferable for people with PD (Table 2) and is included in the flow diagram (Figure 2). The content analysis provided further context about factors such as the disease stage and functional capacity, which need to be considered by clinicians when identifying pools suitable for individuals with PD (see Chapter 4 Appendices: Appendix B, Table 4). Some experts advised that warm pool temperatures (≥ 33°C) need to be used with caution. They suggested that warmer water may be appropriate only for lower intensity aquatic activities or when treating people with advanced PD with reduced functional capacity.

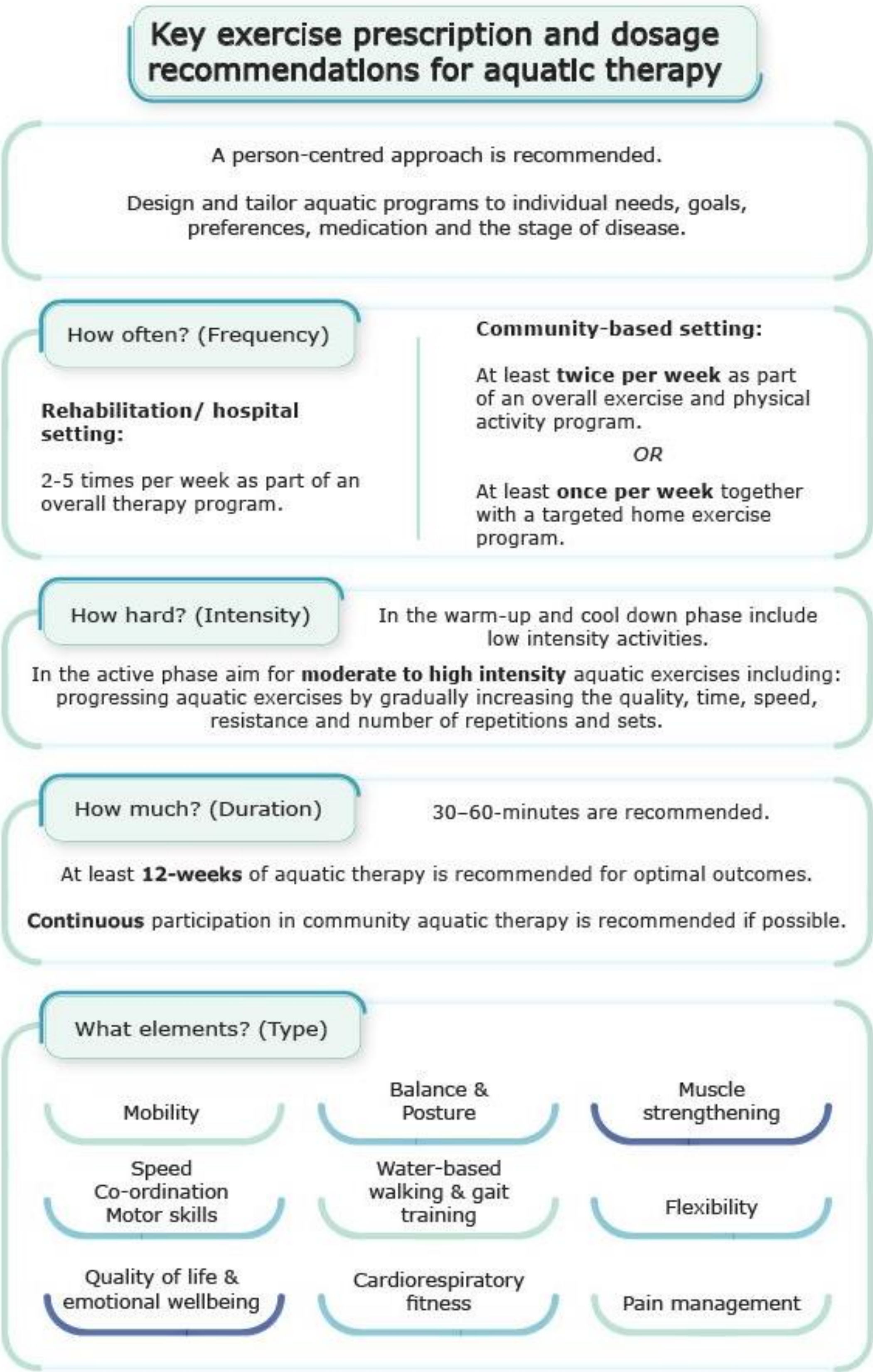
(3) Safety and supports

Expert consensus was gained for 13 statements about the safety and support needs of people with PD, such as fear of water and or falling, dressing, and showering requirements. Agreement about group size, level of supervision, and equipment requirements to support safe transfers in the pool environment was also achieved (Table 2). There was consensus for providing support for accessing community-based aquatic classes and the role of skilled healthcare professionals in providing basic training to patient support workers and other identified community pool workers. Experts agreed that people in the advanced disease stages could benefit from aquatic therapy, with one-to-one therapy sessions provided by skilled healthcare professionals indicated (Table 2). The key recommendations are outlined in the flow diagram (Figure 2).

(4) Tailored aquatic program

Expert consensus was achieved for all four statements (Table 2). The majority of respondents agreed that the aquatic program ought to be tailored according to individual goals and preferences and level of impairment, with access to groups for specific disease stages optimal where available (Table 2). The main recommendations are illustrated in the flow diagram (Figure 2). It is recommended that they be considered in line with the exercise prescription recommendations presented in Figure 3, using the frequency, intensity, time, type (FITT) framework (see Chapter 4 Appendices: Appendix B, guideline infographic).

Figure 3. Key exercise prescription and dosage recommendations



(5) Dosage: Frequency of aquatic therapy

The expert panellists agreed that performing at least two sessions per week is optimal for people with PD engaging in community-based aquatic therapy (Figure 3). Where people with PD only have access to one session per week, there was consensus that a home exercise program prescribed by their primary physiotherapist is recommended to be provided (Figure 3). When people with Parkinson's disease undergo intensive rehabilitation within a rehabilitation or hospital facility, experts agreed that between two to five sessions of aquatic therapy per week could improve rehabilitation outcomes if feasible (see Chapter 4 Appendices: Appendix B, Table 6).

(6) Dosage: Intensity of aquatic therapy

In the absence of specific guidance around aquatic therapy exercise prescription, there was consensus that the American College of Sports Medicine (ACSM) physical exercise guidelines for people with chronic diseases (American College of Sports Medicine 2016) could offer guidance for clinicians when designing and progressing aquatic therapy programs. Expert feedback highlighted that the level of intensity achieved for each individual is dependent on their medical status and co-morbidities. During the active component of the aquatic class, moderate to high levels of intensity, determined using valid and reliable measurement tools, are recommended (Figure 3). There was agreement among the experts that performing cardiovascular aquatic exercises at a reasonably vigorous-intensity level, or a predetermined heart rate is essential, particularly in the earlier disease stages. While the experts agreed that to support people to progress, the number of repetitions, sets, and rest periods are essential components of the aquatic therapy program, they also indicated that these could be challenging to monitor, report, and control for during group-based aquatic therapy in comparison to one-to-one aquatic interventions where there is likely to be a higher staff-to-patient ratio.

(7) Dosage: Duration of aquatic therapy

The respondents agreed that sessions should last between 30 to 60 minutes to achieve maximal therapeutic effects. The expert's feedback did highlight, however, that this may vary according to different aquatic activities (e.g., shorter 30-minute session for high-intensity aerobic exercises), individual functional capacity (e.g., shorter 30-minute session to limit fatigue), and the disease stages (e.g., shorter 30-minute for people with advanced PD in a one-to-one setting). Following round two of the Delphi questionnaires, the optimal duration of aquatic therapy was inconclusive (Table 2). Most experts who engaged in the consensus meeting process agreed that at least 12-weeks of aquatic therapy is recommended to achieve optimal outcomes (Figure 3). In addition, there was consensus among most experts that continuous participation in community aquatic therapy was preferable to support long-term adherence and maintain therapy effects (Figure 3). (See Chapter 4 Appendices: Appendix B, Table 6 and 7).

(8) Aquatic therapy elements

The expert panellists agreed that a multicomponent aquatic program targeting different movement disorders and non-motor symptoms should be included (Table 2). When designing and developing an aquatic therapy program, key elements for consideration have been included within the guidelines (Figure 3).

4.5 Discussion

This modified Delphi study aimed to gain consensus rigorously and systematically on a core list of statements to inform new aquatic therapy guidelines for people living with PD. As outlined in the guidelines, people with Parkinson's disease can benefit from access to information on exercise and its benefits at the time of diagnosis, with aquatic therapy one option for consideration (Carroll *et al.* 2021). Findings from our qualitative study (Carroll *et al.* 2021) suggest that early access to aquatic therapy services, delivered by suitably qualified healthcare professionals with PD knowledge, may enhance patient outcomes and increase long-term adherence for some people with mild to moderate disease. These guidelines support the timely delivery of an individually tailored aquatic program for people with PD, an approach that is widely supported in the literature (Bloem *et al.* 2020) and other available guidelines (Keus *et al.* 2014; NICE 2017).

As part of the initial screening process described, the list of contraindications and precautions agreed by the expert group can be used to assess suitability and optimize safety and independence during participation. This list reflects screening criteria previously outlined, for example, in the UK and Australian aquatic physiotherapy guidelines (Aquatic Physiotherapy Group 2015; Aquatic Therapy Association of Chartered Physiotherapists 2015); however, specific criteria for Parkinson's disease need to be individually considered. For example, orthostatic hypotension (Velseboer *et al.* 2011), cardiac disease (Scorza *et al.* 2018), freezing of gait (Lewis and Barker 2009), and sudden "off" periods causing motor fluctuations (Chou *et al.* 2018) need to be screened for by skilled healthcare professionals before beginning aquatic therapy. In addition, our guidelines recommend that fear of water and or falling associated with the pool environment and safety when dressing and showering, which were reported by a small portion of people with PD (Carroll *et al.* 2021), are identified during assessment. These issues may be addressed by providing key supports to individuals, as well as introducing graded exercise activities to enhance water confidence during the initial aquatic therapy sessions, within a safe pool environment (Carroll *et al.* 2021; Terrens *et al.* 2021).

Regarding dosage, the recommended duration of 30–60-minute aquatic therapy sessions aligns with the aquatic therapy research for people with PD (Carroll *et al.* 2020; Gomes Neto *et al.* 2020; Terrens *et al.* 2020). Most experts agreed that to achieve optimal outcomes, at least 12-weeks of aquatic therapy is recommended. This recommendation can be considered in conjunction with the client's needs, therapy goals, and service capacity. This recommendation is consistent with other research evidence, suggesting that prolonged strength training (Corcos *et al.* 2013; Morris *et al.* 2017), aerobic training (Shulman *et al.* 2013; Carvalho *et al.* 2015; van der Kolk *et al.* 2019), dance therapy (Hackney and Earhart 2009; Volpe *et al.* 2013), and Tai Chi (Hackney and Earhart 2008; Li *et al.* 2014) can produce long-term beneficial effects for people with PD engaged in physiotherapy and exercise. Notably, the findings from our meta-analysis (Carroll *et al.* 2020) found short-term positive effects on balance, gait, and mobility in comparison to land-based exercise or physiotherapy, following between 3-11 weeks of aquatic interventions. Short-term benefits gained from aquatic therapy in people with PD could be considered better than none (Keus *et al.* 2014; Paillard *et al.* 2015). Owing to the progressive nature of PD, the expert group recommended that practitioners encourage people to continuously engage in community-based aquatic therapy throughout the disease course as a means of maintaining their physical function and wellbeing. This is supported by the literature, which indicates that regular and consistent exercising in people with PD is associated with positive long-term effects on mobility, physical activity, and health-related quality of life (van Nimwegen *et al.* 2013; Rafferty *et al.* 2017).

When designing an aquatic therapy program for people with PD, the experts agreed that including a range of different exercise elements, tailored, and progressed according to the individual needs, is recommended. Findings from the systematic review and meta-analysis (Carroll *et al.* 2020) indicate that there is moderate to good quality evidence from a small number of aquatic therapy trials (n=14) to support the inclusion of functional mobility, balance, gait, and posture training within the aquatic therapy program for people with mild to moderate PD. Most of the included trials (Carroll *et al.* 2020) incorporated a warm-up, cool-down phase, and a core exercise component targeting flexibility, aerobic fitness, strength and endurance, mobility (Volpe *et al.* 2014; Daniele Volpe *et al.* 2017a), balance (Vivas *et al.* 2011; Volpe *et al.* 2014; Palamara *et al.* 2017; Daniele Volpe *et al.* 2017a), posture (Daniele Volpe *et al.* 2017a), walking (Carroll *et al.* 2017; Daniele Volpe *et al.* 2017b; Clerici *et al.* 2019), obstacle training (Carroll *et al.* 2017; Zhu *et al.* 2018), and dual-task training (da Silva and Israel 2019). For example, a trial by Volpe *et al*. (2017a) included specific water-based exercises, primarily performed in a standing position, designed to target postural deformities in people with PD, such as performing trunk extension and flexion to challenge the individual's point of stability in the water. While the buoyancy and hydrostatic effects of water immersion can enable people with PD to perform such exercises in water, these exercises would be difficult to perform on land due to the risk of falls and injury. In addition, the systematic review findings also indicate some preliminary evidence for using established aquatic therapy approaches such as Halliwick (Vivas *et al.* 2011; Zhu *et al.* 2018; Terrens *et al.* 2020) and Ai Chi (Kurt *et al.* 2018). Methods such as the Bad Ragaz Ring method (BRRM) and Watsu require further investigation to confirm their effectiveness in PD. These established aquatic methods incorporate core exercise components such as joint mobilization (BBRM, Ai

Chi), stretching (Watsu), muscle strengthening (BRRM), muscle relaxation (BBRM, Watsu), pain modulation (BRRM), proprioception (Ai Chi, BRRM), trunk stabilization and rotation (Halliwick, BRRM, Ai Chi), and endurance (Halliwick) (Becker and Cole 2010).

It is also important to consider the findings from previous exercise literature, which supports the inclusion of a range of challenging and complex exercises (Shen *et al.* 2016). For example, including highly challenging balance training could lead to more robust improvements in balance outcomes (Conradsson *et al.* 2015). Adding resistance exercises (Hirsch *et al.* 2003; Corcos *et al.* 2013), alongside cognitive training and dual-task training (da Silva and Israel 2019) could optimize the results for people with PD engaging in aquatic programs. In line with the growing body of research highlighting the importance of high-intensity aerobic exercise in slowing disease progression (Schenkman *et al.* 2018; van der Kolk *et al.* 2019), these guidelines recommend that aquatic exercises are performed at a vigorous intensity, particularly in the earlier disease stages. At present, no substantial evidence exists to support the efficacy and safety of aquatic exercise performed at a higher intensity (Ayán and Cancela 2012), with few studies including valid intensity measures (Carroll *et al.* 2020). Future trials comparing the feasibility and safety of high-intensity aquatic programs, along with the optimal pool temperatures, and aquatic therapy programs delivered as an early intervention for people with PD are warranted. In addition, further research is needed to establish the optimal intensity measures for water-based exercise, including how to measure cardiac function reliably (Becker 2020).

Strengths and limitations

A significant strength of these practice guidelines was the inclusion of different professions with extensive expertise and years of experience from over 15 international countries. The active engagement of patient stakeholders (Parkinson's panel) during all stages of this study also ensured that the guidelines are relevant and feasible to implement in practice (Slade *et al.* 2016; Armstrong *et al.* 2018). While limited research evidence (Carroll *et al.* 2020) may limit the strength of guideline recommendations, the high recruitment and Delphi completion rates by practice experts indicate the relevance, timeliness, and demand for aquatic therapy guidelines to assist in decision-making for all healthcare professionals (Ward *et al.* 2014).

Males were underrepresented in the consensus process. This may be explained by the number of female physiotherapists who formed a large portion of our expert panel and tend to work in neurology, geriatrics, and public healthcare (Öhman *et al.* 2002). Nevertheless, the sample was representative of a diverse range of research and practice experts. This research study was conducted during the Covid-19 global pandemic. Due to the evolving landscape, information around changes to practice including, minimizing social contact, group size, pre-screening, additional hygiene, and pool cleaning measures, required for the safe delivery of aquatic therapy during the pandemic, was not included when developing the consensus statements and guideline recommendations, (Aquatic Therapy Association of Chartered Physiotherapists 2021). It is advised that healthcare professionals implement any additional guidelines in line with national and local public health guidance, alongside individual organisation's policies and procedures.

4.6 Conclusion

At present, there is an unmet need for aquatic therapy guidelines in PD. In this regard, we present internationally agreed guidelines for prescribing and delivering aquatic therapy for adults with PD. These evidence-based practice guidelines are a valuable reference for healthcare professionals and could facilitate improved clinical outcomes for people living with Parkinson's disease.

Acknowledgments

We thank all the expert panellists who completed the Delphi questionnaires. We acknowledge with thanks those who contributed their time and expertise to the consensus meeting process: Emily Dunlap (USA), Dr. Emine Eda Kurt (Turkey), Fleur Terrens (Australia), Josefa Domingos (Portugal), Judy Goroncy (Australia), Johan Lambeck (the Netherlands), Jacqueline Pattman (UK), Dr. Lucia Cugusi (Italy), Moira Smith (Australia), Dr. Osnat Fliess Douer (Israel). We thank our Parkinson's patient and public involvement panel for their input and expertise. We also acknowledge the work of Dr. Simon Haines (La Trobe University, Australia) for his contribution to the qualitative content analysis.

4.7 Epilogue

This phase of the thesis project achieved its aim to establish international expert consensus for a list of key statements. The statements informed the final aquatic therapy guideline, including important information about safety, content, dosage contraindications, and the optimal aquatic therapy delivery for people with mild to advanced PD. This is the first aquatic therapy study to include practice-based evidence, along with patient evidence and involvement, to support the development of practice-based guidelines for people with PD. Thus, the findings provide novel evidence, which can be used by healthcare professionals when planning and designing aquatic therapy programs in clinical practice for their clients. Furthermore, while we did engage a PPI Parkinson's panel and recruited experts from a range of professional backgrounds, it must be acknowledged that some of the information provided in the final guidelines may have been shaped differently if the opinions of family members, carers, and other key healthcare professionals (e.g., occupational therapists) were included in the design and development of phase two (Chapter 3) and phase three (Chapter 4) of this project.

In addition, a two-page guideline infographic was produced along with this study to boost the impact of the guidelines. Reasons for designing and developing the visual infographic included that information and knowledge are presented to target audiences in easy to read and digestible pieces and takes less time to read (Ahmad 2016). Thus, feedback from stakeholders (Parkinson's panel and international practice experts) was sought to ensure that the information included in the study's infographic was clear, understandable, and relevant to the target audience of healthcare professionals and people with PD. Some other key factors were considered when designing the infographic to ensure understanding and recall. According to Ahmad (2016), the most effective infographics contain an average of 396 words thus, a total of 391 words (Scott *et al.* 2016) were included in the study's infographic across the two pages. Findings by Majooni *et al.* (2018) suggest that infographics that include vertical columns (see Chapter 4 Appendices: Appendix B, Guideline Infographic, page 1) and zigzag organisation (see Chapter 4 Appendices: Appendix B, Guideline Infographic, page 2) of text are associated with increased comprehension and impose less of a cognitive load on the reader. Thus, it is anticipated that the accompanying infographic will be well received among the targeted PD stakeholders.

CHAPTER 5: Discussion

5.0 Introduction

This discussion chapter will discuss the key research findings and explore the unique and novel contributions of the research described in this thesis. The impact and implications of the findings for future research and clinical practice will be discussed, along with the strengths and limitations and dissemination of the outputs. This chapter will conclude with recommendations for future research and concluding statements.

5.1 Summary of key findings

Findings from the systematic review (Phase 1) showed that at the time of the search, there was only very low to moderately strong evidence from a small number of studies indicating that aquatic therapy may be as effective as land-based exercise interventions, especially in the early to middle stages of disease progression in PD. Overall, the systematic review found that aquatic therapy could be helpful for improving mobility, balance, motor disability, gait, and quality of life in some people with mild to moderate PD. Of note, exercise prescription varied significantly across trials and across countries. Findings from the qualitative study (Phase 2) suggest that aquatic therapy was well accepted by people with PD who had previously engaged in this exercise approach and is considered beneficial to their general health and well-being. This is the first published study to include the opinions of people living with PD with no experience of participating in aquatic therapy and identified fear of water as a potential barrier, while increased awareness and education about the benefits of aquatic therapy are recommended to increase participation. The consensus study (Phase 3) built on the findings from phase one and phase two to design and develop aquatic therapy guidelines incorporating the four pillars of evidence-based practice. The resultant published guidelines are the first internationally applicable guidelines to provide healthcare practitioners with practical, easy to access and valuable information about the optimum dosage, safety, content, and delivery of aquatic therapy for people with PD.

5.2 Key findings in the context of the literature

The aims of phase one were to appraise and synthesise all available RCTs examining the effectiveness of aquatic therapy for people with PD and to explore the optimal exercise prescription, using the FITT framework, for an effective aquatic therapy program in PD. This review successfully synthesised data from 14 RCTs to provide key information on the effectiveness of aquatic therapy for people with PD, and a summary of intervention components, which provided the foundation for the thesis project. The findings from very low to moderate quality evidence suggest that aquatic therapy can yield similar positive benefits as other land-based interventions for mobility, balance, motor disability, gait, and quality of life. Our findings are supported by a recent meta-analysis (Radder *et al.* 2020) of physiotherapy modalities for PD, conducted as part of an update of the European Physiotherapy Guidelines for Parkinson's disease. Similar to our results, Radder and colleagues found that there is low to moderate evidence that aquatic therapy effectively improves balance and mobility and reduces fear of falling compared to standard physiotherapy or PD exercises. Taken together, healthcare professionals and people with mild to moderate PD can be somewhat confident when choosing aquatic therapy as an exercise option to improve mobility and balance deficits.

During phase one of the thesis project, challenges arose when trying to provide recommendations for the optimal exercise prescription to achieve a favourable effect for people with PD. The interventions across the trials varied in terms of their exercise prescription and were under-dosed in most trials. For example, the therapy duration varied from three to 11-weeks, which is low compared to other effective land-based intervention studies for PD, which typically average at 12-weeks (Shulman *et al.* 2013; Uc *et al.* 2014; Ni *et al.* 2016a; Domingos *et al.* 2019). Longer duration interventions are thought to afford greater beneficial effects, with a training period of 12-weeks or longer required, to delay disease progression related to increased neuroplasticity (Oguh *et al.* 2014), and to achieve clinically meaningful changes in motor disability measured on the Unified Parkinson's Disease Rating Scale (UPDRS-III) (Mak *et al.* 2017). Prior to completing the phase one systematic review, no reviews had considered the optimal dosage parameters (FITT) for delivering aquatic therapy and their relationship to key outcome measures for people with PD. This knowledge is key to help people design effective aquatic therapy programmes. Thus, this review provides valuable information for researchers and healthcare practitioners about the minimum dosage requirements and increasing the dosage affects of aquatic therapy for people with PD. In the discussion (Chapter 2), it was hypothesised that longer durations of aquatic therapy could lead to overall increased positive effects. This was explored further in the phase three consensus study where experts recommended that community-based aquatic programs are performed for 30-60 minutes, over a minimum 12-week period for optimal outcomes; or if possible, on a continuous basis throughout the disease course, for as long as it can be done safely. Considering that PD is a long-term progressive condition, continuous and frequent exercise participation is argued to enhance mobility, quality of life, physical activity, and cognitive performance (van Nimwegen *et al.* 2013; Oguh *et* *al.* 2014; Rafferty *et al.* 2017). Therefore, the information outlined in the final aquatic therapy guideline and accompanying infographic can provide healthcare professionals with a key starting point for delivering aquatic therapy in practice, which prior to this research project, was not available to them.

This qualitative study provides a unique exploration of the ways to promote access to, participation in, and long-term adherence in aquatic therapy from the perspective of people living with PD along with culture and context. No current or previously published studies explored the opinions and beliefs of people with PD from Ireland and Australia about participating in community-based aquatic therapy. This novel study highlighted the need for healthcare professionals to consider the voices and experiences of people living with PD, alongside cultural influences, and contextual factors such as, prior experiences of water and swimming, when delivering an aquatic therapy in practice. Within clinical practice, a person-centred care approach is advocated (Lennon and Bassile 2018). Thus, this research is important as the patient experiences outlined can be used by service providers to develop, deliver, and evaluate treatment outcomes within a person-centred practice framework (Leplege *et al*. 2007)). Context was also a key consideration in phase three of the project where recommendations were provided from experts from different countries, healthcare settings, along with varied models of service delivery, funding, and resources. Another key feature of the qualitative study presented in this thesis is that it is the first and only study published to date, to consider the opinions and perspectives of people living with PD who have no prior experience of engaging in aquatic therapy. Going forward, this new knowledge could be applied by professionals, to support and engage people with PD with different levels of experience in aquatic therapy programs, and to enhance participation throughout the disease course.

The main aim of this project was to develop pragmatic guidelines, informed by the four pillars of evidence-based practice (EBP), that could be easily accessed by a range of healthcare professionals, particularly professionals (e.g., new graduates) new to working with people with PD or who might be unsure of where to start, or how to safely delivery aquatic therapy. Thus, our aquatic therapy guidelines are novel as they are the first to provide professionals with information about key components such as safety, contraindications, optimal dosage, and delivery of aquatic therapy. While the recently published American Physical Therapy Association Clinical Practice Guideline for the Physical Therapist Management of Parkinson's disease (American Physical Therapy Association 2021) recommend that aquatic therapy may be considered over land-based treatment, by physiotherapists, for reducing fear of falling and quality of life in people with mild to moderate PD (H&Y stage 1-3) (American Physical Therapy Association 2021), these recommendations are based soley on findings from small scale RCTs and do not consider different patient perspectives and practice-based exptertise.

In addition, the Parkinson's Foundation (2021) in collaboration with the America College of Sports Medicine recently published exercise recommendations for people with Parkinson's disease and exercise professional. Like our guidelines, the Parkinson's Foundation provides the required guidance about the optimal dosage requirements for frequency, intensity, time, type, with the further addition of volume and progression (FITT-VP) for targeting balance, aerobic, strengthening, and flexibility in people with PD. For example, the guideline recommends that people with PD perform continuous or intermittent, moderate to vigorous aerobic activities (e.g., walking, swimming, cycling), 3 days per week (Parkinson's Foundation 2021). Our aquatic therapy guidelines recommend that people with PD engage in aquatic therapy as part of a regular exercise routine (e.g., home exercise program). Thus, it is anticipated that healthcare professionals and people with PD consider both these guidelines (American Physical Therapy Association 2021; Parkinson's Foundation 2021) in line with our aquatic therapy recommendations to maximize the potential disease-modifying effects of regular exercise participation (Oguh *et al.* 2014).

5.3 Reflexivity

Throughout the three phases of this research project, I maintained a reflective journal. This was to ensure that I reflected on my own role in the research and the position of my supervisory team. The journal also helped me to reflect and consider the influences of my beliefs and behaviours on the research process. For example, during the systematic review I deliberated about using the term “aquatic therapy” as a suitable umbrella term, to best capture the application of various water-based exercise approaches used for people with PD. As a physiotherapist and as a member of various national and international specialist aquatic interest groups, I was most accustomed to using the term “aquatic physiotherapy.” While I was acutely aware of my position as a physiotherapist, I wanted to remain open to ensure that the final published guidelines would be accessible to different professionals globally, in addition to people with Parkinson’s disease, their families and carers. During data collection, the use of this term was queried by a few experts, who believed that it was important to preserve physiotherapist’s ownership of this treatment approach but upon reflection the final guidelines were ultimately strengthened by the range of different disciplines, knowledge and expertise used to inform and develop the guidelines.

Having delivered aquatic therapy in clinical practice to people with PD for several years, I was conscious as a novice researcher to remain open-minded. For instance, I was aware of subtle changes in how I interacted with participants in phase two’s qualitative study and with members of the Parkinson's panel during phase three's guideline development process. For both phases, whether I was collecting data or discussing the research process I was mindful not to impose my own point of view and used reflective listening along with the participant's own words when relaying information back. In my reflexive journal I noted my perspectives and objectivity during the interview process, which helped me to contextualise aquatic therapy from the perspective of people with PD across two jurisdictions. Prior to this research, I had a preconceived view of how aquatic therapy was perceived by my clients however, the qualitative analysis opened my mind to the role of different factors such peer support and financing of classes, when designing and implementing aquatic programs long-term. Finally, when engaging with members of the PPI Parkinson's panel, I noted my surprise by participants openness to engage in the research process and their strong desire to take ownership and highlight their key role in the dissemination of the published guidelines. As a PhD candidate and researcher, I observed this as a new and valuable experience, as during the conception and initial stages of the PhD I had become accustomed to leading and taking responsibility for all aspects of the project. Thus, by actively engaging the PPI Parkinson's panel in this research, I have become further aware of the benefits and importance of PPI in the research process, an awareness I will bring forward to future research projects.

5.4 Findings in the context of policy recommendations

Phase two of this thesis identified that people with PD want greater access to community-based aquatic therapy programs to reduce barriers associated with access, transport, and cost. Phase three also identified that healthcare professionals recognise the importance of people with PD accessing aquatic therapy services in the community.

This is consistent with the recommendations from Irish and European policy reports, realising the importance of integrated community care and keeping people fit and healthy within their local community (National Clinical Programme for Rehabilitation Medicine 2014; European Parkinson's disease Association 2017; Government of Ireland 2019; Healthy Ireland 2021). In line with these policy recommendations, an important finding from our qualitative study (phase 2) was that people with PD reported that engaging in community-based aquatic therapy groups was beneficial to their health and wellbeing, which is a crucial factor in helping to promote sustained exercise adherence (Schootemeijer *et al.* 2020). In terms of promoting effective behaviour change, this finding is important as the literature indicates that people are more likely to participate in an exercise programme if they understand its benefits (van Nimwegen *et al.* 2013).

Community-based exercise group programs have become increasingly popular across the globe as a means to increase physical activity uptake and long-term adherence in people with PD, with evidence for their effects growing (Combs *et al.* 2013; Foster *et al.* 2013; Domingos *et al.* 2019). Findings from our systematic review showed that only a third of the aquatic therapy programs occurred in a community-based hydrotherapy pool or swimming pool setting. Further evidence is needed to assess the effectiveness of community-based aquatic therapy and evaluate how best to deliver and implement such programs, based on the guideline recommendations, in the long-term (Domingos *et al.* 2019). If feasible, acceptable, and effective this may provide evidence to support additional opportunities to exercise in local community pools. Finally, as outlined in Chapter 1 of this thesis, and in line with a growing interest in the effects of 'blue exercise' on the physical health and well-being of adult populations, future research trials could also compare the effects of exercising in water in natural environments versus man-made pools, to explore potential challenges and evaluate its effects, particularly in the early stages of PD. If it is feasibly, 'blue exercise' could afford additional opportunities for people with PD to access and engage in water-based exercise within their local communities.

5.5 Global significance and impact

Each stage of this research demonstrated international applicability, reach and impact. The systematic review included eligible trials from seven counties across Europe, Asia, and South America. This review showed that while aquatic therapy research is still in its infancy, it has become a popular intervention approach for PD and is adopted by healthcare professionals in many countries across the globe. The qualitative study explored the opinions and perceptions of people with PD about aquatic therapy in Ireland and Australia. The consensus statements compiled as part of this thesis were considered by experts from over 15 countries, covering six continents. Thus, these new aquatic therapy recommendations could be regarded as valid in countries where healthcare professionals utilise aquatic therapy in an inpatient, rehabilitation, or community-based setting, as outlined in the guidelines.

5.6 Research translation and guideline dissemination

It is anticipated that the infographic developed as part of this thesis (see Chapter 4 Appendices: Guideline Infographic) will be shared widely with PD stakeholders via social media platforms (e.g., Twitter, Facebook, WhatsApp) to national and international professional and patient organisations, once the corresponding consensus paper is published. Realising that the guideline paper alone will not ensure guideline uptake and application, a 2-page infographic was developed as part of this project to create impact by ensuring that the reach of the guideline recommendations is as long-lasting and well-known as possible. Infographics have become a popular means for communicating critical messages in healthcare research (Scott *et al.* 2016). They are used to attract attention, boost comprehension, and facilitate changes in behaviours and practice (Houts *et al.* 2006; Scott *et al.* 2016). For example, the American Parkinson's Foundation (2021) and Grimes *et al.* (2019) developed visual summaries of their exercise and clinical practice recommendations for healthcare professionals involved in the management of PD, of which Grimes *et al.* (2019) published the infographic alongside their original research paper. Therefore, it is anticipated that the infographic will be well received amongst the wider scientific community, healthcare professionals and people with PD worldwide.

Beyond the dissemination of the three peer-reviewed papers published as part of this thesis, the author will continue to pro-actively disseminate the research findings to further boost the project’s impact by presenting at local and international lectures, conferences and information days for healthcare professionals and patient support groups. The results will also be presented to the national Parkinson’s support groups (e.g., Move4Parkinsons, Parkinson’s Association of Ireland, Young Parkinson’s Ireland) and other relevant organisations. Furthermore, this research could also be used by national patient organisations to advocate for better services for people with Parkinson’s disease nationally and internationally.

5.7 Future research recommendations

Recommendations for future research directions were highlighted throughout the thesis. Additional recommendations will be discussed in this section.

As with all guidelines, this international aquatic therapy guideline will require updating in line with emerging evidence in the area. The guideline is considered a dynamic document. It is estimated that an update of the systematic review will be conducted as new research is produced in this area using the criteria set out by Johnston et al. (2003). In the interim, an implementation study could be conducted to explore whether the approach presented in this guideline is practical and effective in clinical practice using appropriate implementation science frameworks (Michie *et al.* 2005; Gagliardi *et al.* 2011; Dintrans *et al.* 2019). For example, following a presentation and distribution of the guidelines to physiotherapists, a survey to assess the usability and implementation of the guidelines in practice could be conducted with practice members of the aquatic therapy subgroup of the Irish Society of Chartered Physiotherapists and the Australian Physiotherapy Association aquatic therapy subgroup. Other methods, which could be considered for this study may include transparent expert consultation (Raine *et al.* 2005; Brighton *et al.* 2018) and semi-structured interviews or focus groups to find out what healthcare professionals and people with PD think about the guidelines and to gain feedback on its usefulness.

Research to establish a core set of aquatic therapy outcomes among practice-based experts for people with PD is warranted. The establishment of a core list of outcome measure would help to validate outcomes in clinical practice and research trials and would also aid study comparability (Terrens *et al.* 2017). Furthermore, in order to overcome the challenges of recruiting large numbers of participants to trials, a national or international database could be established across university, and medical organisations whereby anonymised participant descriptors are shared, along with pre-post intervention data for outcomes included in the core outcomes set. The aquatic therapy interventions would be designed and tailored to target the individual patient needs, in accordance with the guideline’s recommendations outlined in this thesis.

The recommendations included in the aquatic therapy guideline are primarily informed by international professionals with expertise in this field and people with PD, based on research and patient evidence, context, and gaps identified in the research evidence (Carroll *et al.* 2020). The gaps in knowledge identified during this thesis project could be addressed in future studies as follows:

1. Most of the published trials included in the systematic review were comparatively small, with between six (Vivas *et al.* 2011) and 36 (Daniele Volpe *et al.* 2017b) receiving aquatic interventions. Many studies were statistically underpowered with potential favourable effects of aquatic therapy over land-based interventions not found for specific outcomes. Subsequently, trials did not reach standard levels of statistical significance nor demonstrate clinically significant effects (Latimer-Cheung *et al.* 2013). A community-based multicentre trial is needed, using data from previous trials to ensure adequately powered trials. This would enable increased participant numbers across trials.

2. Most of the prior randomised controlled trials conducted to date cover only a short period (<11 weeks). As a result, it was not feasible to perform a meta-analysis of the long-term effects of aquatic therapy for people with mild to moderate PD. Parkinson's disease is a chronic condition, and it appears that a prolonged training duration of 12-weeks or more appears may be required to show clinically meaningful improvements for outcomes such as motor function using the UPDRS-III (Radder *et al.* 2020). Subsequent aquatic therapy studies should also consider a long-term standpoint, along with a longer follow-up period of 6 months to one year, to assess the full effects of

this approach.

3. The majority of prior trials focused on the effects of aquatic therapy in the early to middle disease stages (H&Y stage 1-3). Future research is required to explore the appropriateness and effectiveness of this approach in de novo PD and advanced PD (H&Y Stage 4). It is possible that aquatic therapy is unsafe for some people who are H&Y Stage 4 or 5 and people with multi-morbidity.

In order to influence future policymaking and ensure that aquatic therapy becomes more widely available as a rehabilitation and structured exercise approach for people with PD, research evaluating the cost-benefits of aquatic interventions is required. A previous cost benefit analysis conducted by Cochrane *et al.* (2007) found positive pain and physical function benefits for people with osteoarthritis who engaged in aquatic therapy long-term. Considering that the findings of this project indicate that group-based aquatic therapy, delivered by a credible professional, in a location of convenience may reduce barriers associated with aquatic therapy adherence, research ought to explore the cost benefits of group-based community aquatic therapy for people with PD, mainly when delivered in the early disease stages. The European Brain Council's (2017) framework for measuring the Value of Treatment for Brain Disorders and recently applied by Dodel *et al.* (2020), could be used to design and implement an economic case study analysis and produce crucial evidence to inform policy decision-makers nationally and internationally.

Considering the potential beneficial effects of water immersion on brain health and some positive effects of aquatic exercise for people with mild Alzheimer's disease (Becker and Lynch 2018), aquatic therapy in the management of cognitive decline warrants further investigation. It is recommended that future studies include valid cognitive measurement tools when designing and developing protocols. Retrospective studies while not without their challenges, including issues regarding missing data and selection bias (Sedgwick 2014), may be another useful method for exploring the long-term effects of aquatic therapy on cognition and dementia outcomes in people with PD who have engaged in water-based exercise therapy for extended periods throughout their disease.

5.8 Research strengths and limitations

The global reach, impact and significance of this new aquatic therapy resource is of benefit to people living with PD and to healthcare professionals and policy makers. Some of the key strengths discussed during this thesis was the development of a pragmatic, and easy to use aquatic therapy guidelines based on the four pillars of evidence-based practice, which is often missing from clinical practice settings. Healthcare professionals are often under pressure timewise to review all the available literature, and work within the ideals of evidence-based practice. Thus, these guidelines and accompanying infographic provide them with a valuable resource to guide their decision making in clinical practice.

Although the limitations of each research study were discussed during the thesis, some fundamental limitations require consideration. A three-step Delphi process was used to establish consensus among the international experts. During the design phase of the consensus study (Phase 3), other consensus methods, including the nominal group technique and consensus development panels, were considered (Waggoner *et al.* 2016). The Delphi technique was considered the best method mainly because it eliminated potential bias and influence that can occur in face-to-face meetings and enabled us to recruit a larger sample of practice experts from all over the world, as it does not require specified meeting times (Waggoner *et al.* 2016).

Every effort was made to ensure the scientific rigor of this method during the project (Trevelyan *et al.* 2015; Jünger *et al.* 2017), however this consensus-building approach is not without its limitations. The process by which the expert panellists come to agree with statements and form consensus remains mostly unknown (Sandrey and Bulger 2008). For instance, it’s unclear if the panellists may have revised their decision-making process in round two because of thorough deliberation or pressure to conform to the groups’ opinions (Sandrey and Bulger 2008; Eubank *et al.* 2016). In addition, only ten experts could attend the online consensus meeting. Thus, the final consensus may be biased in favour of the experts who participated in this meeting. However, the consensus meeting presented a significant opportunity to seek clarification from experts with a high level of practice expertise, and to generate open discussion and debate concerning any disagreements. Notably, key discussion points concerning differences of opinion raised during the consensus meeting provided context for some of the key guideline recommendations highlighted in the paper’s discussion section (Chapter 4). In addition, Powell *et al.* (2003) suggest that the success of the Delphi method lies in the pooled proficiency and judgments of the expert panellists. In this regard, the quality of the international panel of experts could be considered high-ranking, based on the large numbers recruited for round one and two of the Delphi process and the increased reliability of combined judgments over a single judgment alone (Murphy *et al.* 1998).

The development of an internationally applicable aquatic therapy guideline primarily based on the collective experience of a prominent expert group can be considered a valuable method for decision-making about key practice-related issues where the evidence is incomplete (Minas and Jorm 2010). It may also be deemed a valid process for developing clinical guidelines (Murphy *et al.* 1998; Powell 2003; Meshkat *et al.* 2014; Eubank *et al.* 2016) and informing policy decision-making and implementation (O'Loughlin and Kelly 2004; Syed *et al.* 2010; Havers *et al.* 2019). However, while the guidelines outlined in this thesis may be considered a valuable resource to guide decision-making, there may be some criticism about the acceptability of expert consensus as a basis to formulate guidelines, not least because evidence derived from specialist opinion is categorised as a lower level of evidence (Burns *et al.* 2011). A counterargument to this was that in the absence of definitive scientific conclusions, the guidelines were also shaped by the pillars of the evidence-based practice model including research and patient centred evidence, along with real-life contextual information (Thompson *et al.* 2002; McCurtin and Clifford 2015; Bengoechea *et al.* 2021).

While the under-representation of North American experts in the aquatic therapy guideline development process is a limitation, every effort was made to recruit experts in this field but was unsuccessful. One reason may be that the numbers receiving specialist rehabilitative therapies in the USA appear to be low compared to other countries (Fullard *et al.* 2017), possibly because alternative exercise programs like aquatic therapy are not included as part of the Medicare insurance cover (Ellis *et al.* 2013). Future guideline updates could be strengthened by exploring ways to recruit and include research and practice experts from this jurisdiction to join the guideline development panel. It is also important to acknowledge that the implementation of these guidelines may be difficult in some parts of the world, which are sparsely populated (e.g., rural areas), or in less economically developed countries, particularly those where large numbers of people with PD already go undiagnosed, and where access to basic medications (e.g., levodopa) are restricted, or too expensive (Bloem *et al.* 2020). It is advised that these aquatic therapy recommendations are adapted in line with local policies and models of healthcare provision, with future research exploring the benefits and effects of aquatic therapy in these underdeveloped countries warranted.

5.9 Concluding statements

The aim of this thesis project was to identify optimal components of aquatic therapy for people with PD and to apply them to the development of an evidence-based practice aquatic therapy guideline. These practice recommendations provide healthcare practitioners around the globe with a basis for current aquatic therapy delivery for people with Parkinson's disease and future policies, clinical practice and research conducted in the area. A number of novel findings were identified during the research process demonstrating the effectiveness, gaps in knowledge, acceptability, motivators, barriers, safety, dosage, and key features of aquatic therapy delivery for people with PD. The results also suggest that aquatic therapy appears to be as effective as some land-based approaches for specific motor outcomes, with increased awareness and communication of its benefits and effects requested by people with PD to increase participation. Of significance, the infographic for healthcare professionals and people with PD will accelerate the long-term impact of the aquatic therapy guideline.

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Appendices

Chapter 2 Appendices

Appendix A: Search Strategy

Search Strategy	
A systematic search of the literature was conducted in Embase, CINAHL complete, PubMed/MEDLINE (Ovid), PsycINFO, Cochrane-CENTRAL, PEDro, Scopus, Web of Science from inception to March 2018. Where appropriate, Boolean operators and Medical Subject Headings (MeSH) were incorporated in the search, with the following search terms used:	
Population	Neurodegenerat* OR Parkinson disease OR Parkinson's disease OR Parkinson*
Intervention	hydrotherapy OR aquatic exercise OR water exercise OR aquatic physiotherapy OR aquatic physical therapy OR aquatic rehab* OR aquatic therap* OR halliwick OR rehabilitation OR therapy

Database – Embase EBSCO, CINAHL Complete Display	
S8	S6 AND S7
S7	S2 OR S5
S6	S1 OR S4
S5	(MM "Hydrotherapy")
S4	(MM "Parkinson Disease") OR (MM "Lewy Body Disease") OR (MM "Neurodegenerative Diseases")
S3	S1 AND S2
S2	hydrotherapy OR aquatic exercise OR water exercise OR aquatic physiotherapy OR aquatic physical therapy OR aquatic rehab* OR aquatic therap* Search modes - Boolean/Phrase Interface - EBSCOhost Research Databases
S1	Neurodegenerat* OR Parkinson disease OR Parkinson's disease OR Parkinson* Search modes - Boolean/Phrase Interface - EBSCOhost Research Databases

Database -Web of Science	
#16	#14 AND #1 Refined by: **DOCUMENT TYPES:** (ARTICLE) *DocType=All document types; Language=All languages;*

#15	#14 AND #1 *DocType=All document types; Language=All languages;*
#14	#9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 *DocType=All document types; Language=All languages;*
#13	#12 AND #1 *DocType=All document types; Language=All languages;*
#12	#11 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 *DocType=All document types; Language=All languages;*
#11	**TOPIC:** (therapy) *DocType=All document types; Language=All languages;*
#10	**TOPIC:** (rehabilitation) *DocType=All document types; Language=All languages;*
#9	**TOPIC:** (halliwick) *DocType=All document types; Language=All languages;*
#8	**TOPIC:** (aquatic therap*) *DocType=All document types; Language=All languages;*
#7	**TOPIC:** (aquatic rehab*) *DocType=All document types; Language=All languages;*
#6	**TOPIC:** (aquatic physical therapy) *DocType=All document types; Language=All languages;*
#5	**TOPIC:** (aquatic physiotherapy) *DocType=All document types; Language=All languages;*
#4	**TOPIC:** (water exercise) *DocType=All document types; Language=All languages;*
#3	**TOPIC:** (Aquatic exercise) *DocType=All document types; Language=All languages;*
#2	**TOPIC:** (hydrotherapy) *DocType=All document types; Language=All languages;*
#1	**TOPIC:** (Neurodegenerat* OR Parkinson disease OR Parkinson's disease OR Parkinson*) *DocType=All document types; Language=All languages;*

Database – PEDro	
Search strategy	Advanced
Abstract and Title	Parkinson’s disease
Therapy	hydrotherapy, balneotherapy
Subdiscipline	Neurology

Appendix B: Detailed Forest Plots

Figure 2. MD (95% CI) of effect of aquatic therapy immediately after 4 to 8 weeks of intervention on balance (Berg balance scale) compared to land-based physiotherapy. Data pooling for six studies (n=173).

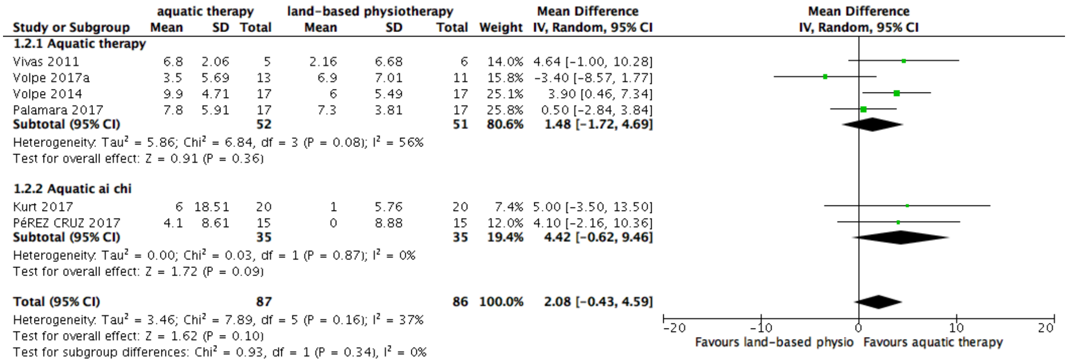


Figure 3. MD (95% CI) of effect of aquatic therapy immediately after 4 to 8 weeks of intervention on motor disability (UPDRS III) compared to land-based physiotherapy. Data pooling for five studies (n=162).

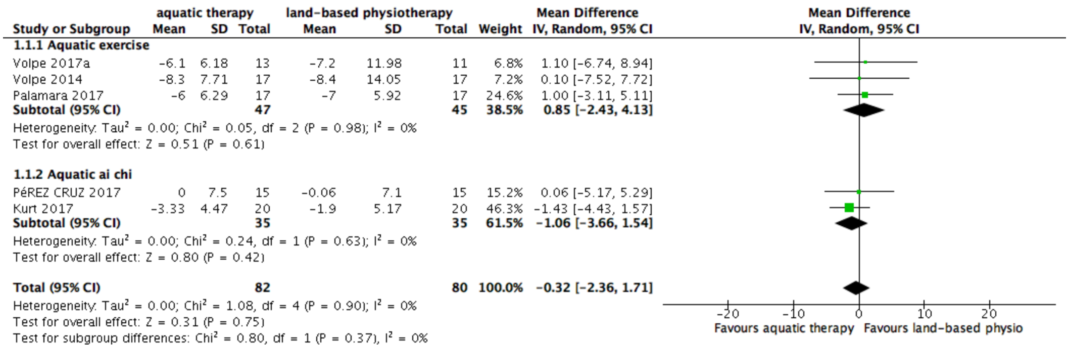


Figure 4. MD (95% CI) of effect of aquatic therapy immediately after 4 to 11 weeks of intervention on functional mobility (Timed Up and Go) compared to land-based physiotherapy. Data pooling for six studies (n=191).

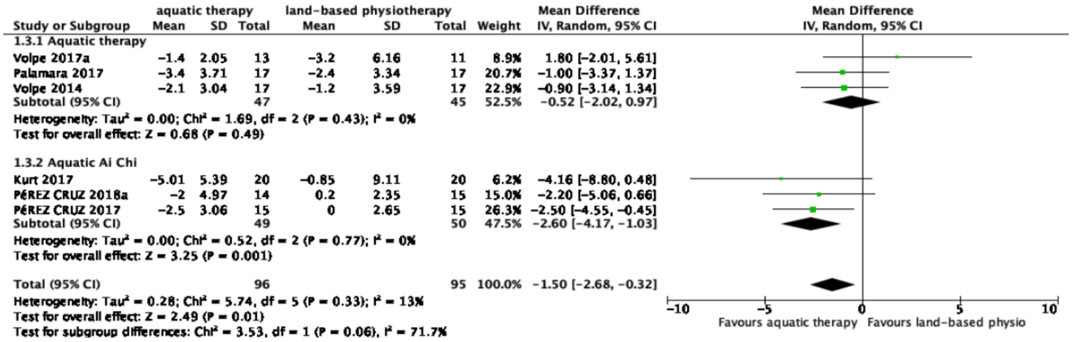
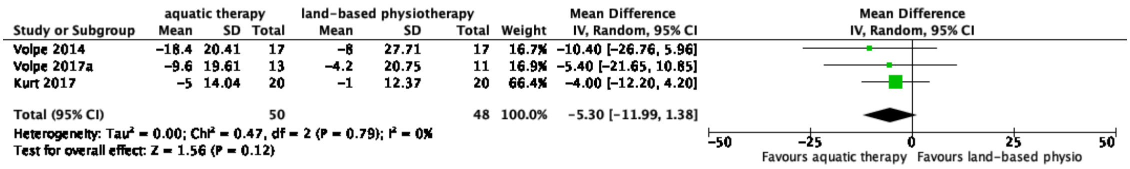


Figure 5. MD (95% CI) of effect of aquatic therapy immediately after 5 to 8 weeks of intervention on quality of life (Parkinson's disease questionnaire 39) compared to land-based physiotherapy. Data pooling for three studies (n=98).



Appendix C: PROSPERO Protocol

Details of the protocol for this systematic review were registered on PROSPERO and can be accessed at:

https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42018085996

Updates to the PROSPERO protocol

Overall, no significant changes were made to the PROSPERO protocol as published. The systematic review was initially completed in 2018, written up for publication and submitted for peer review to a reputable rehabilitation journal in January 2019. However, as the manuscript was not sent for review, for reasons not provided, it was requested to be returned to the authors in May 2019. During this time additional RCTs were published thus, it was agreed that an updated systematic search of the databases was warranted. The PROSPERO protocol was subsequently updated to include a systematic search of all databases from “inception until August 2019.

Appendix D: Data Extraction Form

Review author			
Study Title			
Author		Contact details	
Year		Journal	

Eligibility				
Confirm eligibility for review (tick yes/no)	YES		NO	
Reasons for exclusion given				

Methods				
Study design				
Aims				
Hypothesis				
Setting				
Bias concerns (if any)				
	Randomisation			
Sequence generation	Yes		No	
Concealed allocation	Yes		No	
Blind assessment	Yes		No	

Study Participants		
	Group 1	Group 2
Total Number		
Age		
Sex (male: female)		

Severity of PD (Hoehn and Yahr)		
Diagnostic Criteria		
Country		
Inclusion Criteria		
Exclusion Criteria		
Co- morbidities		
Mini-Mental State Examination (MMSE)		

Intervention(s)								
FITT	Group 1				Group 2			
Frequency (number of days per week)								
Intensity of intervention								
Duration (minute/hours)								
Type of Intervention								
Total number of sessions								
Is the intervention replicable?	Yes		No		Yes		No	

Outcomes		
	Primary	Secondary
Outcome measurement tools		
Assessment times		
Baseline	**Group 1**	
	Group 2	
End of Intervention	**Group 1**	
	Group 2	

Follow-up	**Group 1**	
	Group 2	

Results								
		Baseline		**Intervention**		**End of intervention**		**Follow-up**
Total number of Participants	**Group 1**							
	Group 2							
Reporting of missing participants	**Group 1**							
	Group 2							
Statistical Analysis	**Estimate of effect (*P* value)**							
	Subgroup analysis							
Outcome	**Between group differences**	**Baseline**		**End**		**Follow-up**		
Normative data		**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
1.	Group 1							
	Group 2							
2.	Group 1							
	Group 2							
3.	Group 1							
	Group 2							
4.	Group 1							
	Group 2							

Non-normative data (If applicable)		**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
1.	Group 1						
	Group 2						
2.	Group 1						
	Group 2						
3.	Group 1						
	Group 2						
4.	Group 1						
	Group 2						

PEDro Scale									
Random allocation	Concealed allocation	Baseline comparability	Blind subjects	Blind therapists	Blind assessor	Adequate follow-up	Intention to treat analysis	Between group comparisons	Point estimates & variability
Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
Total score	**/10**								
Downs and Black									
Total score	**/27**								

Conclusion	
Key findings of study	
Study limitations	
Future Research (gaps, recommendations etc.)	
Follow up correspondence with author(s)	

Funding source	
Any other comments by reviewer	

Appendix E: Copyright Permission for Published Paper

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Appendix F: GRADE

Table 5. Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) Evidence Table.

Certainty assessment						Effect	Certainty
Study design	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Absolute (95% CI)**	
Balance (BBS)							
6 RCTs	serious[a,b,c]	not serious	not serious	serious[d]	none	MD **2.08 higher** (0.43 lower to 4.59 higher)	⊕⊕◯◯ Low
UPDRS motor impairment							
5 RCTs	serious[a,b,c]	not serious	not serious	not serious	none	MD **0.32 lower** (2.36 lower to 1.71 higher)	⊕⊕⊕◯ Moderate
Mobility (TUG)							
6 RCTs	serious[a,b,c]	not serious	not serious	serious[d]	none	MD **1.5 lower** (2.68 lower to 0.32 lower)	⊕⊕◯◯ Low
QoL (PDQRS-39)							
3 RCTs	serious[b,c]	not serious	not serious	very serious[e,f]	none	MD **5.3 lower** (11.99 lower to 1.38 higher)	⊕◯◯◯ Very low

RCT, randomised controlled trial; BBS, Berg Balance Scale; UPDRS, Unified Parkinson's Disease Rating Scale; TUG, Timed Up and Go; PDQRS, Parkinson's Disease Quality of life Rating Scale; CI: confidence interval; MD: mean difference.

Explanations

[a] Failure to complete intention to treat analysis and allocation concealment unclear in some studies

[b] Assessors not blinded and selective outcome reporting in some trials

[c] Most Participants and therapists not blinded

[d] Large confidence interval

[e] Small number of trials with wide confidence interval around the effect estimate

[f] Very large confidence interval

Chapter 3 Appendices

Appendix A: Participant Information and Consent

Email information sheet and consent form: Irish participants

Study title: Aquatic therapy for people with Parkinson's disease: a qualitative study

STUDY DETAILS

You are invited to take part in this study identified which is being carried out by researchers from the School of Allied Health at the University of Limerick with the hydrotherapy pool in St. Gabriel's Centre, Dooradoyle Limerick and the Health Service Executive.

<u>What is the study about?</u>

Aquatic therapy consists of water-based exercise with a trained physiotherapist providing the class and usually takes place in a suitably heated pool similar to St. Gabriel's hydrotherapy pool. This study aims to interview a number of people with Parkinson's disease who have previously attended an aquatic therapy class led by a physiotherapist. We also want to know what people with Parkinson's disease who have **never / have never** participated in an aquatic therapy session with a physiotherapist think about this programme. This study will

note any problems people may have with completing the programme note things that people believe may help them to complete aquatic therapy

identify ways to improve aquatic therapy for a future research study

Who will be involved?

Anyone with a diagnosis of Parkinson's disease who has previously or who has never taken part in aquatic therapy.

What are the benefits of this research?

We want to learn from people who are currently participating in aquatic therapy and also people who have never attended aquatic therapy provided by a physiotherapist. While this study might not benefit you directly, you will help to inform how these services may be delivered in Ireland in the future.

Are there any risks?

There are no known risks to taking part in this study.

Compensation

There is no compensation for your participation in this study.

What will you be asked to do?

You will be asked to attend a 60-minute focus group with no more than six other people with Parkinson's disease.

You are invited to seek an additional chance to ask any further questions about the research before you give consent by contacting the lead researcher, louise.carroll@ul.ie.

Copies of each consent form with the study details are at the back of this form.

Your privacy

Any details gathered about you in this study will be kept private. Your name won't be recorded, instead we will use a number as your ID. All details kept on the computer will be in a locked file and the computer will have a password. All details kept on paper will be kept in a locked filing cabinet at the University of Limerick. The details are kept for 7 years and then destroyed. All details will only be accessed by researchers involved in this study.

Taking part is your choice

Taking part in this study is voluntary. You will only take part if you give consent. Please note you can still take part in your regular aquatic therapy class organised by the Midwest Parkinson's group even if you do not take part in this research.

Stopping the study

If you decide to stop taking part, you can withdraw from the study at any point without giving reason.

Further information

If you have any questions about the research at any point, please contact the research team at the details below

Researcher	Email	Phone
Louise Carroll	Louise.Carroll@ul.ie	xxxxxxxxx
Amanda Clifford	Amanda.Clifford@ul.ie	xxxxxxxxx

If you have any concerns about this study please contact the Research Ethics Committee, UL Hospitals Group, Mid-West Region at the details below:

Contact Person: Ms. Joanne O'Connor, Administrator.

Address: Quality and Safety Department,

3rd Floor Nurses Home,

University Hospital Limerick,

Dooradoyle, Limerick.

Tel: 061 482519/087 6713064

E-Mail: joanne.oconnor@hse.ie

This leaflet is for you to keep

http://www.ul.ie/schoolalliedhealth/programmes

Study title: Aquatic therapy for people with Parkinson's disease: a qualitative study

Study details for patients

What will you be asked to do?

Attend a focus group, lasting about 60 minutes, with up to 6 other people who have previously taken part in physiotherapy led aquatic therapy in a swimming pool or hydrotherapy pool. We will talk about exercising in water and your opinions on this type of exercise intervention for Parkinson's disease. We will also talk about your interest in using technology to support aquatic therapy and about a future research study that we are planning on conducting in Ireland and Australia to get your opinion about it.

Everyone who takes part in the focus group will be asked to keep the details about the people who attend and what we talk about private.

The researcher, Louise Carroll will be at the focus group and will also keep anything you talk about private. Your physiotherapist will not be present during the focus group.

Study title: Aquatic therapy for people with Parkinson's disease: a qualitative study

CONSENT FORM

I have read and understood the leaflets about this study and have

- had time to think about being part of this study and
- had a chance to talk to the researchers about any questions I have.

I know that taking part is my choice and I can stop taking part in the study at any time without giving any reason. If I choose to stop I know that this will not affect my relationship with the researcher(s) and my physiotherapist or affect my ability to continue in the exercise programme.

I consent to attending a focus group	YES ☐	NO ☐
I understand that I should keep the details about the people who attend the focus group and what we talk about private	YES ☐	NO ☐
I agree to have voice recorders used during this the focus groups and understand this will be used only for the purpose of the research study and will be destroyed immediately following analysis.	YES ☐	NO ☐

Participant's Name (BLOCK CAPITALS): ________________________

Participant's signature: _______________________ Date: _____________

Phone number / contact details:____

Researcher's name (BLOCK CAPITALS): __________________________

Researcher's signature: _______________________

Date: _____________

Email information sheet and consent form: Australian participants

<table>
<tr><td colspan="3">Aquatic therapy for people with Parkinson's disease
The research is being carried out by the following researchers:</td></tr>
<tr><td>Role</td><td>Names</td><td>Organisation</td></tr>
<tr><td>Primary Investigator
Co-investigator
Co-investigator
Co-investigator</td><td>Professor Meg Morris
Ms. Louise Carroll
Dr. Amanda Clifford
Professor William O'Connor</td><td>La Trobe University, Australia
Univeristy of Limerick, Ireland
Univeristy of Limerick, Ireland
Univeristy of Limerick, Ireland</td></tr>
<tr><td>Research funder</td><td colspan="2">This research is supported by funding from Professor Meg Morris research account, La Trobe University Australia.</td></tr>
</table>

1. What is the study about?

You are invited to participate in a study to explore factors influencing recruitment, retention and sustainability of aquatic therapy for people living with Pakrinson's disease. Aquatic therapy consists of water-based exercise with a trained physiotherapist providing the class and usually takes place in a suitably heated hydrotherapy pool. This study aims to interview a number of people with Parkinson's disease who **have** attended an aquatic therapy class led by a physiotherapist. We also want to know what people with Parkinson's disease who **have never** participated in an aquatic therapy session with a physiotherapist think about this programme. This study will:

- Better understand any problems people with Parkinson's disease may have with participating in aquatic therapy
- note things that people with Parkinson's disease believe may help them to safely complete aquatic therapy
- identify ways to improve aquatic therapy trial design for a future large research study

Your contact details were obtained when you responded to us after hearing about the project from advertisements at Parkinson's Victoria, neurologists, your medical practitioner, physiotherapist, a health professional or the media.

2. Do I have to participate?

Being part of this study is voluntary. If you want to be part of the study, we ask that you read the information below carefully and ask us any questions. You can read the information below and decide at the end if you do not want to participate. If you decide not to participate this will not affect your relationship with your doctor or therapist or any other organisation.

3. Who is being asked to participate?

You have been asked to participate because you are a person living with Parkinson's disease who has indicated that you would like to give feedback and advice on the benefits and limitations of aquatic therapy for people with Parkinson's.

4. What will I be asked to do?

If you wish to take part in this study, we ask you to read and complete the consent form attached with this information sheet. You will be invited to participate in a 60-minute focus group with no more than 12 other people.

The focus group will include:

- A focus group moderator and assistant moderator who will facilitate the focus group
- A series of questions on aquatic therapy aimed at generating group discussion
- Audio recording devices will be used to record the focus group discussion.

We shall also request information on your age, sex, diagnosis, co-morbidities, disease duration and prior aquatic therapy and exercise experience.

What are the benefits?

The benefits of you taking part in this study is that it will give you an opportunity to provide valuable information to researchers and to the Parkinson's community about the value of aqua therapy classes.

5. What are the risks?

With any study, there are (1) risks we know about, (2) risks we do not know about, and (3) risks we do not expect. It is anticipated that there will be no harm to you as a participant involved in this study.

There is a very small risk of distress or discomfort during the focus groups or individual sessions and we shall aim to prevent this by asking all group members to repect privacy and confidentiality each participants right to talk and to share their individual thoughts and opinions without interruption where possible. We shall also ensure that at any time, participants can freely abstain from answering any of the interview or focus group questions.

If you experience something that you are not sure about, please contact us immediately so we can discuss the best way to manage your concerns.

Name/Organisation	Position	Telephone	Email
Professor Meg Morris	Physiotherapist Professor	61 433405 662	m.morris@latrobe.edu.au

6. What will happen to information about me?

All information collected from you will be anonymous. You will not be identifiable in any of the reporting of outcomes. During the study, all files will be kept secure for the duration of the project. Following completion of the study, project documentation will be kept in a secure, lockable location in the office of one of the lead researchers. Data will be stored for 7 years. No data will be used for other projects. We will keep your information for 7 years after the project is completed. After this time, we will destroy all of your data.

We will collect, store and destroy your data in accordance with La Trobe Universities Research Data Management Policy which can be viewed online using the following link: https://policies.latrobe.edu.au/document/view.php?id=106/.

The information you provide is personal information for the purposes of the Privacy and Date Protection Act 2014 (Vic). You have the right to access personal information held about you by the University, the right to request correction and amendment of it, and the right to make a complaint about a breach of the Information Protection Principles as contained in the Information Privacy Act.

7. Will I hear about the results of the study?

We will let you know about the results of the study by December 2020.

8. What if I change my mind?

At any time, you can choose to no longer be part of the study. You can let us know by:

1. Completing the 'Withdrawal of Consent Form' (provided at the end of this document);
2. Calling us;
3. Emailing us

Your decision to withdraw at any point will **not** affect your relationship with La Trobe University or any other organisation listed.

When you withdraw, we will stop asking you for information. Any identifiable information about you will be withdrawn from the research study. However, once the results have been analysed we can only withdraw information, such as your name and contact details. If results haven't been analysed you can choose if we use those results or not.

9. Who can I contact for questions or want more information?

If you would like to speak to us, please use the contact details below:

Name/Organisation	Position	Telephone	Email
Professor Meg Morris	Physiotherapist	61 433405 662	m.morris@latrobe.edu.au

10. What if I have a complaint?

If you have a complaint about any part of this study, please contact:

Ethics Reference Number	Position	Telephone	Email
HEC19157	Senior Research Ethics Officer	+61 3 9479 1443	humanethics@latrobe.edu.au

Consent Form – Declaration by Participant

I (the participant) have read (or, where appropriate, have had read to me) and understood the participant information statement, and any questions have been answered to my satisfaction. I agree to participate in the study; I know I can withdraw at any time. I agree information provided by me or with my permission during the project may be included in a thesis, presentation and published in journals on the condition that I cannot be identified.

Please indicate whether you **have or have not** previously participated in aquatic therapy since your Parkinson's disease diagnosis:

☐ I have previously or am presently participating in aquatic therapy;

☐ I have never participated in an aquatic therapy

I would like my information collected for this research study to be:

☐ Only used for this specific study;

☐ Used for future related studies;

☐ Used for any future studies

Participant Signature

☐ I have received a signed copy of the Participant Information Statement and Consent Form to keep

Participant's printed name	
Participant's signature	
Date	

Consent to be contacted for telephone interview

☐ I consent to be contacted for a follow up telephone interview.

Contact Phone No.	

Declaration by Researcher

☐ I have given a verbal explanation of the study, what it involves, and the risks and I believe the participant has understood;

☐ I am a person qualified to explain the study, the risks and answer questions

Researcher's printed name	
Researcher signature	
Date	

* All parties must sign and date their own signature

Consent Form – Declaration by Participant

I (the participant) have read (or, where appropriate, have had read to me) and understood the participant information statement, and any questions have been answered to my satisfaction. I agree to participate in the study; I know I can withdraw at any time. I agree information provided by me or with my permission during the project may be included in a thesis, presentation and published in journals on the condition that I cannot be identified.

Please indicate whether you **have or have not** previously participated in aquatic therapy since your Parkinson's disease diagnosis:

☐ I have previously or am presently participating in aquatic therapy;

☐ I have never participated in an aquatic therapy

I would like my information collected for this research study to be:

☐ Only used for this specific study;

☐ Used for future related studies;

☐ Used for any future studies

Participant Signature

☐ I have received a signed copy of the Participant Information Statement and Consent Form to keep

Participant's printed name	
Participant's signature	
Date	

Consent to be contacted for telephone interview

☐ I consent to be contacted for a follow up telephone interview.

Contact Phone No.	

Declaration by Researcher

☐ I have given a verbal explanation of the study, what it involves, and the risks and I believe the participant has understood;

☐ I am a person qualified to explain the study, the risks and answer questions

Researcher's printed name	
Researcher signature	
Date	

* All parties must sign and date their own signature

Withdrawal of Consent

I wish to withdraw my consent to participate in this study. I understand withdrawal will not affect my relationship with La Trobe University of any other organisation or professionals listed in the Participant Information Statement. I understand the researchers cannot withdraw my information once it has been analysed, and/or collected as part of a focus group.

I understand my information will be withdrawn as outlined below:

- ✓ Any identifiable information about me will be withdrawn from the study
- ✓ The researchers will withdraw my contact details so I cannot be contacted by them in the future studies unless I have given separate consent for my details to be kept in a participant registry.
- ✓ The researchers cannot withdraw my information once it has been analysed, and/or collected as part of a focus group

***if you have consented for your contact details to be included in a participant registry you will need to contact the registry staff directly to withdraw your details.*

I would like my already collected and unanalysed data

☐ Destroyed and not used for any analysis

☐ Used for analysis

Participant Signature

Participant's printed name	
Participant's signature	
Date	

Please forward this form to:

CI Name	Professor Meg Morris
Email	m.morris@latrobe.edu.au
Phone	61 433405 662
Postal Address	La Trobe University Kingsbury Drive Bundoora 3086 Victoria Australia

Appendix B: Supplementary Material

Box 1. Theme 1: Choosing aquatic therapy

Subtheme 1: *Aquatic therapy to keep moving*

1. You feel that we need to do something for ourselves, and we associated with the pool. (FG1, Ire, P6, PD diagnosis ≥6 years, aquatic therapy ≤5 years)
2. There would be the odd time I would get up and think I'm not going today now, I've enough of all these things, and I get cross about Parkinson's, and sure as, I'll still go away and get ready, and I'm always glad I came, always, always! (FG2, Ire, P5, PD diagnosis ≥12 years, aquatic therapy ≥5years)
3. For people that are not able to walk, once they get into a pool, it's giving them a freedom that they don't really have, I think, out of it, ya. (FG1, Ire, P2, PD diagnosis ≥9 years, aquatic therapy ≤5 years)
4. I was saying I do a bit of hillwalking, and that helps, but I'd like to get involved with the aqua thing; I think it would be more beneficial. (FG3, Ire, P5, PD diagnosis ≥3 years, no aquatic therapy)
5. It's supposed to be very good exercise in water. (FG3, Ire, P4, PD diagnosis ≥3 years, no aquatic therapy)

Subtheme 2: Perceived benefits of aquatic therapy for Parkinson's disease

1. It helps your muscles move better. (FG4, Aus, P2, PD diagnosis ≥11 years, no aquatic therapy)
2. The benefits to me would be movement, movement. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy)
3. It makes you feel good, makes you feel more alive. (FG1, Ire, P5, PD diagnosis ≥4 years, aquatic therapy ≤3 years)

4. Well, because of where I live, the humidity is just so intense, I sweat – I have the head sweats, which is one of the symptoms of Parkinson's. Yes, and it's one of my exercises I can do to keep my body temperature down to relatively normal. (Int7, Aus, PD diagnosis ≥11 years, aquatic therapy ≤3 years)
5. I can't quantify the benefit, I can't scientifically prove the benefit, but anecdotally, I definitely feel more relaxed when I've been swimming…even though the effects may not last for days afterward, I feel that I'm looser and more agile, and generally feel better and less tense and tight than most of the other exercises I do. (Int8, Aus, PD diagnosis ≥5 years, aquatic therapy ≤1 years).
6. Am, it's I suppose, to me, its beneficial for people for weight-bearing purposes or for people whose balance isn't great because they're more comfortable in the water and then I suppose, a heated pool too, it makes it a little bit easier. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)
7. I know it's good for me, and that's because I sweat a lot, and exercising in water, I can do it for longer. (Int7, Aus, PD diagnosis ≥11 years, aquatic therapy ≤3 years)

Subtheme 3: Unique properties of water immersion

1. The water is beautiful; you get the benefit (FG1, Ire, P5, PD diagnosis ≥4 years, aquatic therapy ≤3 years)
2. The temperature of the water is a great help as well. (FG1, Ire, P4, PD diagnosis ≥3 years, aquatic therapy ≤3 years)
3. It's deceptive what exercises you are doing when you are up to your waist in water, as opposed to walking on the road, when you've got the resistance from

the water itself, and you don't feel it. (FG2, Ire, P1, PD diagnosis ≥3 years, aquatic therapy ≤3 years)

4. If I did a lot of walking, my leg would be stiff ya, whereas in the pool, I don't be no; if I did an hour of walking, say, and I did an hour of the pool, I'd be worse after the walking. (FG1, Ire, P2, PD diagnosis ≥9 years, aquatic therapy ≤5 years)
5. It makes it easier to repeat an action because there is less-well, there's a resistance, but it's constant and light. (FG4, Aus, P3, PD diagnosis ≥6 years, no aquatic therapy)
6. It takes the weight off your joints and the force out of the movement. (FG4, Aus, P1, PD diagnosis ≥6 years, no aquatic therapy)
7. I think because, people with Parkinson's, you know your balance being such an issue and I think being in the water, I think you'd feel more, I would feel more secure, now I don't know how everybody else with Parkinson's would be. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)
8. Like to me, water is a natural environment. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)
9. As we were saying before, the water is good for anything, some people ah, pull a muscle in the leg, they go into the water and walk up and down like, to take it away, it helps it all, I think anyway. (FG3, Ire, P5, PD diagnosis ≥3 years, no aquatic therapy)

Box 2. Theme 2: Fear: water and falls

Subtheme 4: Attitudes and cultural experiences associated with fear of water

1. I had a near neighbour drowned in the sea. (FG3, Ire, P2, PD diagnosis ≥9 years, no aquatic therapy)
2. Am, I suppose it goes back to my childhood. Am, parents. Father who came from the coast who wouldn't put a foot in water and mother who had a bad experience. Am, therefore we never really went into water. (Int6, Ire, PD diagnosis ≥22 years, no aquatic therapy)
3. I can't swim (laughs), so if I fell, I've had it. (FG3, Ire, P4, PD diagnosis ≥3 years, no aquatic therapy)
4. I nearly drowned myself as a young fellow, but it took me a year to get used to it, going back in the water, but I persevered. (FG3, Ire, P5, PD diagnosis ≥3 years, no aquatic therapy)
5. Ya, but I have an awful fear of water! Like so much, all of mine (children) they had to learn to swim. That was it because they weren't going to end up like me. (Int4, Ire, PD diagnosis ≥3 years, no aquatic therapy)
6. I think it's an age thing, plus possibly Irish. Certainly, an age thing. I can't recall any of my father's family ever going near the sea, and they were maybe two miles from it. (Int6, Ire, PD diagnosis ≥22 years, no aquatic therapy)
7. I think the difference nowadays is swimming pools in town. We didn't have anything. There was no place to overcome your fear. (Int6, Ire, PD diagnosis ≥22 years, no aquatic therapy)
8. The biggest problem is with people that can't swim; they think they are going to drown. (FG2, Ire, P4, PD diagnosis ≥10 years, aquatic therapy ≥5 years)

Subtheme 5: Fear of falling is associated with the pool environment in some people

1. Ya and the other thing I'd say just for safety is the area where we change; that floor there can be a bit dangerous, I think; I slow down with the walk. I think

you'd want the non-slip shoes. (FG2, Ire, P5, PD diagnosis ≥12 years, aquatic therapy ≥5years)

2. Fear of falling because I feel as though I can't tread water, and I can only go down a certain length. (Int4, Ire, PD diagnosis ≥3 years, no aquatic therapy)
3. I sank twice to the bottom, only for the physiotherapist; I'd say I was gone, on the tile, I slipped on the floor (of the pool), and I went down straight away. (FG1, Ire, P3, PD diagnosis ≥32 years, aquatic therapy ≤3 years)
4. You see, with the Parkinson's, like (FG3, Ire, P4, PD diagnosis ≥3 years, no aquatic therapy) said, you can slip very easily like, and especially if you, you can slip very easily when you become short-stepped. (FG3, Ire, P2, PD diagnosis ≥9 years, no aquatic therapy)

Subtheme 6: Water confidence to allay fears

1. I think if they see the benefits ya. And I think more and more people understand how important exercise is for Parkinson's. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)
2. I think it might be because you, well, I speak for myself; I'm not steady on my feet anyway, so I have a little bit of worry that I would fall. (FG3, Ire, P4, PD diagnosis ≥3 years, no aquatic therapy)
3. Yes, it would be a lot more positive than dealing with a swimming teacher. (FG4, Aus, P1, PD diagnosis ≥6 years, no aquatic therapy)
4. Even if it's a group of four people and we are all starting off, again, I go back to the idea; we are all starting as equals. I think that's a very good idea. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy)
5. I wouldn't really be interested because I do other things. (FG4, Aus, P3, PD diagnosis ≥6 years, no aquatic therapy)

6. I think people newly diagnosed if you could get, and I don’t know how, maybe through the PD Specialist Nurse, is probably, she is the first person that gets to know somebody who has been diagnosed with Parkinson’s am, and getting that message out to them to say, you know, there is great benefit from this, come and maybe two sessions before it starts in September, try and encourage people to come, talk about the benefits of it. (FG2, Ire, P7, PD diagnosis ≥8 years, aquatic therapy ≥5 years)

Box 3. Theme 3: Effective aquatic therapy

Subtheme 7: *Optimal aquatic therapy content and dosage*

1. Well, I would imagine it’s a continuing thing; you do it as part of your daily life, so do it frequently. (FG4, Aus, P3, PD diagnosis ≥6 years, no aquatic therapy)
2. It’s not on often enough (FG1, Ire, P2, PD diagnosis ≥9 years, aquatic therapy ≤5 years)
3. Once a week doesn’t seem enough. It might be for some people, but I think if people are here twice a week, exponentially, you’re getting much more. (FG2, Ire, P1, PD diagnosis ≥3 years, aquatic therapy ≤3 years)
4. You want to do things that you’ll enjoy. (Int9, Aus, PD diagnosis ≥8 years, aquatic therapy ≤1 years)
5. I’d rather use my - use swimming laps as my aerobic/anaerobic exercise. I’d mainly be using the warm water pool to relax my muscles, so stretching exercises, I believe, is more important in the warm water for me than actual exercise. (Int8, Aus, PD diagnosis ≥5 years, aquatic therapy ≤1 years)

6. A variety as well, I prefer swimming, but a variety is good too like. I'm a bad swimmer. I do five or six strokes, and I've to stand like you know! (FG3, Ire, P1, PD diagnosis ≥5 years, no aquatic therapy)
7. Ya ya, the more activities, the more, the better we like it ya. (FG1, Ire, P2, PD diagnosis ≥9 years, aquatic therapy ≤5 years)

Subtheme 8: Important attributes of a credible instructor

1. The physiotherapist nearly puts us to shame; that's why we do it as well. She can do it so well, so we do be trying to keep up with her. (FG1, Ire, P6, PD diagnosis ≥6 years, aquatic therapy ≤5 years)
2. Make it fun. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy)
3. It's a bit of fun when we do the exercise together, and as I said, you've got to get good, positive teachers like. (Int9, Aus, PD diagnosis ≥8 years, aquatic therapy ≤1 years)
4. A good instructor who would be confident. If he or she is confident. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy)
5. I'd say a physiotherapist or an occupational therapist, who would know what you are capable of doing, you know how much you could do or what you wouldn't be capable of doing! (FG3, Ire, P3, PD diagnosis ≥1.5 years, no aquatic therapy)
6. I would like there to be a physio there because am; it's so difficult to get a physio appointment anyway unless you pay for it privately and, I think the benefit of somebody who actually knows how your body works and specialises in Parkinson's is much more beneficial than going to a local aqua aerobics class where you are hopping around and jumping because it's not

focusing on your needs and what you want. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)

Subtheme 9: A tailored aquatic therapy approach for each individual

1. You've got to understand that every Parkinson's person has a different experience. And I know they're talking about making Parkinson into - calling it 'Parkinson's syndrome' because it's not going to be one way of treating it but several ways of treating Parkinson's. (Int9, Aus, PD diagnosis ≥8 years, aquatic therapy ≤1 years)
2. I think if you had a physio there who was there with you, to show you what you should be doing, to benefit you, I just think that would be amazing d'you know because I mean, I could be doing all the wrong things, myself. I think I might be doing great, but I mightn't be using the muscles I need to use or concentrating on the muscles I need to concentrate on. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)
3. Ya, I mean well you'd have an overall but then you know there might be some people who are better on their right or their left. My left isn't my good side so I know I'd have to work on my left rather than my right, but then what would I do to work on my left, to bring it, you know? (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)
4. Well, the big attraction was ah, the fact that the class were led by a physiotherapist. And you straight away were attracted to it, you feel you were not only exercising in the water, but you were doing the right exercises for your condition. (FG2, Ire, P6, PD diagnosis ≥13 years, aquatic therapy ≥5 years)

5. If we were all going to the aqua thing, I wouldn't mind, but I wouldn't like to be going to a session where you're a stage three, and this ladies stage four, and that man is at stage six; I'd like to be at the same levels as, as a newbie and then work up to whatever stage. (FG3, Ire, P5, PD diagnosis ≥3 years, no aquatic therapy)
6. People who are worse obviously can't do something; they might be better off in their own group. (Int3, Ire, PD diagnosis ≥2 years, no aquatic therapy)
7. I think there are benefits; I do because even the one or two times I have gone to (Parkinson's meeting) and do the little exercise and walking around, you know, they kind of team you up with someone who is maybe more advanced than you and it's nice to be able to talk to them and walk with them and be. (Int5, Ire, PD diagnosis ≥5 years, no aquatic therapy)

Box 4. Theme 4: Optimising engagement

Subtheme 10: Information to increase awareness of aquatic therapy

1. I don't think you can ever have enough information; I think information is vital. (FG3, Ire, P2, PD diagnosis ≥9 years, no aquatic therapy)
2. I suppose the most effective way of spreading the word is by word of mouth, by telling a friend, you know, explain to them how much you enjoy it. (FG2, Ire, P6, PD diagnosis ≥13 years, aquatic therapy ≥5 years)
3. I have tried to get people to come; they say no, "I couldn't; I can't swim." You don't have to be able to swim. (FG2, Ire, P4, PD diagnosis ≥10 years, aquatic therapy ≥5 years)

4. I think it would be very important that at the time of diagnosis, the patient is advised of the importance of exercise, including water therapy, by the doctor or the GP, and I base that on my experience. (FG4, Aus, P5, PD diagnosis ≥7 years, no aquatic therapy)

Subtheme 11: Support with all aspects of the program

1. Reassurance that I can do it without being able to swim because it'll be new to me going into water. I know the resistance and everything, that sensation, the process that wouldn't bother me; it's just the fact that, once I'm reassured, safe enough, and that it benefits me is very important. (Int1, Ire, PD diagnosis ≥2 years, no aquatic therapy)
2. You wouldn't like to be in the pool on our own. (FG1, Ire, P6, PD diagnosis ≥6 years, aquatic therapy ≤5 years)
3. Some people might think that they're too stiff or they're gone too far before they come. To assure people you know that they'll be met at their own level. (FG2, Ire, P3, PD diagnosis ≥3 years, aquatic therapy ≤3 years)

Subtheme 12: Key motivators to continue aquatic therapy

1. The other thing is you can make it fun! It can be a social event because one thing with Parkinson's or another thing is that you can become socially isolated. (Int2, Ire, PD diagnosis ≥3 years, no aquatic therapy)
2. I've got a couple of friends who – we all go to the same class because it just pushes you. It's good to have a buddy, someone to – yes because you feel like you're letting them down if you don't go. (Int7, Aus, PD diagnosis ≥11 years, aquatic therapy ≤3 years)
3. I couldn't wait to get back because I needed it, my legs, the walk, everything! (FG2, Ire, P2, PD diagnosis ≥12 years, aquatic therapy ≤5 years)

Appendix C: Consolidated Criteria for Reporting Qualitative Research (COREQ) Checklist

Table 3. The Consolidated Criteria for Reporting Qualitative Research Checklist

	Topic	Guide Questions/Description	Comment/ Reported on Page No.
Domain 1: Research team and reflexivity			
Personal characteristics			
1	Interviewer/facilitator	Which author/s conducted the interview or focus group?	Ireland: • Interviews were conducted by the first author (LC). • Focus groups with people who had previous aquatic therapy experience were conducted by a post-doctoral researcher and a research assistant who had been briefed on the study's aims and interview guide. • One focus group with people with PD who had never completed aquatic therapy was conducted by the first author. A research assistant took detailed field notes. Australia • The focus group was conducted by second author. A research assistant took detailed field notes. • Telephone interviews were conducted by a healthcare professional independent of the study who was briefed on the study's aims and interview guide.
2	Credentials	What were the researcher's credentials? E.g., PhD, MD	Louise M. Carroll (MSc.); Meg M. Morris (Ph.D.); William T. O'Connor (Ph.D.); Amanda M. Clifford (Ph.D.)
3	Occupation	What was their occupation at the time of the study?	Louise M. Carroll (Physiotherapist & Ph.D. candidate); Meg M. Morris (Professor; Physiotherapist); William T. O'Connor (Professor); Amanda M. Clifford (Senior Lecturer in Physiotherapy)
4	Gender	Was the researcher male or female?	75% (n=3) of the researchers were female and 25% male (n=1)
5	Experience & training	What experience or training did the researcher have?	The primary author had completed postgraduate training in qualitative research methods as part of the structured Ph.D. training program. All other authors were experience qualitative researchers.
Relationship with participants			
6	Relationship established	Was a relationship established prior to study commencement?	All of the qualitative interviewers had no professional relationships with the participants, as detailed in Chapter 3 'Data

			Collection' on page 69. The primary author delivered aquatic therapy classes to some participants recruited to the Irish sample. For this reason, a post-doctoral researcher and research assistant, independent of the study, conducted the two focus groups in Ireland with people with PD who had previously engaged in aquatic therapy. For all other participants recruited to the study, the authors had no prior relationship.
7	Participant Knowledge of the interviewer	What did the participants know about the researcher? e.g., personal, goals, reasons for doing the research	A detailed information sheet was provided to prospective participants during the recruitment phase (see Chapter 3 Appendix A, page 201-204)
8	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g., Bias, assumptions, reasons, and interests in the research topic	Potential bias and reasons for conducting the research are set out in Chapter 1 Introduction, page 19-20.
Domain 2: Study design			
Theoretical framework			
9	Methodological orientation and theory	What methodological orientation was stated to underpin the study? e.g., grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Inductive thematic analysis was stated to underpin the study's methodological orientation and is detailed in Chapter 3 'Rationale for choice of methodological approach' on page 62 and page 75 'Data analysis.'
10	Sampling	How were participants selected? e.g., purposive, convenience, consecutive, snowball	A mixture of purposive and snowball sampling was conducted and is detailed in Chapter 3 'Participants' on page 67.
11	Method of approach	How were participants approached? e.g., face-to-face, telephone, mail, email	Participants were recruited through local advertising, word of mouth, and local PD exercise and support group meetings.
12	Sample size	How many participants were in the study?	The sample size (n=34) is detailed in Chapter 3 'Participants' on page 67-68 and in Table 1 on page 70.
13	Non-participation	How many people refused to participate or dropped out? Reasons?	One participant declined to participant as they were unable to travel to the focus group venue. There were no dropouts recorded.
Setting			
14	Setting of data collection	Where was the data collected? e.g., home, clinic, workplace	All data collection took place at a location of convenience such as the participant's home, hydrotherapy pool facilities, community center, and via telephone (Chapter 3 'Data collection' page 68)
15	Presence of non-participants	Was anyone else present besides the participants and researchers?	For all focus groups a second researcher acted as a note taker (Chapter 3 'Data collection' page 68-69).
16	Description of sample	What are the important characteristics of the sample? e.g., demographic	Demographic details are outlined in Chapter 3 'Participants' on page 67-68 and in Table 1 on page 70.

		data, date	
Data collection			
17	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Yes, an interview guide (see Chapter 3, Table 2, page 71) was provided. The interview guide was pilot with a research assistant prior to the first interview/focus group.
18	Repeat interviews	Were repeat inter views carried out? If yes, how many?	Yes, n=9 interviews and n=4 focus groups were conducted (see Chapter 3, Table 1, page 70).
19	Audio/ visual recording	Did the research use audio or visual recording to collect the data?	Yes, see Chapter 3 'Data analysis' page 71.
20	Field notes	Were field notes made during and/or after the interview or focus group?	Yes, see Chapter 3 'Data collection' page 69.
21	Duration	What was the duration of the interviews or focus group?	Interviews and focus groups lasted from 25 to 70 minutes (see Chapter 3 'Data collection' page 69).
22	Data saturation	Was data saturation discussed?	While data saturation was not outlined in the published manuscript (Chapter 3) due to word limitations, data collection was completed when new codes were identified during the analysis phase "generating codes."
23	Transcripts returned	Were transcripts returned to participants for comment and/or corrections?	One focus group and one interview transcript were issued to two of the randomly picked Irish participants to check for accuracy. No additional comments or changes were made.
Domain 3: analysis and findings			
Data analysis			
24	Number of data coders	How many data coders coded the data?	Three. The primary author coded all transcripts. Two authors (AC, WO'C) independently coded 9 transcripts (see Chapter 3 'Data analysis' page 71).
25	Description of the coding tree	Did authors provide a description of the coding tree?	The coding tree was not provided as part of this study.
26	Derivation of themes	Were themes identified in advance or derived from the data?	Themes were derived from the data (see Chapter 3 'Data analysis' page 71).
27	Software	What software, if applicable, was used to manage the data?	The data management software NVivo 12 was used during the analysis (see Chapter 3 'Data analysis' page 71).
28	Participant checking	Did participants provide feedback on the findings?	One Irish participant provided feedback on the results section of the manuscript prior to completion. No additional changes were made.
Reporting			
29	Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g., participant number	Yes (see Chapter 3 'Results' pages 74-85.

30	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes, see results and discussion sections (Chapter 3 pages 74-90).
31	Clarity of major themes	Were major themes clearly presented in the findings?	Yes (see Chapter 3 ‘Results’ pages 74-85 and Figure 1, page 73.
32	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes (see Chapter 3 ‘Results’ pages 74-85 and Figure 1, page 73.

Checklist from: Tong A, Sainsbury P, Craig J. (2007) ‘Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups,’ *International Journal for Quality in Health Care*, 19(6), 349 –357

Appendix D: Copyright Permission for Published Paper

From: permissionrequest@tandf.co.uk <permissionrequest@tandf.co.uk>
Sent: 27 July 2021 08:50
To: Louise.Carroll <Louise.Carroll@ul.ie>
Subject: RE: Permission for including paper in PhD thesis

EXTERNAL EMAIL: This email originated from outside of the University of Limerick. Do not click on links or open attachments unless you recognize the sender's email address and know the content is safe.

26 July 2021

Dear Louise,

Louise M. Carroll, Meg. E. Morris, William T. O'Connor & Amanda M. Clifford (2021): Community aquatic therapy for Parkinson's disease: an international qualitative study, Disability and Rehabilitation, DOI: 10.1080/09638288.2021.1906959

Thank you for your correspondence requesting permission to post the **Authors Original Manuscript** for the above mentioned article on University of Limerick repository.

As you are the author of the above article, we are pleased to grant you permission to include your article as it was originally submitted to the journal on the condition that you make the following acknowledgement:

This is an **Author's Original Manuscript** of an article published by Taylor & Francis Group in Disability and Rehabilitation on 07 APR 2021 available online: https://doi.org/10.1080/09638288.2021.1906959

You will also need to obtain permission from any co-author's of this article.

Please note we are unable to grant you permission to include the **final accepted version** within the **12** month embargo period.

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Thank you for your interest in our Journal.

Yours sincerely,

Sue McCarthy

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Chapter 4 Appendices

Appendix A: Participant Information and Consent

Information sheet – Parkinson's Patient and Public Involvement Panel

<u>Title of Study:</u> Developing an evidence-based aquatic therapy guideline for Parkinson's disease: A modified Delphi consensus study

<u>Information sheet:</u> Parkinson's disease Aquatic Therapy Stakeholder Panel

If you are over 18 years of age and have a diagnosis of Parkinson's disease, you are invited to join a Research stakeholder panel at the University of Limerick and contribute to a consensus study on aquatic therapy for people living with Parkinson's disease.

What will I have to do?

Taking part means attending:

• A **<u>two-hour panel meeting</u>** up to four times yearly with other people with Parkinson's disease. These meetings will be facilitated by the principal researcher who is a physiotherapist who has specialist knowledge in aquatic therapy for Parkinson's disease.

• A **<u>one-to-one meeting</u>** with the principal researcher

The panel meetings will involve discussing your experience as a person with Parkinson’s disease on the topic of aquatic therapy for the purpose of a research study. At no time will you be asked to reveal any medical or personal information about yourself. You may be asked for example to discuss if a guideline is easy to read for people with Parkinson’s disease or you could be asked to talk with researchers about the consensus study they are planning to conduct.

The interview will be scheduled if further details or information is required or if you are unable to attend a panel meeting.

The panel meetings will run for approximately 9 to 12 months from spring 2019 to winter 2020. There will be no more than 4 panel meetings in total during this time period and no more than two interviews.

Who is organising the study?

Louise Carroll is a PhD student at the University of Limerick. She will be supervised throughout this process by Dr Amanda Clifford, Professor William O’Connor at the University of Limerick and Professor Robinson at La Trobe University, Melbourne, Australia.

Location?

The meetings and interview will be held at the University of Limerick or in an accessible hotel in Limerick

You may withdraw at any stage without any consequence.

What are the benefits?

The findings of the study will help researchers in the University of Limerick and outside of Ireland to develop a guideline recommendation that is relevant to people with Parkinson's disease who wish to partake in aquatic therapy. It can help researchers make sure it is easy for people with Parkinson's disease to access and read.

What are the risks?

There are no anticipated risks associated with taking part in the stakeholder's panel or interview.

What if I do not want to take part?

Participation in this study is voluntary and you can choose not to take part or to stop involvement at any time. You can choose to take part in the panel meetings without taking part in the interviews.

What happens to the information?

The panel meetings and the interview will be audio recorded and will be stored securely and safely on the researchers' computer. The computers are protected with a password. Your name will not appear on any information or in any report arising from the study. The information that is gathered in the study will be kept for seven years. After this time, it will be destroyed.

Who else is taking part?

A small group of 4 to 6 people living with Parkinson's disease who have or have no previous experience of aquatic therapy, and who are living in the Midwest region of Ireland will be included in the panel.

What if I have more questions?

If you have any questions about the study, you may contact the researchers – contact details listed below. It is important that you feel that all your questions have been answered.

What happens if I change my mind during the study?

At any stage should you feel that you want to stop taking part in the study, you are free to withdraw with no consequences.

What should I do if I am interested in taking part?

Please contact **Louise Carroll** at the either of the following telephone number or email:

Louise Carroll, School of Allied Health, University of Limerick, Tel: ___________

Louise.Carroll@ul.ie

Contact name and number of Research supervisor:

Dr. Amanda Clifford, School of Allied Health, University of Limerick, Tel (061) 234118

Email: Amanda.Clifford@ul.ie

Thank you for taking the time to read this. I would be grateful if you would consider participating in this study.

This research study has received Ethics approval from the Education and Health Sciences Research Ethics Committee (quote approval number).

If you have any concerns about this study and wish to contact someone independent, you may contact:

Chairman Education and Health Sciences Research Ethics Committee

EHS Faculty Office

University of Limerick

Tel (061) 234101

Participant consent form - Parkinson’s disease Aquatic Therapy Stakeholder Panel

UNIVERSITY OF LIMERICK
OLLSCOIL LUIMNIGH

EHSREC Approval Number:

2020_02_17_EHS

EHS RESEARCH ETHICS COMMITTEE - PARTICIPANT CONSENT

Title of Study: Developing an evidence-based aquatic therapy guideline for Parkinson's disease: A modified Delphi consensus study

Should you agree to participate in this study please read the statements below and if you agree to them, please sign the consent form.

- I have read and understood the participant information sheet.
- I understand what the project is about, and what the results will be used for.
- I understand that what the researchers find out in this study may be shared with others but that my name will not be given to anyone in any written material developed.
- I am fully aware of what I will have to do, and of any risks and benefits of the study.
- I know that I am choosing to take part in the study and that I can stop taking part in the study at any stage without giving any reason to the researchers.

This study involves audio/video recording. Please tick the appropriate box

- I am aware that my participation in this study may be recorded (video/audio) and I agree to this. However, if I feel uncomfortable at any time, I can ask that the recording equipment be switched off. I understand that I can ask for a copy of my recording. I understand what will happen to the recordings once the study is finished. ☐
- I do not agree to being audio/video recorded in this study. ☐

After considering the above statements, I consent to my involvement in this research project.

Name: (please print): ____________________________

Signature: ______________________________________ Date: _______________

Investigator's Signature __________________________ Date: ________________

Recruitment poster - Parkinson’s disease Aquatic Therapy Stakeholder Panel

AQUATIC THERAPY FOR PARKINSON'S DISEASE

Ethics number: xxxxxx

University of Limerick researchers are looking for people with Parkinson's disease to take part in a research stakeholder panel.

We want to hear your views on research.

Contact:
Louise Carroll

Tel: 0877679990
Email:
Louise.Carroll@ul.ie

School of Allied Health,
Health Sciences Building,
University of Limerick
V94 T9PX

Are you interested in joining a research stakeholder panel?

If you have any concerns about this study, you can contact an independent person:
The EHS Research Ethics Contact Point of the Education and Health Sciences Research Ethics Committee,
Room E1003, University of Limerick, Limerick
Tel: (061) 234101 /Email: ehsresearchethics@ul.ie

Email information sheet – Expert panel (Delphi method)

Dear <INSERT PROFESSIONAL GROUP NAME> Member,

We are seeking informed perspectives from researchers or healthcare practitioners to take part in a Delphi study to establish expert consensus for the optimal aquatic therapy intervention and treatment dosage for people living with Parkinson's disease. We are particularly interested in the views of people working internationally.

If you would like to be involved or would like further information, please contact Louise.Carroll@ul.ie. Further details on the study are provided below.

Thank you for taking the time to consider participating in our consensus study.

Yours sincerely,

Louise Carroll

Structured PhD Candidate,

School of Allied Health,

University of Limerick,

Ireland.

Information Sheet: Expert panel member (Delphi method)

Title: Developing an evidence-based aquatic therapy guideline for Parkinson's disease: A modified Delphi consensus study"

Aquatic therapy offers health care practitioners a unique therapeutic environment to treat people with Parkinson's disease (PwPD). There is a growing body of moderate to high quality evidence that aquatic therapy is an effective physiotherapy intervention approach for PwPD. However, summarising evidence on what the optimal dosage and accepted aquatic therapy program - tailored to the individual impairments encountered in PD – can be difficult, due to large variations in research trials and insufficient patient informed qualitative data on aquatic therapy. While there have been several high-quality randomised controlled trials and systematic reviews recently published, there are currently no evidence-based guidelines on aquatic therapy for PwPD. Clinical guidelines can help to support decision making in clinical practice; to promote effective interventions, and to preventing ineffective – or unsafe – practice. This research aims to establish expert consensus, based on scientific evidence for the optimal aquatic therapy intervention and treatment dosage for people living with Parkinson's disease.

We believe that you meet the following **inclusion criteria** for this study:

- Adult> 18 years (male and female) with an undergraduate/postgraduate qualification as a health care professional (include but not limited to physiotherapist, occupational therapy, nurse, medical doctor)
- Health care professional with a clinical specialism in aquatic therapy and/or Parkinson's disease.
- Aquatic therapy and/or Parkinson's disease post-graduate/academic researcher.

If you meet this inclusion criteria and are willing to participate in this consensus study, we would be grateful if you would complete the consent form attached/enclosed and return it to Louise Carroll by the **<insert return date>.**

What will I have to do?

This study will be carried out using a modified Delphi technique. It will include a minimum of 3 online questionnaires, which will aim to achieve consensus. With your consent, the questionnaires will be emailed or posted to you. When we receive your signed consent form, the first questionnaire will be emailed to you within a 2-week period. We will include clear and concise information on how to complete each questionnaire. If feasible, a final online group meeting with other panellists (experts) taking part in the study, will be scheduled at the after the questionnaires are completed to enable you to provide final feedback and to discuss…

How long will it take to complete each questionnaire?

Time taken to complete each questionnaire will vary for each panellist but should range from 30-45 minutes. There are no right or wrong answers and all replies are important. We are seeking your own expert opinion.

Who is organising the study?

Louise Carroll is a PhD student at the University of Limerick. She will be supervised throughout this process by Dr Amanda Clifford, Professor William O’Connor at the University of Limerick and Professor Robinson at La Trobe University, Melbourne, Australia.

What are the benefits?

We believe that by taking part, you will find the Delphi process interesting and thought provoking. The results of the study and final guideline document will be made available to you at the conclusion of the study. If you complete all 3 rounds of the Delphi questionnaires, you will be invited to have your name included in a list of contributors in the final published guideline document.

If I do not want to take part?

Participation in this study is voluntary and you can choose not to take part or to stop involvement at any time.

What happens to the information collected from the Delphi questionnaires?

This study is being undertaken as part of my PhD research project undertaken at the University of Limerick and will be written up and published as part of this process. Any information collected will be entirely confidential and anonymous when the results of the study are reported/published. You will be assigned a specific code, which can only be identified by Louise Carroll and will be anonymous to other panellists taking part in the Delphi process. The completion and return of each Delphi questionnaire will imply your consent to participate.

What happens if I change my mind during the study?

At any stage should you feel that they want to stop taking part in the study, you are free to withdraw with no consequences.

What if I have more questions?

It is important that you feel that all your questions have been answered. If you have any questions, please email/telephone the following:

Researcher	Email	Phone
Louise Carroll	Louise.Carroll@ul.ie	(+353)
Dr. Amanda Clifford	Amanda.Clifford@ul.ie	(+353)

Thank you for taking the time to read this. I would be grateful if you would consider participating in this study.

This research study has received Ethics approval from the Education and Health Sciences Research Ethics Committee 2020_02_17_EHS.

If you have any concerns about this study and wish to contact someone independent, you may contact:

Chairman Education and Health Sciences Research Ethics Committee

EHS Faculty Office

University of Limerick

Tel (061) 234101

Consent form- Expert panel (Delphi method

EHSREC Approval Number:

2020_02_17_EHS

Expert Panel Consent (Delphi Method)

Title of Study: Developing an evidence-based aquatic therapy guideline for Parkinson's disease: A modified Delphi consensus study

Should you agree to participate in this study please read the statements below and if you agree to them, please sign the consent form.

- I have read and understood the participant information sheet.
- I understand what the project is about, and what the results will be used for.
- I understand that what the researchers find out in this study may be shared with others but that my name will not be given to anyone in any written material developed without my further consent.
- I am fully aware of what I will have to do, and of any risks and benefits of the study.
- I know that I am choosing to take part in the study and that I can stop taking part in the study at any stage without giving any reason to the researchers.

This study involves audio/video recording for the final consensus group meeting. Please tick the appropriate box

- I am aware that my participation in this study may be recorded (video/audio) and I agree to this. However, if I feel uncomfortable at any time, I can ask that the recording equipment be switched off. I understand that I can ask for a copy of my recording. I understand what will happen to the recordings once the study is finished. ☐
- I do not agree to being audio/video recorded in this study. ☐

After considering the above statements, I consent to my involvement in this research project.

Name: (please print): ____________________________

Signature: ______________________________________ Date: _______________

Investigator's Signature __________________________ Date: _______________

Email information sheet and consent form – Expert panel (Consensus meeting)

Information Sheet: Expert panel member (Delphi method)

Title: Developing an evidence-based aquatic therapy guideline for Parkinson's disease: A modified Delphi consensus study"

Aquatic therapy offers health care practitioners a unique therapeutic environment to treat people with Parkinson's disease (PwPD). There is a growing body of moderate to high quality evidence that aquatic therapy is an effective physiotherapy intervention approach for PwPD. However, summarising evidence on what the optimal dosage and accepted aquatic therapy program - tailored to the individual impairments encountered in PD – can be difficult, due to large variations in research trials and insufficient patient informed qualitative data on aquatic therapy. While there have been several high-quality randomised controlled trials and systematic reviews recently published, there are currently no evidence-based guidelines on aquatic therapy for PwPD. Clinical guidelines can help to support decision making in clinical practice; to promote effective interventions, and to preventing ineffective – or unsafe – practice. This research aims to establish expert consensus, based on scientific evidence for the optimal aquatic therapy intervention and treatment dosage for people living with Parkinson's disease.

We believe that you meet the following **inclusion criteria** for this study:

- Adult> 18 years (male and female) with an undergraduate/postgraduate qualification as a health care professional (include but not limited to physiotherapist, occupational therapy, nurse, medical doctor)

- Health care professional with a clinical specialism in aquatic therapy and/or Parkinson's disease.
- Aquatic therapy and/or Parkinson's disease post-graduate/academic researcher.

If you meet this inclusion criteria and are willing to participate in this consensus study, we would be grateful if you would complete the consent form attached and return it to Louise Carroll (lcarroll@ul.ie) by the **<insert return date>.**

What will I have to do?

The aquatic therapy guidelines were developed following two rounds of an online Delphi questionnaire, which occurred between July 2020 and December 2020, with over 45 international experts in the field of aquatic therapy and Parkinson's disease . With your consent, you are being asked to participate in an online consensus meeting with a group of 10-15 international experts. When we receive your signed consent form, you will receive an email with a copy of the aquatic therapy guidelines document. We will include clear and concise information on how to review the guidelines document before the consensus meeting. It is imperative that you treat this document as confidential, and do not print or share, until after the research paper and guidelines are finalised and published. The purpose of the consensus meeting will be as follows:

(1) Review the guidelines and suggestions for improvement (if any content is irrelevant or in conflict with your experiences)

(2) Discuss whether the guideline is understandable and accessible

(3) Discuss whether the guideline is representative of client centred care and Evidence Based Practice

(4) Debate statements not meeting consensus from round two of the Delphi questionnaire.

How long will the consensus meeting take?

Time taken to complete the consensus meeting will be no longer than one hour. There are no right, or wrong answers and all replies are important. We are seeking your own expert opinion.

What are the benefits?

We believe that by taking part, you will find partaking in the consensus meeting interesting and thought provoking. The results of the study and final guideline document will be made available to you at the conclusion of the study. You will be invited to have your name acknowledged as a contributor to the consensus meeting in the published research paper.

If I do not want to take part?

Participation in this study is voluntary and you can choose not to take part or to stop involvement at any time.

What happens to the information collected from the consensus meeting?

Ideas and information gathered during the consensus meeting may be shared with other international experts partaking in a separate, second consensus meeting. The researcher (Louise Carroll) will explicitly state during the consensus meeting, whether non-identifiably information from the meeting is intended to be shared or sumarised during a second meeting. This study is being undertaken as part of my PhD research project undertaken at the University of Limerick and will be written up and published as part of this process. Any information collected will be entirely confidential and anonymous when the results of the study are reported/published. You will be assigned a specific code, which can only be identified by the principal investigator (LC).

What happens if I change my mind during the study?

At any stage should you feel that they want to stop taking part in the study, you are free to withdraw with no consequences.

Reimbursement:

There is no reimbursement for academic researchers or clinicians participating in this study.

What if I have more questions?

It is important that you feel that all your questions have been answered. If you have any questions, please email/telephone the following:

Researcher	Email	Phone
Louise Carroll	Louise.Carroll@ul.ie	(+353)
Dr. Amanda Clifford	Amanda.Clifford@ul.ie	(+353)

Thank you for taking the time to read this. I would be grateful if you would consider participating in this study.

This research study has received Ethics approval from the Education and Health Sciences Research Ethics Committee 2020_02_17_EHS.

If you have any concerns about this study and wish to contact someone independent, you may contact:

Chairman Education and Health Sciences Research Ethics Committee

EHS Faculty Office

University of Limerick

Tel (061) 234101

UNIVERSITY OF LIMERICK
OLLSCOIL LUIMNIGH

EHSREC Approval Number:

2020_02_17_EHS

Expert Panel Consent (Delphi Method)

Title of Study: Developing an evidence-based aquatic therapy guideline for Parkinson's disease: A modified Delphi consensus study

Should you agree to participate in this study please read the statements below and if you agree to them, please sign the consent form.

- I have read and understood the participant information sheet.
- I understand what the project is about, and what the results will be used for.
- I understand that what the researchers find out in this study may be shared with others but that my name will not be given to anyone in any written material developed without my further consent.
- I am fully aware of what I will have to do, and of any risks and benefits of the study.
- I know that I am choosing to take part in the study and that I can stop taking part in the study at any stage without giving any reason to the researchers.

This study involves audio/video recording for the final consensus group meeting. Please tick the appropriate box

- I am aware that my participation in this study may be recorded (video/audio) and I agree to this. However, if I feel uncomfortable at any time, I can ask that the recording equipment be switched off. I understand that I can ask for a copy of my recording. I understand what will happen to the recordings once the study is finished. ☐
- I do not agree to being audio/video recorded in this study. ☐

After considering the above statements, I consent to my involvement in this research project.

Signature: ____ Date: ________________

Investigator's Signature ___________________________ Date: ______________

Appendix B: Supplementary material

Tables 3-7 and Figures 4-8

Table 3. Delphi questionnaire. Round one results.

	Statement/Question	Md (IQR) % Score
	1. Aquatic therapy delivery	
1	It is important that people with Parkinson's disease begin aquatic therapy as early as possible/ immediately after receiving their diagnosis.	7(4) 70%
2	It is important that a Physiatrist (Physical Medicine Rehabilitation Doctor) or Neurologist with expertise in Parkinson's disease provide a prescription of exercises to be conducted as part of the aquatic therapy program.	5(7) 38%
3	It is important that people with Parkinson's disease receive one-to-one aquatic therapy session(s) with a qualified instructor before joining any group-based aquatic therapy.	8(3) 68%
4	It is important that people with Parkinson's disease become confident exercising in water before beginning targeted aquatic exercises for their impairment.	8(4) 72%
5	It is important that all aquatic therapy activity undertaken by people with Parkinson's disease is supervised by a healthcare professional or suitably qualified people (e.g., therapy assistants).	9(5) 72%
6	It is important to have a checklist for identifying the exclusion criteria for aquatic therapy participation in Parkinson's disease.	10(1) 96%
7	It is important that people with Parkinson’s disease have access to inpatient (e.g., hospital, rehabilitation centre) aquatic therapy services.	8(4) 64%
	2. Location and pool environment	
8	For safety, it is important that people with Parkinson's disease only attend pools, which are fully accessible (chair lift, hoist, underfloor heating, graded pool depth).	8(4) 64%
9	It is important that people with Parkinson's disease exercise in a heated pool (between 32- 35.5 degrees Celsius).	7(3) 68%
10	It is important that the level of immersion is recorded and reported when performing aquatic exercises.	8(3) 88%
11	It is important that people with Parkinson's disease have access to aquatic therapy services in their local community (e.g., swimming pool, hydrotherapy pool).	10(2) 90%
	3. Safety and supports	

12	It is important that healthcare professionals support people with Parkinson's disease to transition towards participating in community-based aquatic groups with a suitably trained instructor.	10(3) 80%
13	It is important to specify the qualifications (e.g., level of training and expertise) of the aquatic therapy instructor.	8(2) 80%
14	To promote self-management in the local community, it is important that healthcare professionals provide training on Parkinson's disease to the following:	
a.	Swimming teachers	5(4) 46%
b.	Aqua aerobics instructors	8(3) 78%
c.	Lifeguards/pool assistants	8(5) 60%
d.	Patient support workers	9(2) 86%
15	It is important to support people with Parkinson's disease who may require assistance with dressing and showering.	10(2) 92%
16	It is important to identify people with Parkinson's disease with a fear of falling, as it may deter them from engaging in aquatic therapy.	9(4) 75%
17	It is important that people with Parkinson's disease who have a fear of water are identified and supported by healthcare professionals to access and participate in aquatic therapy.	10(2) 91.7%
18	It is important to provide clear information and address any safety concerns of people with Parkinson's disease in preparing for the first aquatic therapy session.	10(0) 87.9%
19	For safety, it is important that people with Parkinson's disease do not enter the poolside without trained personnel (e.g., lifeguard, pool manager) or an aquatic therapy instructor present.	10(2) 85.4%
20	It is important that all people with Parkinson's disease wear non-slip shoes when accessing and exercising in the pool.	9(4) 68.7%
21	It is important to document and report any incidents or adverse events that occur during an aquatic therapy session.	10(0) 97.9%

22	For safety (and in accordance with the ATACP space recommendation of 2m² per bather), it important to have no more than 6-8 people with Parkinson's disease per aquatic therapist in a pool.	9(3) 85.1%
23	For reasons of safety, it is important that people with advanced Parkinson's disease (Hoehn and Yahr stages 4-5) do not participate in aquatic therapy.	1(5) 14.6%
24	It is important that people with advanced Parkinson's disease (Hoehn and Yahr stages 4-5) only participate in one-to-one aquatic therapy with a trained healthcare professional.	10(2) 81.2%
25	It is important that aquatic therapy instructors regularly assess people with Parkinson's disease for changes in their swimming ability.	8(5) 60.4%
4. Tailored aquatic program		
26	It is important that each individual's personal goals and preferences are identified and evaluated.	10(1) 97.9
27	It is important that group aquatic exercises are tailored to each individual's impairment(s) and symptoms.	10(2) 93.7
28	It is important that people with Parkinson's disease have access to aquatic therapy groups specifically targeting their level of disease severity (e.g., Hoehn and Yahr level 1, level 2, level 3-4).	9(3) 81.2
29	It is important to report whether the planned aquatic program and individual performance of the program matched.	9(3) 89.6
5. Dosage: Frequency of aquatic therapy		
30	For aquatic therapy to be effective, please indicate the optimal time for people with Parkinson's disease. **(See Results of round 1. Single choice question: Figure 3)**	
31	In a community-based setting, please indicate how many sessions per week is optimal to a sustained treatment effect for people with Parkinson's disease? (**See Results of round 1. Single choice questions Figure 4)**	
32	In a community-based setting, if people with Parkinson's disease can only participate in aquatic therapy once a week, it is important to provide them with a specified home exercise program.	10(2) 94%
33	In an inpatient setting, please indicate how many sessions per week is optimal for people with Parkinson's disease? **(See Results of round 1. Single choice question: Figure 5)**	
6. Dosage: Intensity of aquatic therapy		

34	It is important that the level of aquatic exercise intensity is measured and recorded (e.g., heart rate monitor, rating of perceived exertion).	8(4) 75.5%
35	It is important that people with Parkinson's disease perform vigorous and sustained aquatic exercises within a pre-determined heart rate zone (e.g., set between 65% and 80% of their heart rate reserve; HHR).	7(3) 55.1%
36	It is important that aquatic exercises for people with Parkinson's disease are progressed as per the American College of Sports Medicine (ACSM) guidelines for physical exercise.	8(3) 70.8%
37	It is important that the number of sets and repetitions of each aquatic exercise performed is reported and recorded.	9(3) 83.7%
38	It is important to describe in detail the criteria for determining when to progress aquatic exercises.	8(2) 87.8
39	It is important that every rest period between exercise sets, and repetitions is reported and recorded.	7(4) 65.3%
7. Dosage: Duration of the aquatic therapy		
40	For aquatic therapy to be effective, please indicate the optimal length of time for people with Parkinson's disease to engage in aquatic therapy. **(See Results of round 1. Single choice question: Figure 6)**	
8. Aquatic therapy elements		
41	For people with Parkinson's disease, it's important to include a variety of exercise components targeting movement disorder impairments in the aquatic therapy program.	10(1) 89.8
42	Many aquatic approaches are adopted for people with Parkinson's disease; please tick which (if any) of the following methods you apply when treating people with Parkinson's disease in the water? **(See Results of round 1. Multiple choice question: Figure 7)**	
43	It is important to include swimming training as a component of the aquatic therapy program for people with Parkinson's disease.	5(3) 28.6
44	It is important to specify how adherence to aquatic therapy will be measured (e.g., exercise diary, goal attainment scale, motivational app) and reported.	8(3) 77.6
45	It is important to specify details of motivation strategies applied during aquatic therapy sessions. (e.g., goal setting, rewards, motivational app, positive reinforcement, auditory and visual cueing).	8(2) 83.7

46	It is important to provide a detailed description of individual aquatic exercises in order for aquatic programs to be replicated. (e.g., picture handout, photographs, videos).	9(2) 85.7
47	It is important that all people with Parkinson's disease participating in aquatic therapy are provided with a specified home exercise program.	9(3) 83.7
48	It is important to describe non-exercise components of the aquatic therapy intervention (e.g., Cognitive training).	8(3) 63.3

Abbreviations: Md=Median; IQR=Interquartile range; % Score = Percentage of experts scoring the statement ≥7 (Median score)

Results of round 1. Single and multiple-choice questions.

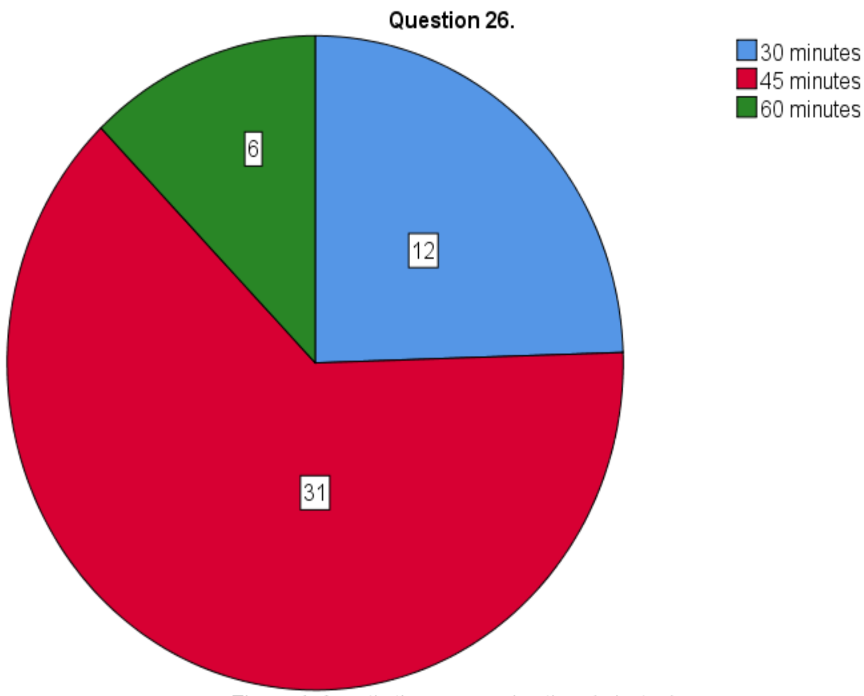

Figure 4. Aquatic therapy session time (minutes)

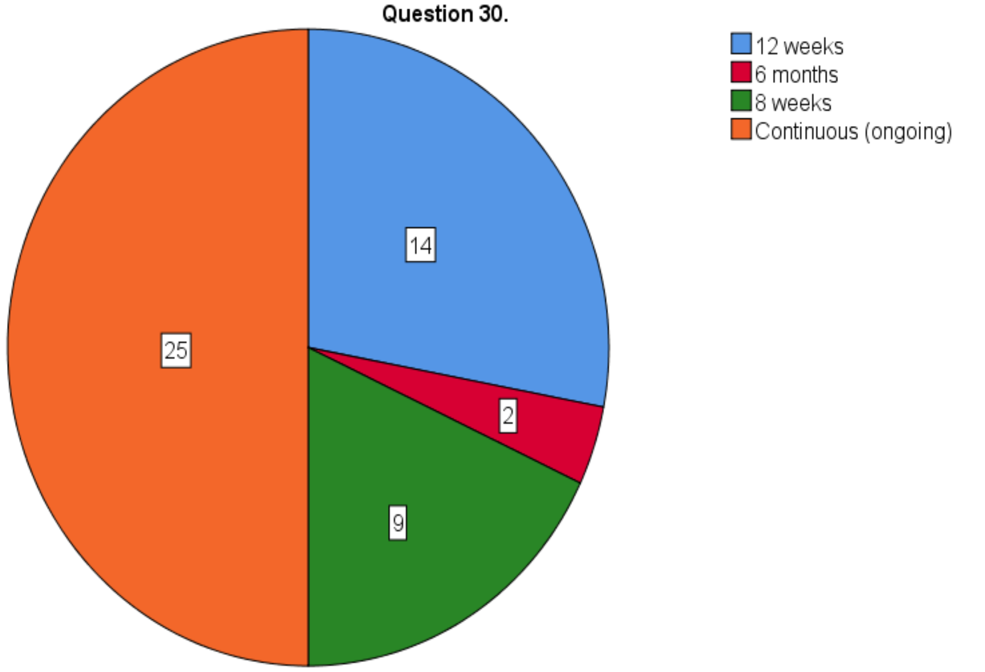

Figure 5. Duration of aquatic therapy (weeks/months)

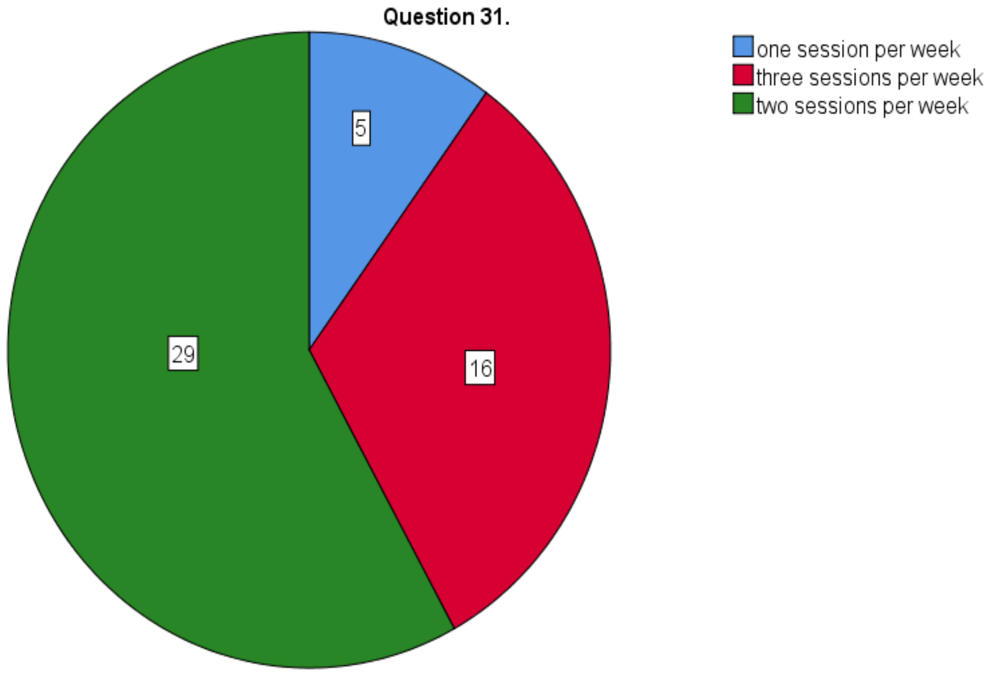

Figure 6. Frequency of community-based aquatic therapy (per week)

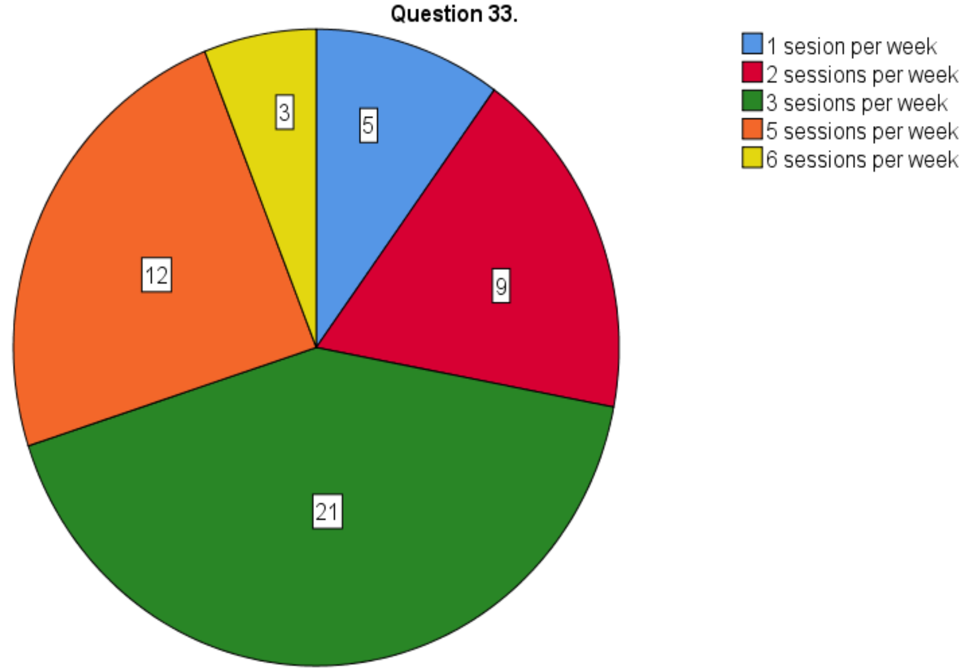

Figure 7. Frequency of aquatic therapy - rehabilitation/ hospital setting (per week)

Figure 8. Types of aquatic approaches applied (Question 42.)

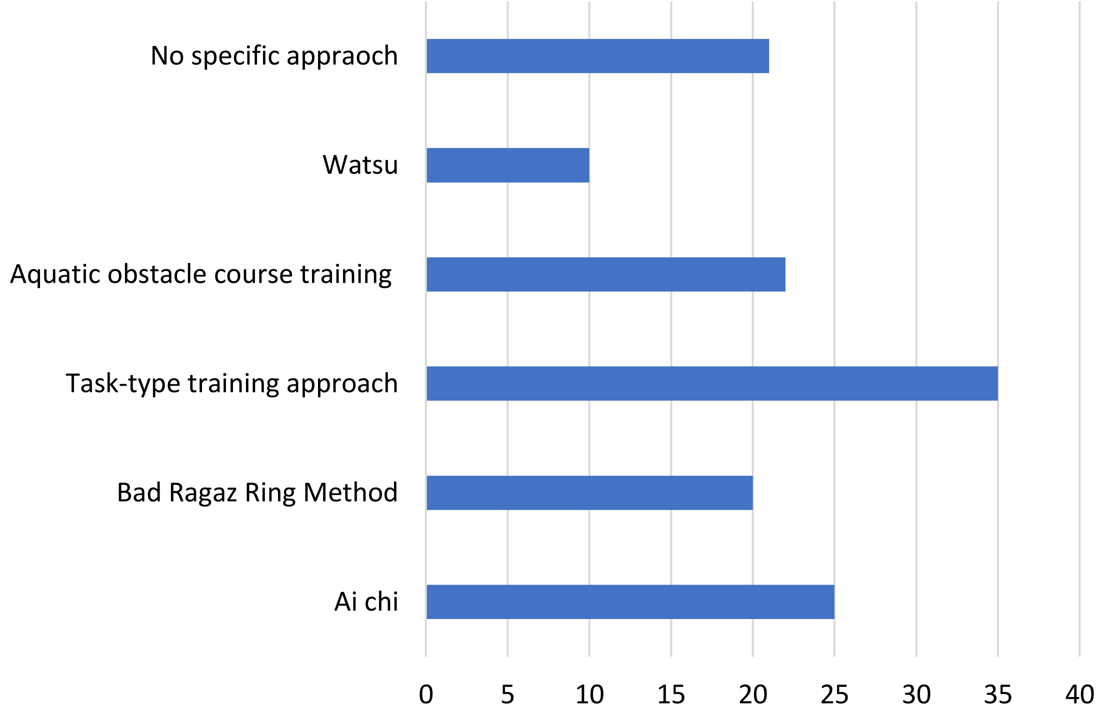

Table 4. Categories and sub-categories: round one and round two Delphi questionnaire open comments

Generic Category		Sub-category
Main Category: Aquatic therapy delivery		
Aquatic therapy referral	1	Role of Doctor/Physician to refer PwPD for aquatic therapy and rule out contraindications
	2	Aquatic therapy is one therapy option for PwPD
	3	Early access to aquatic therapy to promote long-term adherence
	4	Healthcare professional with knowledge of PD and exercise prescription best to deliver aquatic therapy
Initial assessment	5	Screen for contraindications and precautions
	6	Identify patient preferences and goals
Initial aquatic therapy intervention	7	Initial aquatic therapy to assess functional capacity in water, client safety, and level of water confidence
	8	Small group (e.g., ≤ 4 PwPD) may be suitable for some PwPD
	9	Healthcare professionals skilled in aquatic therapy prescribe, monitor, and review the aquatic program
Criteria for one-to-one versus group aquatic therapy	10	Group aquatic therapy suitable in earlier disease stages
	11	Basic water confidence for PwPD a pre-requisite for group participation
	12	One-to-one aquatic therapy required for people in the advanced disease stages
Main Category: Location & pool environment		
Access to suitable pools	13	A fully accessible pool is ideal but not necessary for all PwPD
	14	Heated therapy pools suitable for people with more advanced PD with reduced mobility
	15	Pool requirements influenced by disease severity, support needs, level of function, and ability
	16	Supervision and support from skilled healthcare professionals could negate need for fully accessible pool
	17	PwPD may benefit from aquatic therapy to enhance therapy outcomes during periods of intensive rehabilitation
	18	Aquatic group size dependent on disease severity, participant's ability levels and water confidence, pool size, and external factors (e.g., Covid-19)
Pool environment	19	Thermoneutral pool temperatures preferable for some PwPD
	20	Higher temperatures (>33.5 degrees Celsius) may only be suitable for lower intensity exercise and or relaxation (e.g., WATSU)
	21	Level of immersion dependent on the exercise type and goals.

Main Category: Safety & supports		
Transition to community-based aquatic exercise programs	22	Community-based aquatic groups appropriate for PwPD to promote participation, socialisation and enhance quality of life
	23	Role of healthcare professionals to facilitate participation in community-based aquatic groups where appropriate
Training for community pool personnel	24	Providing education and training about Parkinson's disease to some workers in community pools is important
	25	Healthcare professionals' skilled in aquatic therapy best to provide training and education to community pool workers
	26	Provide information on warning/danger signs and exercise contraindications
Dressing & showering support needs	27	Role of the health care professional to establish the level of supports required by PwPD for dressing and showering
	28	Family members and or carers could provide dressing and showering support for PwPD
Fear	29	Aquatic therapy is a suitable exercise option for people with a fear of falling and or water
	30	Aquatic therapy targeting motor impairments can be performed without increasing fear of falling/injury
Aquatic therapy for people with advanced Parkinson's disease	31	Aquatic therapy may be appropriate for people with advanced Parkinson's disease when other exercise options are limited
Safe transfers: pool and surrounding pool environment	32	Support and assistive equipment may not be necessary for all disease stages when transferring in and around the pool environment
	33	Use of equipment (hoist, chair, rollator, non-slip footwear) to reduce the risk of falls/slips/injury
Main Category: Tailored aquatic program		
Tailored aquatic program to improve patient outcomes	34	Tailored programs according to the individual's goals, preferences, impairment level, functional capacity, and water confidence
	35	Aquatic therapists to provide options for aquatic exercise progression or regression in a group setting
	36	Tailor group classes according to specific disease levels to improve therapeutic outcomes
	37	Frequently reassess and adapt individual programs to maintain functional independence in pool and ensure continued safe participation
Main Category: Aquatic therapy prescription and dosage		
Dosage: Frequency of aquatic therapy	38	Frequency of aquatic therapy dependent on disease severity, patient's goals, and ongoing assessment of care needs.
	39	12-week aquatic therapy to promote adherence and influence behaviour change
	40	Two or more aquatic therapy sessions per week for PwPD participating in community-based aquatic therapy, alongside other land-based exercise/therapy activities

	41	More than one session of aquatic therapy per week may not be feasible for some PwPD
	42	The frequency of aquatic therapy sessions in a rehabilitation facility dependent on disease-related factors and rehabilitation goals
Dosage: Intensity of aquatic therapy	43	Higher intensity levels are beneficial for PwPD but need to be paced to prevent fatigue.
	44	Use objective and reliable intensity measures to achieve optimal intensity levels (e.g., Borg Scale RPE)
	45	The level of intensity is dependent on medical status and individual co-morbidities
	46	Exercise progression, number of repetitions, sets, and rest periods can be challenging to monitor, control, and report in group-based aquatic therapy
Dosage: Duration of the aquatic therapy	47	The duration of aquatic therapy sessions is dependent on disease stage, fitness levels, level of aquatic exertion, fatigue, exercise history
	48	Shorter sessions (≤30 minutes) suitable for PwPD in more advanced disease stages
	49	30-minute sessions appropriate for higher intensity aquatic classes
	50	45–60-minute sessions to include warm-up and cool-down
Aquatic therapy elements	51	Include adapted swimming to teach safe recovery to standing and water confidence if appropriate
	52	Include a range of elements in the aquatic program, comprising of cognitive training (attention), movement strategy training (dual-task), dual-task and task type training (transferable skills)
	53	Provide tailored home exercise programs to promote functional skills transfer for land-based tasks
	54	Role of the primary physiotherapist to provide a home exercise program

Abbreviations: PwPD = People with Parkinson’s disease; PD = Parkinson’s disease.

Table 5. Delphi questionnaire: round two results

	Statement/Question	Md (IQR) % Score
	1. Aquatic therapy delivery	
2	It is important that a suitably qualified therapist (e.g., physiotherapist or aquatic physiotherapist) prescribes individualised exercises as part of the aquatic therapy program.	9(2) 90.9% ≥ 7
3	Depending on individual needs, some people with Parkinson's disease should receive one-to-one aquatic therapy session(s) with an aquatic physiotherapist prior to joining group-based aquatic therapy.	9(2) 95.5% ≥ 7
7	People with Parkinson's disease admitted to inpatient services (e.g., hospital, rehabilitation centres), can benefit from access to aquatic therapy services.	9(2) 93.2% ≥ 7
	2. Location and pool environment	
8	For safety, it is important that people with Parkinson's disease with balance and mobility impairments only attend pools, which are fully accessible (e.g., chair lift, hoist, underfloor heating, graded pool depth).	9(3) 84.1% ≥ 7
9	Where possible, it is important that people with Parkinson's disease access a thermoneutral pool (33.5-35.5 degrees Celsius).	8(3) 72.7% ≥ 7
	3. Safety and supports	
14	It is important that aqua aerobics instructors, lifeguards, and patient support workers receive basic training on aquatic therapy for people with Parkinson's disease from healthcare professionals to empower self-management in the local community.	9(3) 84.1% ≥ 7
20	It is important that safe, non-slip footwear is worn by people with Parkinson's disease when accessing the pool and/or exercising in the pool.	10(2) 90.9% ≥ 7
25	It is important that aquatic physiotherapists regularly assess people with Parkinson's disease for changes in their ability.	10(1) 97.7% ≥ 7
	4. Dosage: Frequency of aquatic therapy	
30	For a maximal therapeutic effect, it is important for people with Parkinson's disease to attend aquatic therapy for a minimum of 12-weeks.	7(2) 66.7% ≥ 7
31	For maximal therapeutic effect and as part of their regular exercise routine, it is important for people with Parkinson's disease to attend community-based aquatic therapy twice weekly.	8(2) 77.3% ≥ 7

33	In an inpatient rehabilitation setting, it is optimal for people with Parkinson's disease to attend aquatic therapy between 3-5 times weekly as part of a multidisciplinary rehabilitation program.	7(3) 53.3% ≥ 7
	5. Dosage: Intensity of aquatic therapy	
35	When safe and able, it is important that people in the early stages of Parkinson's disease perform vigorous and sustained exercises within a pre-determined heart rate zone to enhance cardiovascular exercise effects.	8(2) 90.9% ≥ 7
39	During one-to-one aquatic therapy, it is important to accurately report and record every rest period between exercise sets and repetitions to enable the progression of the aquatic program.	8(3) 72.7% ≥ 7
	6. Dosage: Duration of the aquatic therapy	
40	For a maximal therapeutic effect, it is important for people with Parkinson's disease to engage in aquatic therapy sessions for 30 to 60 minutes.	9(2) 93.2% ≥ 7
	7. Aquatic therapy elements	
43	It is important to include swimming training as a component of the aquatic therapy program for some people with Parkinson's disease in order to improve confidence and water safety.	8(4) 64.4% ≥ 7
48	Where applicable, it is important to describe non-exercise components of the aquatic therapy intervention (e.g., cognitive training).	8(3) 62.2% ≥ 7

Abbreviations: Md=Median; IQR=Interquartile range; % Score = Percentage of experts scoring the statement ≥7 (Median score)

Table 6. Consensus meeting. Poll voting results on statements not meeting consensus in round 2.

Statements adapted from Round 2		Consensus (Polls)			Discussed amendments/ agreed wording:
		Yes	No	Neither agree/ disagree	
30	12-weeks or continuous participation in aquatic therapy (is recommended) to achieve maximal therapeutic effects.	75% (n=9)	17% (n=2)	8% (n=1)	1. At least 12-weeks of is recommended for optimal outcomes. 2. Continuous participation in community aquatic therapy is recommended if possible.
33	In an inpatient rehabilitation setting, two to three sessions per week may enhance therapeutic outcomes.	92% (n=11)	8% (n=1)	-	In a rehabilitation setting 2-5 sessions per week as part of an overall therapy program
43	Swimming training can be included as a component of the aquatic therapy program where relevant.	92% (n=11)	-	8% (n=1)	Swimming training can be included as a component of the aquatic therapy program where relevant
48	Where applicable, it is important to describe non-exercise components of the aquatic therapy intervention (e.g., cognitive training, coaching, mindfulness).	92% (n=11)	-	8% (n=1)	Where applicable, it is important to describe and document all non-exercise components of the aquatic therapy intervention (e.g., cognitive training, coaching, mindfulness).

Table 7. Exclusion list and precautions.

Exclusions	Precautions
• Unstable cardiac conditions (e.g., Orthostatic hypotension, cardiac failure) • Recent deep vein thrombosis, pulmonary embolism, myocardial infarction • Acute illness (especially pyrexia, vomiting, diarrhoea) • Shortness of breath at rest • Resting angina • Chlorine allergy • Unstable epilepsy • Chronic kidney disease	• Fear of water • Fear of falling • History of falls • Hearing or visual impairment • Dressing or showering assistance needed • Recent changes to medication • Infusion therapy (pump administered Duodopa) • Sudden OFF periods (unpredictable motor or non-motor fluctuations) • Deep brain stimulation* • Changes in medical status • Freezing of gait • Deterioration in memory and cognitive status (Mini mental state exam ≤24)

*Deep brain stimulation of the subthalamic nucleus (STN-DBS) is not contraindicated for water immersion post-surgery. There is cautionary evidence from one published case series study (n=9) (Waldvogel *et al.* 2020) that the swimming skills of people with Parkinson's disease may be negatively affected post deep brain stimulation.

Reference

1. Waldvogel D, Baumann-Vogel H, Stieglitz L, Hänggi-Schickli R, Baumann CR. Beware of deep water after subthalamic deep brain stimulation. Neurology. 2020;94(1):39-41.


AQUATIC THERAPY
GUIDELINES
for people with
Parkinson's disease
A person-centred approach is recommended.
Design and tailor aquatic programs to individual needs, goals, preferences, co-morbidities, medication and the stage of disease.
FREQUENCY: HOW OFTEN?
Community-based setting:
At least twice per week as part of an overall exercise and physical activity program
OR
At least once per week together with a targeted home exercise program
Rehabilitation/ hospital setting:
2-5 times per week as part of an overall therapy program
INTENSITY: HOW HARD?
In the warm-up and cool down phase include low intensity activities.
In the active phase aim for moderate to high intensity aquatic exercises including:
progressing aquatic exercises by gradually increasing the quality, time, speed, resistance and number of repetitions and sets.
DURATION: HOW MUCH?
30-60-minutes are recommended.
At least 12-weeks of aquatic therapy is recommended for optimal outcomes.
Continuous participation in community aquatic therapy is recommended if possible.
TYPE: WHAT ELEMENTS?
Mobility
Balance and posture
Muscle strength
Speed, co-ordination and motor skills
Water-based walking & gait training
Flexibility
Quality of life and emotional wellbeing
Cardiorespiratory fitness
Pain management


PERSON WITH PARKINSON'S DISEASE
1
Referral for aquatic therapy
Aquatic therapy is one exercise therapy choice.
Early referral to a physiotherapist or healthcare professional skilled in aquatic therapy is recommended.
2
Assessment
Land-based screening & assessment to assess suitability.
Identify individual preferences & goals.
Identify fears relating to water or falls risk.
Use valid measurement tools & document baseline values
3
Safety & support
Establish if dressing & showering support is required.
Time sessions for 'ON' medication.
Use suitable equipment & strategies to prevent falls.
Regularly re-assess on land & in water for changes in disease severity, well-being & functional capacity.
4
Location & pool environment
Facilitate access to aquatic therapy in the local community.
Thermoneutral water temperatures (33.5°C -35.5°C) ideal but not always applicable.
Consider pool accessibility based on person's mobility, & ensure safe pool entry & exits.
5
Initial aquatic therapy
Build water confidence.
One-to-one or small group setting (≤4 people)
Ensure ability to recover safely to a standing position.
6
Aquatic therapy considerations
Tailor to individual needs & preferences.
Target individual movement disorders, health & wellbeing.
Group sessions are suitable in the early to middle disease stages.
Mixed ability groups: provide options for aquatic exercise progression or regression.
Provide group-based aquatic therapy for specific disease stages (if safe & feasible).
7
Advanced Parkinson's disease
Only administer if safe.
One-to-one with skilled healthcare professional.
Short, targeted sessions in a fully accessible pool.
Infographic summary of key recommendations from:
Carroll LM, Morris ME, O'Connor WT, Volpe D, Salsberg J, Clifford AM, (2021) Evidence-based aquatic therapy guidelines for Parkinson's disease: An International Delphi study.
Carroll LM, Morris ME, O'Connor WT, Clifford AM, (2021) Is aquatic therapy optimally prescribed for Parkinson's disease? A systematic review and meta-analysis, Journal of Parkinson's disease. 10;59-76. DOI 10.3233/JPD-191784