



Aquatic exercise and mental health: A scoping review

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ABSTRACT

Objectives: The aims of this review were to 1) summarise the breadth and types of research regarding the impact of aquatic exercise on mental health completed to date, 2) provide a clear indication of the intervention type, volume, measurement tools used, and populations best served in relation to this activity and its effectiveness and 3) to identify domains within the literature that can be developed so recommendations can be made for future investigations.

Method: A scoping review was performed under the PRISMA guidelines. A systematic search of Pubmed, SPORTDiscus, PsycInfo and Google Scholar databases was conducted. Studies observing the effect of aquatic exercises on mental health and related parameters were considered for inclusion. The data from the selected studies were then extracted and analysed methodically.

Primary conditions measured: Depression, anxiety, mood, self-esteem, and psychological well-being were the primary mental states for which findings could be clearly extracted.

Results: Of the 1635 articles that resulted from the search, 23 articles met all inclusion criteria. Of these, 12 were randomised controlled trials. Cumulatively, the findings of this review trend towards aquatic exercise being effective in generating positive changes in mental health.

Conclusion: Aquatic exercise, specifically winter swimming, leisure swimming, competitive swimming and aquatic aerobics, can be a promising conservative therapy for mental health management. However, it is recommended that further research be conducted to solidify these findings and establish the long-term effects of this intervention on mental health.

The World Health Organization (WHO) defines global health as "a state of complete physical, mental *and* social well-being", and emphasises that mental health, in particular, is vital to our ability as individuals to think, emote and interact with one another⁵⁹. There is a deep-rooted history of mental illness in society, with references to mental health disorders documented as early as 6500 BCE.¹⁶

However, the once invisible field has only recently gained its due recognition on the global health stage.²⁹ Results from the 2007 National Survey of Mental Health and Wellbeing in Australia suggest that almost half of the national population (45.5%) will experience a mental health disorder at some point in their lifetime⁴. Similarly, statistics from the 2020 Canadian Community Health Survey on Mental Health show that one in seven Canadians used a mental health service between 2016 and 2017 and go on to estimate that a third of Canadians will be affected by a mental illness at some point during their lifetime⁴¹.

Not only do these disorders impact the daily life of those suffering, but they also pose a substantial cost to society²⁶. As of 2019, WHO

reports that depression and anxiety results in an estimated \$1 trillion (USD) per year due to lost productivity worldwide⁶¹. This amount does not account for the social and emotional cost placed on the friends and family of those who are suffering. Fortunately, the increased understanding and respect for mental health disorders is expected to cause an increase in international funding for mental health research and services²⁹. However, it's important that health care providers, government officials and leaders in global health continue to advocate for the mental health of all people and communities around the world, as professionals believe international funding and research in this field remains inadequate²⁹. This is especially true now more than ever after the outbreak of COVID-19. A study was conducted at the start of the pandemic on residents in 194 cities in China. The results state that 54% of respondents rated the psychological impact of the COVID-19 outbreak as moderate or severe, with 29% reporting moderate to severe anxiety symptoms and 17% reporting moderate to severe depressive symptoms⁵⁷.

The exponential growth of society's mental health literacy has led to

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a steady increase in the utilisation of mental health treatment and services by those suffering. For example, a 10-year study on US college students shows the rate of treatment for mental illness increased from 19% in 2007 to 34% by 2017³¹. Although medication is an option for those suffering, many individuals seek alternatives to mitigate their symptoms. Previous research has shown there is a negative connotation attached to taking medication, provoking feelings of shame and embarrassment¹⁴. Read and Williams⁴³ state that many wish to avoid the side effects associated with prescription drugs for mental illness including sexual difficulties, weight gain and “emotional blunting”.

A commonly used and highly effective form of treatment for such disorders is physical activity³³. There is an abundance of high-quality studies that suggest physical activity can be successful in the management of mental health diseases. For example, a systematic review and meta-analysis conducted on patients diagnosed with major depressive disorder found that aerobic exercise had a large antidepressant effect (-0.79 , CI -1.01 to -0.57 , $p < 0.001$) when compared to non-exercise treatments³⁴.

Promising conclusions such as this have led several other investigators to consider if a particular form of exercise is more successful than others at alleviating the symptoms of mental illness.

In the current literature, aquatic exercise is established as a highly regarded form of exercise as it can offer several physiological benefits. These benefits include reductions in joint pain and improved joint mobility. Furthermore, it offers an opportunity for those unable to participate in weight bearing land-based activities to enhance their cardiovascular fitness²⁸. A study conducted on patients with fibromyalgia concluded that after a 12-week swimming programme, pain had significantly improved¹⁷. Over the years, various authors have investigated whether aquatic exercise can also be considered a suitable form of exercise in the treatment of mental illness. Aquatic exercise and its influence on mental health is a topic of interest as the literature already suggests water has substantial therapeutic effects on mental health. For example, a systematic review by Britton et al.⁸ concludes that exposure to visible outdoor surface waters can have a direct benefit on mental health and psycho-social well-being. In addition, floatation therapy, where participants float in a large tank of warm water and Epsom salt, has been shown to elicit improvements in anxiety and related symptoms⁵⁴. Therefore, combining the therapeutic effects of water exposure with the therapeutic benefits of exercise could potentially establish aquatic exercise as a superior mental health intervention over land-based exercise for some populations. However, to the authors knowledge, no attempt has been made to summarise the findings of this topic, indicating clear paucity of understanding on the efficacy of aquatic exercise on mental health.

Scoping reviews are considered the ideal tool to establish the extent of literature on a given topic and map any apparent themes that emerge in the findings (Munn et al., 2018). Therefore, a scoping study was conducted to provide a comprehensive overview of the current literature relevant to aquatic exercise and its effect on mental health and overall well-being amongst a wide range of populations.

1. Objectives

The primary objectives of this review were to 1) summarise the breadth and types of research on this subject completed to date, 2) provide an explicit indication of the intervention type, volume, measurement tools used, and populations best served in relation to aquatic exercise and its effectiveness and 3) to identify any domains within the literature that can be developed so recommendations can be made for future investigations.

2. Methods

2.1. Protocol and registration

A protocol was developed in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation⁵⁵. The completed protocol was registered with the Open Science Framework (DOI 10.17605/OSF.IO/K37G9) on October 27, 2020.

2.2. Eligibility criteria

The population-concept-context (PCC) framework model by Joanna Briggs Institute (JBI) was utilised for the eligibility criteria. The criteria for inclusion were: 1) the full text version of the article was available, 2) the full text version was translatable to English, 3) the publication type was a peer-reviewed journal article, 4) the design of the study corresponds to the National Health and Medical Research Council (NHMRC) evidence levels I, II, III or IV (systematic review, randomised controlled trial, cohort study or case study), 5) the subjects in question were humans, 6) aquatic exercise was the primary intervention for which findings could be clearly extracted and 7) mental health, psychological well-being, and/or related parameters were the variables for which findings could be clearly extracted.

2.2.1. Population

In this review, no restrictions were made on populations assessed. All genders, ages, ethnicities, socioeconomic background and level of aquatic exercise and swimming expertise were considered for inclusion.

2.2.2. Concept

The concept of this scoping review was to investigate the potential impact that aquatic exercise may have on mental health and relevant parameters. These parameters include depression, anxiety, mood, self-esteem, and psychological well-being. Depression is a condition characterised by “persistent sadness and a lack of interest or pleasure in previously rewarding or enjoyable activities”⁶⁰. Anxiety is defined as a persistent emotion characterised by “feelings of tension, worried thoughts and physical changes like increased blood pressure”²⁴. Mood is considered a group of persisting emotions that can influence all future evaluations, feelings, and actions³. Self-esteem refers to an individual’s subjective appraisal of one’s own self-worth and the extent to which the individual holds positive or negative views about themselves⁴⁷. In this regard, high self-esteem consists of an individual respecting themselves and considering themselves of high value (Rosenberg, 1965). Finally, psychological well-being is the amalgamation of feeling good and functioning effectively. Therefore, people with high psychological well-being report feeling “capable, well-supported and satisfied with life”²².

Aquatic exercise was defined as “an activity that is done in a body of water, such as a pool, a lake, or the ocean”¹⁸. Many activities can be completed in water. The ACSM specifies that exercise is “a type of Physical Activity consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness”⁴⁴. Swimming is considered an example of such activity, as its definition is “the sport or activity of immersion into water and propelling oneself through water using the limbs”⁵¹. However, for this review aquatic exercise was exclusive of craft water sports such as surfing, kayaking, and sailing. The purpose was to limit activities that required equipment such as boards, boats, or paddles. These activities can be difficult to access due to high cost and skill requirements, potentially preventing participants from selecting and/or adhering to exercise in this form. Furthermore, the aim of this review was to assess the mental health benefits of exercising while being submerged in water. Therefore, the participants of eligible studies were to be fully immersed in the water.

2.2.3. Context

Study designs including systematic reviews, randomised controlled trials, non-randomised controlled trials, cohort studies and case studies were equally considered. Furthermore, all forms of aquatic exercise interventions were considered, including in-water training for swimming competitions, recreational swimming, and hydrotherapy. In addition, studies conducted across all settings were considered for this review. This included but was not limited to community pools, outdoor bodies of water, saltwater, freshwater, and pool water treated with chlorine. Waters of all temperatures in which exercise occurred were also considered for inclusion. Furthermore, no restrictions were placed on the time period in which the study was completed or length of follow up post intervention.

2.3. Information sources and search strategy

A three-step approach was employed for gathering relevant articles for this scoping review. First, an initial search of the research topic was conducted on Google Scholar which enabled the analysis of keywords contained in the titles and abstracts of the resulting references. A table was developed to gather these terms. Once the chart was completed, key words were chosen according to their relevance to this topic. Second, a comprehensive search was developed for PubMed using the identified keywords in combination with Medical Subject Headings (MeSH) and Title-Abstract (TIAB) attachments. The PubMed search was then converted into a compatible format for both Psycinfo and SPORTDiscus using the SRA Polyglot tool²³. Finally, a search was conducted on Google Scholar. Conversion of the previous search strategy using the SRA Polyglot tool was not possible for Google Scholar. Therefore, the comprehensive search was stripped of its MeSH and TIAB attachments so only the originally gathered keywords remained. The search strategies utilised for all databases can be found in the [Appendix](#).

2.4. Study selection

Search results from each database were exported into Endnote and duplicates were removed. An initial duplicate search by title, author, and date was completed. A second duplicate search was undertaken by title only, as some references of the same title had formatted the authors differently. Following the removal of duplicates, reviewers Morgan Jackson (M.J.) and Manjot Kang (M.K.) screened the remaining papers based on title and abstract independently. Any title and abstract that did not distinctly evaluate the effect of aquatic exercise (inclusive of swimming) on mental health, wellbeing and/or related parameters were deemed irrelevant to this review. After the initial screening by title and abstract, the full text versions of the studies considered relevant to this review were retrieved for further analysis against the eligibility criteria. These studies were reassessed by the two authors (M.J. and M.K.) independently using the inclusion and exclusion criteria in relation to the full-text version of the study. Any disagreements between the two authors were discussed and resolved with third author James Furness (J. F.) until the eligible studies were finalised. The results of the study selection process were exhibited using a PRISMA flow diagram.

2.5. Data extraction

Following the selection of eligible studies, an initial data extraction chart was created by the two reviewers in accordance with the JBI Methodology Guidance for Scoping Reviews⁴⁰. Primary areas of interest were highlighted in this chart, such as details of the citation (author, year of publication, country of origin and study design), key study characteristics (sample size, participant characteristics, study objectives, form and context of intervention, measurement tools used, and outcomes measured) and main findings relevant to the research question. After discussion with the third reviewer (J.F.), the fields of the data extraction table were updated, resulting in the addition of six more fields

for thematic analysis (article title, level of evidence, recruitment process, inclusion/exclusion criteria, subject dropout, and relevant statistical information). Regarding the level of evidence, each included study was graded according to the Australian National Health and Medical Research Council (NHMRC) criteria. This process was conducted by two reviewers independently (M.J. and M.K.) and there were no disagreements to discuss. Together, the reviewers then screened the included studies for relevant data and plotted the information from each into the table. Since the primary aim of this review is to map the extent of the existing evidence on the effects of aquatic exercise on mental health, a critical appraisal of individual studies was not executed at this time.

2.6. Data synthesis

Once data extraction was completed, the authors categorised the findings of each study according to the mental state assessed. Each study was sorted into one or more of the following groups: The effect aquatic exercise had on: 1) depression, 2) anxiety, 3) mood, 4) self-esteem and/or 5) psychological well-being. It's important to note that the authors of some studies evaluated more than one mental health outcome. Therefore, these articles were often categorised into more than one group.

To group studies with similar interventions together, the authors also classified the intervention of each study into one of the following categories: 1) an Aquatic Aerobics Class, 2) A Swim-Learning Programme, 3) Swim Training for Competition, 4) A Swimming Exercise Class, 5) Winter Swimming, 6) Leisure Swimming, and 7) Other (i.e., swimming with animals). The key study characteristics and findings have been tabulated for this review.

3. Results

3.1. Search strategy results

The PRISMA flow diagram ([Fig. 1](#)) displays the search results for this scoping review. A total of 1623 articles from PubMed, Psycinfo and SPORTDiscus, and another 12 from Google Scholar were inputted into the EndNote Reference Management Software. After the removal of duplicates, 1439 articles were left for screening. The articles were then screened using the predetermined inclusion criteria by both title and abstract. Full text versions of 57 articles were compiled of which 34 were further excluded due to the following reasons: Two articles did not have mental health as the primary outcome, two articles were not translated in English, two articles were either a theoretical model or expert opinion piece, three did not have aquatic exercise as the primary intervention, and four were not journal articles. This left a final result of 23 articles to be included in this scoping review.

3.2. Study characteristics

Two researchers reviewed all 23 articles. A detailed description of the included studies is provided in three separate tables.

[Table 1](#) presents the general information of the 23 articles including the year of publication, the country in which the study was conducted, the study design and the population observed.

3.2.1. Year

Of the 23 studies included, most were conducted between the years 2015 and 2019^{2,9,11,12,25,32,39,42,45,49,52,56}. Four studies were conducted between 2000 and 2004^{21,30,35,58}, three before the year 2000⁵⁻⁷, two between 2010 and 2014^{36,38}, one between 2005 and 2009¹⁵, and one in 2020 or later⁴⁸.

3.2.2. Geographical region

The studies used for this scoping review were conducted in a variety of different locations around the world. 13 different countries contributed to the results of this review. Most studies were completed in the

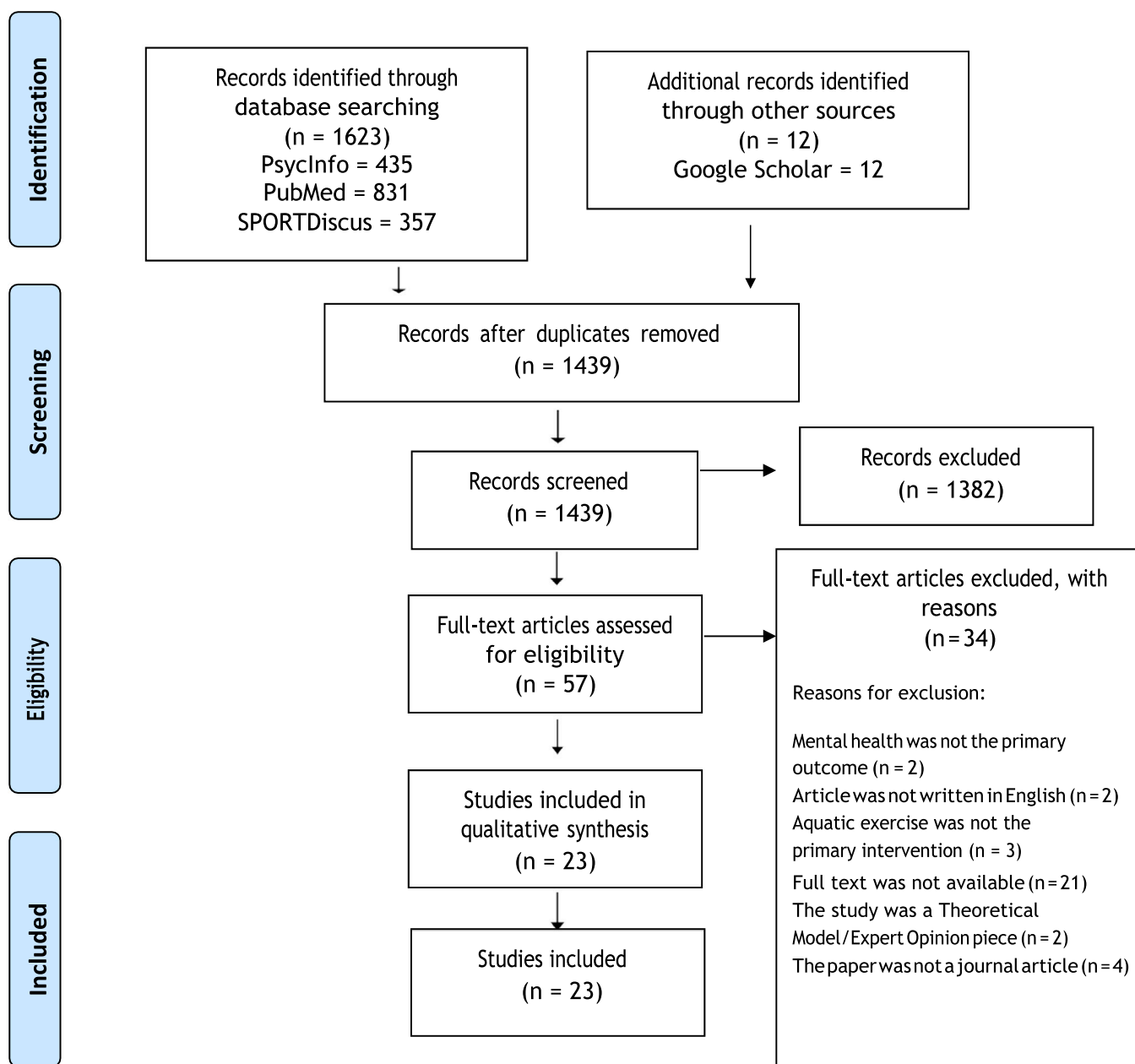


Fig. 1. Study Flow Diagram (PRISMA-ScR flow chart).

United States (N = 5). The remaining studies were completed in the following countries: Brazil (N = 4), Australia, Finland, Spain (N = 2 respectively), Egypt, Greece, Hungary, Iran, Israel, Korea, the United Kingdom and Venezuela (N = 1 respectively).

3.2.3. Research design

The most commonly used research designs were randomised controlled trials (N = 12) followed by non-randomised controlled trials (N = 8). Two studies adopted a quasi-experimental approach, providing observational pretest-posttest data. In addition, there was one case study which followed the individual of interest over the course of 5 months. Qualitative data was collected for the aforementioned study via interview.

3.2.4. Populations

Within the included 23 studies, samples sizes varied anywhere from one to 193 participants. The population most frequently studied was relatively healthy adults (3).

Other populations of interest included competitive swimmers (2), college students (2), persons with dementia (2) and persons with depression (2). The remaining populations were observed once: elderly individuals, female teachers, teens with Attention Deficit Hyperactivity Disorder (ADHD), women with premenstrual syndrome (PMS), and individuals with either brain injuries, haemophilia, hypertension, Multiple Sclerosis, Type 2 Diabetes, Parkinson's Disease and pregnant women at 17 weeks' gestation.

3.3. Measurement tool and intervention volume

Table 2 outlines the measurement tools used and provides detailed information about the aquatic exercise intervention adopted by each study. This includes the mode, context, duration of sessions, frequency of sessions, intensity, and length of intervention for all.

Of the 23 articles included, 18 different measurement tools were used. The Profile of Mood States and the Beck Depression Inventory were utilised most frequently (N = 4 for each). This was closely followed

Table 1
General Characteristics.

Characteristic	Number of Studies	References
Year of Publication		
Before 2000	3	5-7
2000–2004	4	21,30,35,58
2005–2009	1	15
2010–2014	2	36,38
2015–2019	12	2,9,11,12,25,32,39,42,45,49,52,56
2020 and after	1	48
Country of Publication		
Australia	2	36,58
Brazil	4	11,12,48,49
Egypt	1	32
Finland	2	21,30
Greece	1	38
Hungary	1	52
Iran	1	42
Israel	1	35
Korea	1	25
Spain	2	2,39
United Kingdom	1	56
United States	5	5-7,15,45
Venezuela	1	9
Study Design		
Randomised Controlled Trial	12	2,11,12,15,25,32,38,39,42,48,49,52
Non-Randomised Trial	8	5-7,21,30,35,45,58
Quasi-experimental Study	2	9,36
Case Study	1	56
Population Studied		
Adolescents with ADHD	1	48
College Students	2	6,7
Competitive Swimmers	2	5,52
Elderly (no further description)	1	38
Elderly Women (no further description)	1	25
Females suffering from PMS	1	32
Female Teachers	1	35
Healthy Adults (no further description)	3	21,30,58
Individuals with brain injuries	1	15
Individuals with Dementia	2	36,45
Individuals with Depression	2	49,56
Individuals with Haemophilia	1	9
Individuals with Hypertension	1	11
Individuals with Multiple Sclerosis	1	42
Individuals with Parkinson's	1	39
Individuals with Type 2 Diabetes	1	12
Pregnant women at 17 weeks' gestation	1	2

by the Beck Anxiety Inventory (N = 3).

Mode also varied significantly between the studies. The most frequently used intervention mode was the aquatic aerobics class (N = 8). Most of the included studies conducted their aquatic exercise intervention in a pool setting (N = 20). Most studies utilised a session-duration of 30–60 min, at a frequency of two to three sessions per week. An exercise intensity of a moderate to high level was adopted frequently amongst the included studies. The length of intervention varied considerably, ranging from five days to 12 months. Only three studies^{2,39,56} attempted to follow up with their subjects once the intervention ceased. This ranged from one month to one year post intervention.

3.4. Summary of findings by mental state

The mental state(s) evaluated, and their corresponding results are displayed in Table 3. This table provides a clear depiction of the available quantitative data and percent improvement relating to aquatic exercise and its impact on the following mental health parameters:

3.4.1. Depression

Changes in depression were assessed in 16 out of the 23 included studies, consisting of nine randomised-controlled trials, six non-randomised controlled trials and one case study. The intervention type used between the 16 studies varied.

Five studies utilised an aquatic aerobics class as the intervention. The results of all five studies report improvements in depression post intervention. The studies conducted by Kim et al.²⁵ and Silva et al.⁴⁹ found the improvements within the intervention group to be significant. In addition, the studies by Kim et al.²⁵ and Aguilar-Cordero et al.² found the changes in depression to be significant between the intervention and control groups.

Huttunen et al.²¹ and Lindeman et al.³⁰ assessed changes in depression after a period of winter swimming. Although improvements in depression showed mild to moderate clinical improvement, there was not enough change to demonstrate statistical significance.

Three studies adopted a swim-learning intervention. Berger & Owen⁶, Berger & Owen⁷ and Silva et al.⁴⁸ found swim-learning to result in a considerable positive change in depression. However, Berger & Owen⁶ stated the change in depression within the intervention group was statistically non-significant.

Two studies had their subjects participate in a swimming exercise class^{32,42}. Both found significant improvements in depression to occur.

Leisure swimming was successful in creating a substantial positive change in depression, as described by Netz & Lidor³⁵ and van Tulleken et al.⁵⁶.

The final two studies that evaluated depression were conducted by Berger et al.⁵ and Perez-de la Cruz³⁹. They used swim training for competition and Ai Chi as their intervention of choice respectively. Despite the difference in intervention type, both studies

found depression had decreased significantly within the intervention groups. The results of the studies that provided pretest-posttest data have been illustrated in Fig. 2.

3.4.2. Anxiety

Changes in anxiety were demonstrated in eight out of 23 articles selected for this review. Of the eight, four were randomised control trials and the other four were non-randomised controlled trials.

Two studies, conducted by Silva et al.⁴⁹ and Da Silva et al.¹¹, utilised an aquatic aerobics intervention. The intervention groups of both studies demonstrated a significant improvement in anxiety.

Two studies adopted a swim-learning intervention. The findings by Silva et al.⁴⁸ and Berger & Owen⁶ both showcased an improvement in anxiety. However, these changes were classified as statistically non-significant.

The remaining four studies utilised varying intervention types. Maged et al.³² had subjects participate in a swimming exercise class, leading to a significant improvement in anxiety compared to controls. The leisure swimmers in the study by Netz and Lidor³⁵ also reported a significant positive change in this parameter. Webb and Drummond⁵⁸ compared leisure swimmers to those swimming with dolphins. Those who had the opportunity to swim with the animals had a significant reduction in anxiety compared to the leisure swimming control group. However, the authors involved in the study by Lindeman et al.³⁰ described the improvement for anxiety as statistically non-significant for winter swimmers when compared to individuals who did not swim.

The results of the studies that provided pretest-posttest data have been illustrated in Fig. 3.

3.4.3. Mood

Changes in mood were evaluated in six of the 23 studies selected for this review.

This included three randomised-controlled trials and four non-randomised controlled trials.

Three of the studies that assessed mood used an aquatic aerobics class as their chosen intervention. One of the three, conducted by

Table 2
Measurement Tool and Intervention Parameters.

Authors	Year	Measurement Tool	Mode	Context	Aquatic Exercise Volume			
					Duration of sessions	Frequency	Intensity	Intervention Length
Aguilar-Cordero et al.	2019	Edinburgh Postnatal Depression Scale (EPDS)	Aquatic Aerobics Class c	Pool	1 h per class	3x per week	Moderate (according to BRPE ^a)	17 weeks (follow up 3 months postpartum)
Berger et al.	1997	Profile of Mood State (POMS)	Normal vs Tapered Swim Training for Competition	Pool	3–4 h total per day	5–6 days per week, 2x per day (morning & afternoon)	High (12,000–14,000 m of swimming) vs Moderate (6500–9000 m of swimming)	5 days total
Berger & Owen	1988	POMS & State-Trait Anxiety Inventory (STAI)	Swim-learning Programme ^d	Pool	40 min per class	2x per week	N/R* *	14 weeks
Berger & Owen	1992	POMS	Swim-learning Programme	Pool	40 min per class	2x per week	Moderate (not specified to any standard)	14 weeks
Boadas et al.	2015	Coopersmith's Self-esteem Inventory	Swim Training for Competition ^e	Pool, ocean & gym combo	N/R	Steady increase from 3 to 4–5 times per week	High (not specified to any standard)	12 months
Da Silva et al.	2018	Beck's Depression Inventory (BDI) & Beck's Anxiety Inventory (BAI)	Aquatic Aerobics Class	Pool	45 min per session	2x per week	Low (according to BRPE)	12 weeks
Delevatti et al.	2018	BDI	Aquatic Aerobics Class	Pool	45 min per class	3x per week	High (measured using 85–100% of heart rate max.)	12 weeks
Driver et al.	2006	Physical Self-Description Questionnaire (PDSQ)	Swimming Exercise Class ^f	Pool	1 h per class	3x per week	Moderate (measured using 50–70% heart rate max.)	8 weeks
Huttunen et al.	2004	POMS	Winter swimming ^g	Ice cold, natural water	Brief dip	4x per week	N/R	4 months
Kim et al.	2015	POMS	Aquatic Aerobics Class	Pool	1 h per class	3x per week	Moderate (according to BRPE)	24 weeks
Lindeman et al.	2002	Crown Crisp Experimental Index (CCEI)	Winter Swimming	Ice cold, natural water	Brief dip	N/R	N/R	8 months
Maged et al.	2018	Daily Symptoms Report	Swimming Exercise Class	Pool	30 min per class	3x per week	N/R	3 months
Netz & Lidor	2003	STAI & The Depression Adjective Check List	Leisure swimming ^h	Pool	90 min	1x per week	N/R	1 year
Neville et al.	2014	The Psychological Well-Being in Cognitively Impaired Persons Scale	Aquatic Aerobics Class	Pool	45 min	2x per week	N/R	12 weeks
Ourania et al.	2011	The 12-item Exercise-Induced Feeling Inventory with 5-Point Scale	Aquatic Aerobics Class	Pool	45 min	20 consecutive days	Moderate (measured using 50–70% heart rate max.)	20 days
Pérez-de la Cruz	2019	Short Geriatric Depression Scale	Aquatic "Ai Chi" programme	Pool	45 min	2x per week	N/R	10 weeks (follow up 1 month later)
Razazian et al.	2016	BDI	Swimming Exercise Class	Pool	60 min	3x per week	N/R	8 weeks
Schilling et al.	2018	5-Point Likert Type Scale	Aquatic Aerobics Class	Pool	30 min	5–7 days	N/R	60 days
Silva et al.	2020	Child Depression Inventory (CDI) & BAI	Swim-learning Programme	Pool	45 min	2x per week	N/R	8 weeks
Silva et al.	2019	BDI & BAI	Aquatic Aerobics Class	Pool	45 min	2x per week	Low (measured using 50–70% heart rate max.)	12 weeks
Szabo et al.	2019	The Positive Affect Negative Affect Scale (PANAS)	Leisure vs Swim Training for Competition	Pool	N/R	1 session	N/R	2 months
Van Tulleken et al.	2018	DSM-1 V & ICD - 10	Leisure swimming	Outdoor open water	1–30 mins	1–2x per week	N/R	6 months (follow-up 1 year later)

(continued on next page)

Table 2 (continued)

Authors	Year	Measurement Tool	Mode	Context	Aquatic Exercise Volume			
					Duration of sessions	Frequency	Intensity	Intervention Length
Webb & Drummond	2001	Self-report questionnaire Spoelberger State-Trait Anxiety Questionnaire	Leisure swimming vs Swim with Dolphins	Marine Park Pool vs Beach	25–30 min	Once	N/R	9 months cumulative

^a BRPE = Borg Rating of Perceived Exertion.

^b N/R = Not reported.

^c An Aquatic Aerobics Class was defined as an intervention involving exercises that did not require proper swimming mechanics i.e.) “water walking” or “jumping jacks”.

^d A Swim-learning Programme was defined as an instructional swim class where participants learned how to swim using proper swimming mechanics i.e.) kicking, backstroke, breaststroke etc.

^e Swim Training for Competition was defined as high level training sessions in preparation for an upcoming contest.

^f A Swimming Exercise Class was defined as an intervention involving proper swimming mechanics i.e.) kicking or breaststroke for laps across the pool or relay races. ^g Winter swimming was defined as a brief dip in cold water. Prolonged swimming or exercise was not involved.

^h Leisure Swimming was defined as swimming with no direction or specific instruction.

Schilling et al.⁴⁵ found no significant change in mood between the aquatic intervention group and land-based control group. Contrastingly, the studies by Kim et al.²⁵ and Ourania et al.³⁸ found mood to improve substantially for the intervention group post aquatic aerobics.

The remaining three studies all used one of the following modes: A swimming exercise class³², swim training for competition⁵ and winter swimming²¹. Huttunen et al.²¹ found the change in mood to be statistically non-significant between the intervention and control groups. The other two aforementioned studies found mood to improve significantly when compared to controls.

The results of the studies that provided pretest-posttest data have been illustrated in Fig. 4.

3.4.4. Self-esteem

Self-esteem was measured in only two studies, both of which demonstrated significant changes. The study by Driver et al.¹⁵ showed that adults with brain injuries can successfully improve self-esteem when exposed to a swimming exercise intervention. Similarly, patients with haemophilia were shown to be positively impacted by swim training for competition, as their self-esteem levels increased significantly post intervention⁹. The results of the studies that provided pretest-posttest data have been illustrated in Fig. 5.

3.4.5. Psychological well-being

Changes in psychological well-being were documented in three of the 23 included studies, all of which demonstrated a significant change. The quasi-experimental study conducted by Neville et al.³⁶ concluded that an aquatic aerobics intervention has a positive impact on psychological well-being in people with moderate to severe dementia. Szabo et al.⁵² conducted a randomised controlled trial and found that psychological well-being was greater in leisure swimmers than competitive swimmers. The non-randomised controlled trial by Webb and Drummond⁵⁸ concluded that those who swam with dolphins had greater levels of psychological well-being when compared to that of beach swimmers with no dolphin contact. In addition, the improvement in well-being for dolphin-swimmers was significant.

The results of the studies that provided pretest-posttest data have been illustrated in Fig. 6.

4. Discussion

The primary aim of this review was to develop a comprehensive summary of the literature to date relevant to aquatic exercise and its impact on mental health and well-being. The main objectives of this review were to (1) summarise the breadth and types of research on this subject completed to date, (2) provide an explicit indication of the

intervention type, volume, measurement tools used, and populations best served in relation to aquatic exercise and its effectiveness and (3) to identify any gaps within the literature that can be developed so recommendations can be made for future investigations. The findings of this review trend towards aquatic exercise being effective in generating positive changes in mental health.

4.1. Overview of the available literature

The keywords and terminology used in the search process allowed us to capture all relevant literature on this subject. However, only 1.6% of the search results met the eligibility criteria for this review. The considerable shortage of available articles on this topic highlights the need for the completion of additional research. The majority of the eligible studies were randomised controlled trials, corresponding with NHMRC Level II. Despite the paucity of available literature, the substantial number of level II studies adds confidence to the findings of this review.

In regard to intervention type, there was a significant lack of consistency among the 23 articles selected for this review. Swimming, as previously defined by Oxford Dictionary⁵¹, was selected as the aquatic exercise intervention by some of the included studies^{32,35,56}. However, swimming is not the only exercise mode appropriate for water. This reality likely contributed to the diverse array of intervention types between the included studies. Research for this review revealed that land-based activities can often be modified for aquatic environments. For example, Perez-de la

Cruz³⁹ selected “Ai Chi” as the mode of aquatic exercise for their participants. Ai Chi is a water-based activity, loosely defined as a modified form of the land-based activity “Tai Chi”³⁹. “Water walking” is another, more simplistic example of a land-based activity being conducted in an aquatic environment. Water walking was utilised in several studies as a warmup before a swimming exercise class³², or as a component of an aquatic aerobics’ session^{12,15,25,38,42,45}. The ability to adapt simple, land-based activities for the water is likely what allowed for the abundance of exercise-mode options.

As previously discussed, the aquatic exercise intervention most frequently chosen was an aquatic aerobics class. It was also the most chosen intervention among all included randomised controlled trials. This can likely be attributed to the simplicity of the exercises involved in an aquatic aerobics class (water walking, water dancing etc.). These sessions do not require proficiency in swimming, making it a straightforward choice of intervention, especially when randomising participants who may not have a background in swimming to an intervention group.

The volume of aquatic exercise was inclusive of exercise frequency,

Table 3
Main Findings.

Study Design	Authors	Intervention	Mental State Assessed	Mean (Standard Deviation)		% Improvement
				Pre-Test	Pre-Test	
Randomised Controlled Trials	Aguilar-Cordero et al., ²	I: Aquatic Aerobics Class	Depression	N/R ^a	I: 6.41 (SD ± 3.68)	N/R
		C: no class			C: 10.17 (SD ± 2.38) *	
	Da Silva et al., ¹¹	I: Aquatics Aerobics Class (hypertension)	Anxiety	I: 15.8 (SD ± 2.1)	I: 6.2 (SD ± 2)	I: 60.8% **
		C: Aquatic Aerobics Class (no hypertension)	C: 4.7 (SD ± 0.9) Depression	C: 4.5 (SD ± 0.7) I: 9.6 (SD ± 2.3)	C: 4.3% I: 8.3 (SD ± 2.7)	I: 13.5% C: 19.2%
	Delevatti et al., ¹²	I: Aquatic Aerobics Class	Depression	I: 9.7 (SD ± 1.1)	I: 8.4 (SD ± 1.6)	I: 13.4%
		C: Dry land exercise class		C: 10.0 (SD ± 1.1)	C: 9.3 (SD ± 1.7)	C: 7%
	Driver et al., ¹⁵	I: Swimming Exercise Class	Self-Esteem	I: 3.66 (SD ± 0.34)	I: 4.37 (SD ± 0.54)	I: 19.4% **
		C: Vocational rehabilitation class		C: 3.78 (SD ± 0.47)	C: 3.82 (SD ± 0.53)	C: 1.0%
	Kim et al., ²⁵	I: Aquatic Aerobics class	Depression	I: 48.52 (SD ± 1.23)	I: 40.68 (SD ± 0.90)	I: 16.2% **
		C: no class		C: 48.68 (SD ± 1.28)	C: 49.40 (SD ± 0.82) *	C: -1.5%
	Maged et al., ^{32b}	I: Swimming Exercise Class	Total Mood Disturbance	I: 171.68 (SD ± 4.96)	I: 133.28 (SD ± 4.68)	I: 22.4% **
		C: no exercise		C: 170.96 (SD ± 4.41)	C: 173.28 (SD ± 4.11) *	C: -1.4%
	Ourania et al., ³⁸	I: Aquatic Aerobics Class	Anxiety	I: 3 (N/R)	I: 0 (N/R)	I: 33.3%
		C: no exercise programme	Depression	C: 5 (N/R)	C: 5 (N/R) *	C: 0%
	Perez de la Cruz ³⁹	I: Aquatic "Ai Chi" Programme	Depression	I: 14 (N/R)	I: 3 (N/R)	I: 78.6%
		C: Dry land physiotherapy		C: 10 (N/R)	C: 12 (N/R) *	C: -15.56%
	Silva et al., ⁴⁹	I: Aquatic Aerobics Class (participants had depression)	Mood swings	I: 3 (N/R)	I: 0 (N/R)	I: 33.3%
		C: Aquatic Aerobics Class (participants had no depression)	Positive engagement (Mood)	C: 6 (N/R)	C: 7 (N/R) *	C: -16.7%
	Silva et al., ⁴⁸	I: Swim-learning Programme	Positive engagement (Mood)	I: 1.5 (SD ± 0.5)	I: 3.6 (SD ± 0.2)	I: 140% **
		C: no exercise		C: 1.2 (SD ± 0.3)	C: 1.5 (SD ± 0.4)	C: 25%
	Szabo et al., ⁵²	I: Aquatic "Ai Chi" Programme	Depression	I: 4.07 (SD ± 2.7)	I: 3.00 (SD ± 2.1)	I: 26.3% **
		C: Dry land physiotherapy		C: 4.33 (SD ± 2.4)	C: 4.20 (SD ± 2.0) *	C: 3%
	Razazian et al., ⁴²	I: Aquatic Aerobics Class (participants had depression)	Anxiety	I: 22.9 (SD ± 4)	I: 11.8 (SD ± 5)	I: 48.5% **
		C: Aquatic Aerobics Class (participants had no depression)	Depression	C: 4.7 (SD ± 1)	C: 4.5 (SD ± 3)	C: 4.3%
	Razazian et al., ⁴²	I: Swim-learning Programme	Depression	I: 28.5 (SD ± 3.8)	I: 15.3 (SD ± 0.8)	I: 46.3%*
		C: no exercise		C: 5.2 (SD ± 1.9)	C: 4.2 (SD ± 1.1)	C: 19.2%
	Razazian et al., ⁴²	I: Swim Training for Competition	Anxiety	I: 18.4 (SD ± 2)	I: 15.7 (SD ± 3)	I: 14.7%
		C: Leisure swimming	Depression	C: 16.4 (SD ± 3)	C: 13.3 (SD ± 4)	C: 18.9%
	Razazian et al., ⁴²	I: Swim Training for Competition	Depression	I: 17.1 (SD ± 2)	I: 10.2 (SD ± 2)	I: 40.4% **
		C: Leisure swimming		C: 15.3 (SD ± 2)	C: 16.4 (SD ± 3) *	C: -7.2%
	Razazian et al., ⁴²	I: Swim Training for Competition	Psychological wellbeing	N/R	I: 12.15 (SD ± 2.67)	N/R
		C: Leisure swimming			C: 10.26 (SD ± 3.51)	
	Razazian et al., ⁴²	I: Swimming Exercise Class	Depression	I: 19.17 (SD ± 7.83)	I: 4.78 (SD ± 3.42)	I: 75.1% **
		I2: Yoga		I2: 19.72 (SD ± 7.04)	I2: 5.06 (SD ± 2.92)	I2: 74.3% **
	Razazian et al., ⁴²	C: No exercise		C: 20.78 (SD ± 6.22)	C: 21.33 (SD ± 6.88) *	C: -2.6%

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Table 3 (continued)

Study Design	Authors	Intervention	Mental State Assessed	Mean (Standard Deviation)		% Improvement		
				Pre-Test	Pre-Test			
Non- Randomised Controlled Trials	Berger et al., ⁵	I : Taper session C : Normal session } Same group of swimmers	Depression	I: 3.17 (SD ± 3.27)	I: 1.86 (SD ± 2.57)	I: 41.3% * *		
				C: 2.63 (SD ± 2.91)	C: 2.47 (SD ± 2.76)	C: 6.1%		
				Total Mood Disturbance	I: 96.23 (SD ± 16.85) C: 95.31 (SD ± 15.80)	I: 91.63 (SD ± 14.37) C: 100.24 (SD ± 15.33) *	I: 4.8% C: -5.2%	
	Berger & Owen, ^{6c}	I1: Swim-learning Programme I2: Body conditioning I3: Fencing I4: Hatha yoga C: Lecture Class	Anxiety	I1: 41	I1: 42	N/R		
				I2: 45 I3: 43 I4: 42.5 C: 44	I2: 42 I3: 44 I4: 45.5 C: 48			
				Depression	I1: 42 I2: 44 I3: 40 I4: 42.5 C: 43	I1: 42 I2: 44 I3: 43 I4: 45.5 C: 44.5	N/R	
			Berger & Owen, ⁷	I1: Swim-learning Programme I2: Yoga class C: Lecture class	Depression	I1: 5.22 (N/R)	I1: 2.69 (N/R)	I1: 48.5%
						I2: 8.78 (N/R)	I2: 3.38 (N/R)	I2: 61.5%
						C: 8.42 (N/R)	C: 6.78 (N/R) *	C: 19.5%
	Huttunen et al., ²¹	I: Winter Swimming C: No swimming	Depression	I: 4.8 (SD ± 5.7)	I: 4.3 (SD ± 4.1)	I: 10.4%		
				C: 5.2 (SD ± 6.6)	C: 3.9 (SD ± 5.9)	C: 25%		
				Total Mood Disturbance	I: 3.0 (SD ± 2.6) C: 2.8 (SD ± 2.8)	I: 2.1 (SD ± 1.8) C: 2.1 (SD ± 1.8)	I: 30% ** C: 25%	
	Lindeman et al., ³⁰	I: Winter Swimming C: No swimming	Anxiety (somatic)	I: 2.4 (SD ± 2)	I: 2.0 (SD ± 1.4)	I: 16.7%		
				C: 2.8 (SD ± 1.5)	C: 2.5 (SD ± 1.4)	C: 10.7%		
			Depression	I: 3.3 (SD ± 2) C: 2.9 (SD ± 1.8)	I: 3.1 (SD ± 1.9) C: 2.7 (SD ± 1.6)	I: 6.1% C: 6.9%		
Netz & Lidor, ³⁵	I1: Leisure swimming I2: Yoga I3: Feldenkrais I4: Dance Aerobics C: Computer class	Anxiety	N/R	I1: 35.91 (SD ± 6.92) I2: 35.36 (SD ± 10.01) I3: 36.22 (SD ± 8.58) I4: 36.76 (SD ± 8.93) C: 38.45 (SD ± 7.72)	N/R			
			Depression	N/R	I1: 6.78 (SD ± 3.37) I2: 7.26 (SD ± 3.83) I3: 8.48 (SD ± 3.46) I4: 7.05 (SD ± 3.64) C: 8.00 (SD ± 3.73)	N/R		
			Mood	N/R	I: 3.88 (N/R)	N/R		
					C: 3.62 (N/R)			
		Schilling et al., ⁴⁵	I : Aquatic Aerobics Class C : land – based activity } Same group of participants	Mood	N/R	I: 3.88 (N/R)	N/R	
						C: 3.62 (N/R)		
		Webb & Drummond, ⁵⁸	I: Swimming with dolphins C: Leisure swimming (no dolphins)	Anxiety	I: 33 (SD ± 2.5)	I: 27 (SD ± 0.75)	I: 18.2%	
					C: 33.5 (SD ± 2.25)	C: 32 (SD ± 1.75) *	C: 4.5%	
Psychological well being	I: 85 (N/R)			I: 89 (N/R)	I: 4.5% **			

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Table 3 (continued)

Study Design	Authors	Intervention	Mental State Assessed	Mean (Standard Deviation)		% Improvement
				Pre-Test	Pre-Test	
Quasi-Experimental Study	Boadas et al., ⁹	I: Swim Training for Competition (combo of swimming and exercise sessions)	Self-Esteem	C: 75 (N/R) Pre: 60% low self-esteem; 40% mid self esteem Post: 88% high self-esteem; 12%; mid self-esteem**	C: 83 (N/R)	C: 10.6%
	Neville et al., ^{36d}	I: Aquatic Aerobics Class	Psychological well being	Pre: 32.5 (N/R) Post: 36.0 (N/R)		10.8% * *
Case Study	van Tulleken et al., ⁵⁶	I: Leisure Swimming	Depression	No more medication required (anti-depressants)		N/R

^a N/R = Not Reported.

^b ³² reported the median, not mean.

^c ⁶ reported T-scores, not mean.

^d ³⁶ reported the median, not mean.

* The change between groups was significant.

** The change within groups was significant.

Percent Improvement in Depression

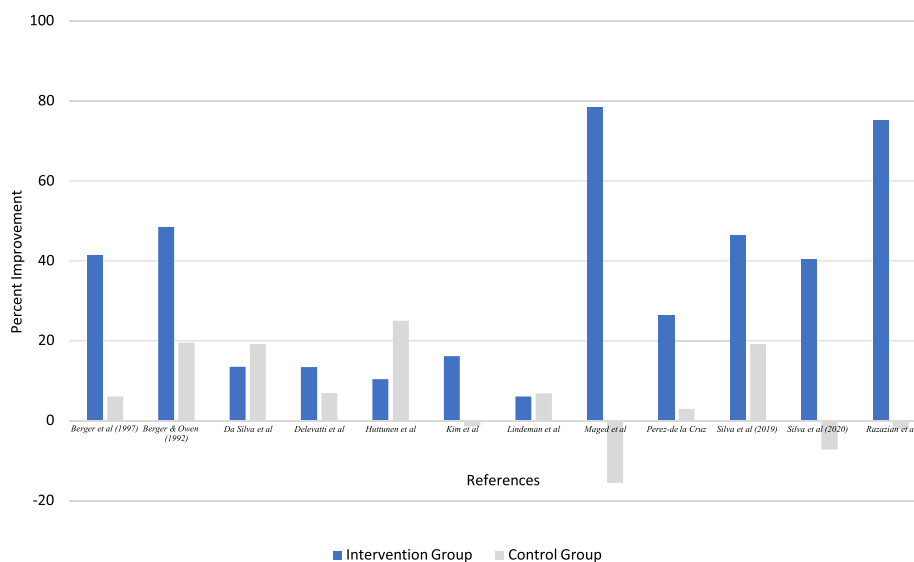


Fig. 2. Percent Improvement in Depression.

duration, intensity and length of the programme. The volume chosen by most studies of this review were homogenous with one another. Most studies adopted a volume of 30–60 min per session, at a frequency of two to three sessions per week. These chosen parameters are validated by previous research indicating that individuals who exercise at least two to three times per week experience significantly less depression and stress than those who don't exercise or do so less frequently ⁵⁰.

With respect to intensity, studies that did depict a level of intensity opted for a moderate to high level. However, several studies did not report this. This is a surprising finding as

intensity is an important parameter when prescribing exercise. When compared to land-based exercise, intensity is often reported. Previous research done using land-based aerobic activities such as jogging, cycling, walking, gardening, and dancing have all shown that a moderate exercise intensity is enough to evoke improvements in mental health ⁴⁶.

Researchers have stated that “thirty minutes of exercise at a moderate intensity three days a week, such as brisk walking, is sufficient for these health benefits” ⁴⁶. Based on the findings of this review, aquatic

exercise of moderate to high intensity should be sufficient to elicit mental health changes. However, caution should be applied when extrapolating results from studies with regards to intensity. Several studies vary in how they discriminate between the different levels of intensity. For example, Silva et al. ⁴⁹ describes low intensity as “50–70% of the participants heart rate maximum”, while Driver et al. ¹⁵ considers 50–70% of the heart rate maximum to be a moderate intensity. Furthermore, numerous studies did not report how exercise intensity was measured.

Of the included studies, the length of intervention ranged from five days to 12 months, with poor consistency between them. There was no explicit indication of a correlation between intervention length and mental health improvement. Furthermore, very few studies followed up with participants post intervention to determine if improvements had been sustained. This can be seen in the studies conducted by Aguilar-Cordero et al., ² and Perez-de la Cruz ³⁹. Each followed up with their participants a few months post intervention and found positive changes were maintained. Similarly, the study by van Tulleken et al. ⁵⁶ found

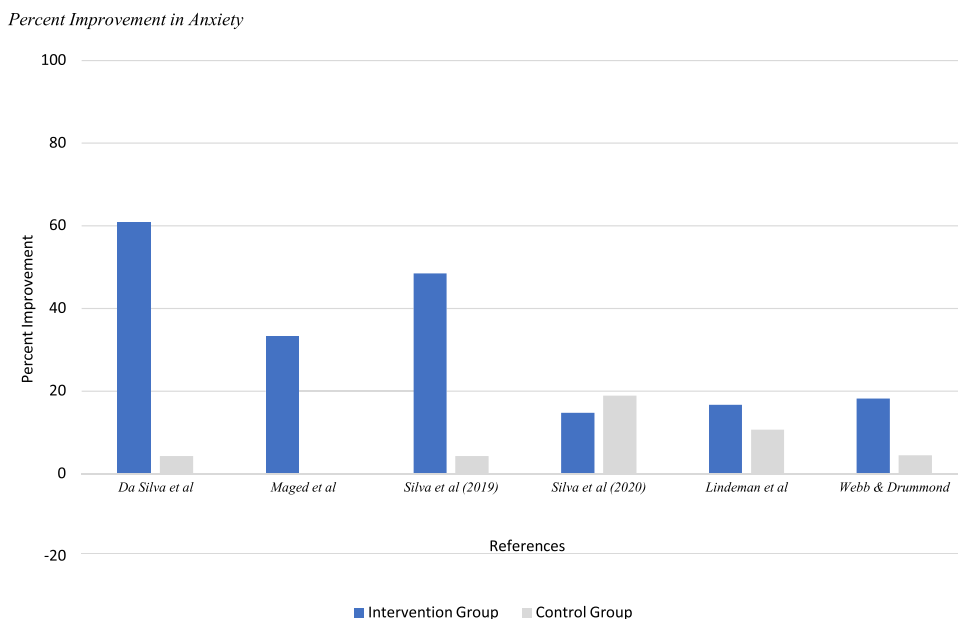


Fig. 3. Percent Improvement in Anxiety.

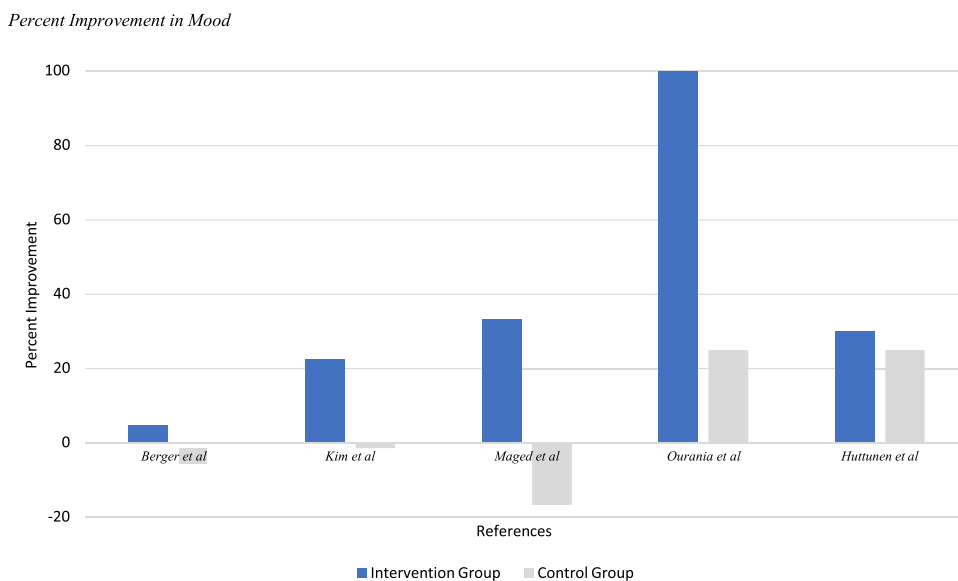


Fig. 4. Percent Improvement in Mood.

their sole participant continued to swim and maintain her mental health improvements one year post intervention. Prior research indicates that intervention effects on lifestyle behaviours are often strongest during the one to two years closest to the intervention programme and often diminish over time³⁷. The lack of follow up among the included studies hinders the ability to determine if lifestyle changes and mental health improvements can be maintained beyond the one-year mark.

A wide range of measurement tools were used, which reduced the ability to accurately compare and contrast end results, specifically for self-esteem and psychological well-being. However, there was relatively high consistency among the measurement tools chosen when assessing depression, anxiety and mood. The Beck Depression Inventory (BDI), Beck Anxiety Inventory (BAI) and Profile of Mood State (POMS) were utilised often for the evaluation of

these mental states. In a multitude of studies examining the relationship between exercise and acute mood changes, the POMS has been described as the gold standard for “identifying underlying mechanisms

that may promote mood alteration”⁷. The BDI is currently one of the most widely used measures in research and clinical practice for assessing depression in both adults and adolescents¹⁹. Similarly, the BAI is a widely accepted tool to measure anxiety and has the ability to discriminate between symptoms of anxiety and depression across several languages, cultures and age ranges²⁰. This may explain the frequency in which the aforementioned tools were used among the studies included in this review.

Between the 23 articles included in this review, 17 different populations were observed. This highlights the prevalence of mental health issues and its ability to impact a wide range of populations. It is difficult to establish which population is best served by aquatic exercise, as very few of the included studies are directly comparable. Research regarding the effect of aquatic exercise on mental health is in its infancy, offering an explanation for the poor comparability and lack of repeated studies available in the literature. However, the findings of this review trend positively towards aquatic exercise being effective for most of the

Percent Improvement in Self-Esteem

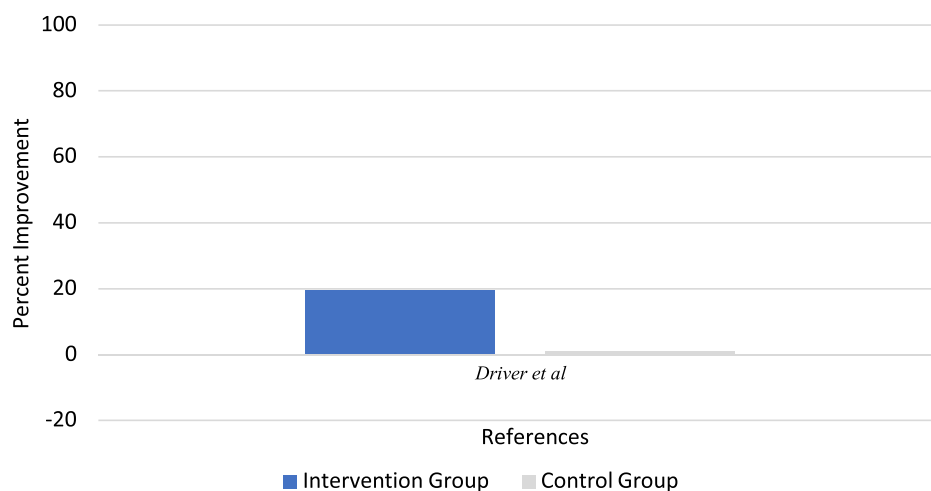


Fig. 5. Percent Improvement in Self-Esteem.

Percent Improvement in Well-Being

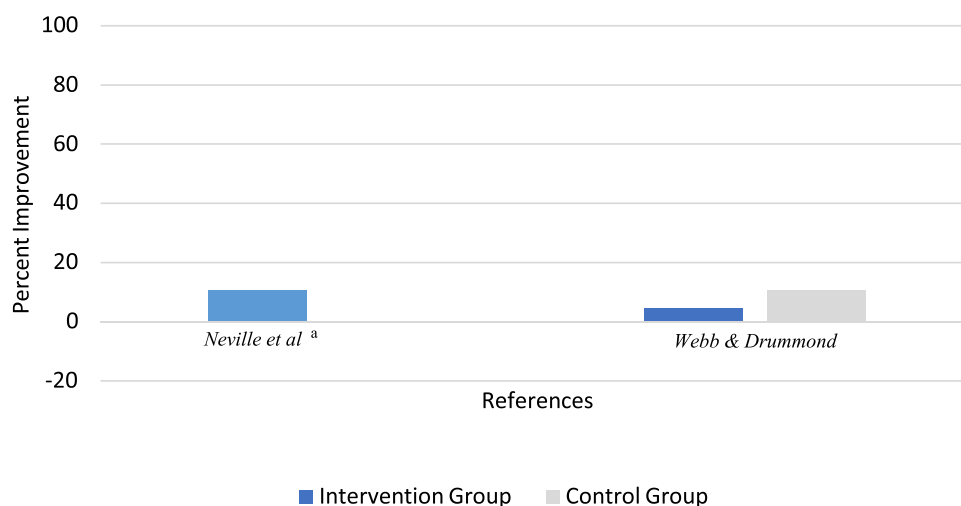


Fig. 6. Percent Improvement in Well-Being^a Neville et al. – subjects were not compared to a control group.

populations observed in this review, indicating that many people can benefit from aquatic exercise as a treatment for mental health.

With respect to the effectiveness of aquatic exercise on mental health, improvements were found in all mental states. Positive changes in depression were the most prevalent. Post-intervention, groups for all studies reported better scores for this parameter. The case study by van Tulleken et al.⁵⁶ is a strong example of how aquatic exercise can mitigate depressive symptoms. The female patient of interest was able to discontinue her antidepressant medication after the leisure swimming intervention. These results are important as they demonstrate the potential effectiveness of aquatic exercise as an alternative treatment for depression. However, more research is needed to confirm this claim. It's important to note that the improvements in depression were minimal for winter swimmers^{21,30} in comparison to their control groups and to the interventions of other studies. This may be because winter swimmers dip briefly in cold water. Several studies suggest that cold water swimming can offer various physiological health benefits, including positive changes in haematological function, endocrine function and can result

in fewer upper respiratory tract infections²⁷. However, the ice-cold water forces an initial shock response that puts the body under stress⁵³. Therefore, this mode may not be the most beneficial for eliciting psychological improvements.

Eight of the 23 included studies in this review compared the effect of aquatic exercise on mental health to that of land-based activity^{12,15,35,6,7,39,42,45}. Five of these studies found aquatic exercise to cause a greater improvement in the mental state(s) assessed^{12,15,35,39,42}. As previously mentioned, there are several variables that may contribute to the superiority of aquatic exercise over land-based exercise. Perez-de la Cruz³⁹ discussed the advantages of physical exercise in water for those with Parkinson's disease suffering from depression. These include the ability to perform easy, low impact exercises and the pleasant water temperature³⁹. Yoga presents as the only land-based activity in the literature that rivals aquatic exercise as a favourable intervention for eliciting improvements in mental health. This may be because some of the therapeutic traits found in aquatic exercise are mirrored in yoga, including the relaxing environment, low-impact movements, and breath control

¹⁰. However, the research comparing these two activities is too limited to draw concrete conclusions.

4.2. Gaps in the research and recommendations

Significant variations in sample size, populations studied, measurement tools and intervention volume among these 23 articles adds difficulty to the task of generalising these results and making them applicable to the general public. The most recognisable recommendation to draw from this review is for more research to be completed on this subject.

More explicitly, authors of future studies should aim for larger sample sizes. This will allow for a smaller margin of error and greater confidence in the effect of aquatic exercise on mental health. In addition, future studies should explore added populations, with wider differences in age, culture, geographical location, and socioeconomic status. This information would provide a greater understanding of the effectiveness of aquatic exercise across a greater range of populations. Children, adolescents, and elderly individuals are largely underrepresented in the literature. There has been an increase of mental health disturbances among children and teens due to social media ¹. Similarly, late life depression is considered one of the most common neuropsychiatric disorders among the elderly ¹³. Therefore, it's recommended that more studies specifically target these sub-groups of the population.

Due to the wide range of measurement tools utilised, it is exceptionally challenging to combine the research results and report them wholly in favour of (or against) aquatic exercise for mental health. It's recommended that future studies choose from a narrow selection of established and validated measurement tools. In turn, this will allow for better comparisons between the findings of these studies.

As previously mentioned, a critical appraisal of individual studies was not completed as this did not align with the aims of this study. However, it is very possible that selection bias was high amongst the included studies as only 12 of the included studies were classified as RCTs. Therefore, selection bias could have occurred during the participant recruitment process due to lack of double-blinding, or the possibility that some participants may have been predisposed to having a certain response to the aquatic therapy. It is suggested that future studies work to minimise selection bias through random sampling to different groups.

Finally, there is a major gap in the literature regarding the long-term effects of aquatic exercise interventions on mental health. The lack of follow-up post intervention underlines the need for longitudinal studies on this subject.

Research regarding the relationship between aquatic exercise and mental health is limited. Furthermore, the heterogeneity between studies was substantial. For these reasons, a systematic review was

deemed an inappropriate method for synthesising the data on this topic.

4.3. Strengths and limitations of this review

One of major strengths of this review was our ability to map the current literature on this subject with reference to location, year and intervention. In addition, we were able to effectively provide insight into gaps within the current literature. Finally, this review was conducted by two reviewers, limiting the risk of bias. However, this scoping review was limited to studies written only in English. For this reason, articles in other languages that may be important and relevant to this review could have been excluded. In addition, several articles were not freely accessible and thus not included, preventing us from obtaining a greater selection of studies.

This review did not report findings regarding physiological or biochemical changes, which may have had an extraneous influence on mental health. Furthermore, studies that assessed other mental health disorders such as schizophrenia, bipolar disease and obsessive-compulsive disorder were not flagged due to the limited list of keywords used. The inclusion of such words may have widened the breadth of studies located during the search process.

5. Conclusion

This scoping review provided a summary of the current literature related to aquatic exercise and its impact on depression, anxiety, mood, self-esteem, and psychological well-being. In addition, it delivers a detailed description of the existing research methods and measurement tools used to evaluate the potential of aquatic exercise in reducing mental health symptoms. All 23 studies reported positive changes in mental health post intervention, with 16 of the studies describing these changes as significant for one or more of the mental states assessed. Therefore, the findings of this review trend towards aquatic exercise being effective in generating improvements in mental health.

However, there was heterogeneity between the studies that were selected for this review. There is a critical need for a greater abundance of studies on this subject to enhance the already positive findings. Further research is also needed to gain a better understanding of the most appropriate mode, context, duration, frequency, intensity, and length of interventions for generating mental health improvements. Moreover, future studies need to evaluate the sustainability of these improvements and the long-term effects of aquatic exercise interventions over time.

Conflict of interest

We have no conflicts of interest to disclose.

Appendix

Search strategies used for each electronic database searched.

Database	Date Searched	Search strategy	# of Results
PubMed	09/10/2020	(swim*[tiab] AND "mental health"[tiab]) OR (swim*[tiab] AND "Mental Health"[Mesh]) OR (swim*[tiab] AND anxiety[tiab]) OR (swim*[tiab] AND "Anxiety"[Mesh]) OR (swim*[tiab] AND depression[tiab]) OR (swim*[tiab] AND "Depression"[Mesh]) OR (swim*[tiab] AND mood[tiab]) OR (swim*[tiab] AND "mood disorders"[Mesh]) OR (swim*[tiab] AND well-being[tiab]) OR (swim*[tiab] AND self-esteem[tiab]) OR ("blue space"[tiab] AND "mental health"[tiab]) OR ("blue space"[tiab] AND "Mental Health"[Mesh]) OR ("blue space"[tiab] AND anxiety[tiab]) OR ("blue space"[tiab] AND "Anxiety"[Mesh]) OR ("blue space"[tiab] AND depression[tiab]) OR ("blue space"[tiab] AND "Depression"[Mesh]) OR ("blue space"[tiab] AND mood[tiab]) OR ("blue space"[tiab] AND "mood disorders"[Mesh]) OR ("blue space"[tiab] AND well-being[tiab]) OR ("blue space"[tiab] AND self-esteem[tiab]) OR	831

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Database	Date Searched	Search strategy	# of Results
Psycinfo	09/10/2020	(aquatic*[tiab] AND "mental health"[tiab]) OR (aquatic*[tiab] AND "Mental Health"[Mesh]) OR (aquatic*[tiab] AND anxiety[tiab]) OR (aquatic*[tiab] AND "Anxiety"[Mesh]) OR (aquatic*[tiab] AND depression[tiab]) OR (aquatic*[tiab] AND "Depression"[Mesh]) OR (aquatic*[tiab] AND mood[tiab]) OR (aquatic*[tiab] AND "mood disorders"[Mesh]) OR (aquatic*[tiab] AND well-being[tiab]) OR (aquatic*[tiab] AND self-esteem[tiab]) OR (swim*.ti,ab AND "mental health".ti,ab) OR (swim*.ti,ab AND "Mental Health") OR (swim*.ti,ab AND anxiety.ti,ab) OR (swim*.ti,ab AND Anxiety) OR (swim*.ti,ab AND depression.ti,ab) OR (swim*.ti,ab AND Depression) OR (swim*.ti,ab AND mood.ti,ab) OR (swim*.ti,ab AND "mood disorders") OR (swim*.ti,ab AND well-being.ti,ab) OR (swim*.ti,ab AND self-esteem.ti,ab) OR ("blue space".ti,ab AND "mental health".ti,ab) OR ("blue space".ti,ab AND "Mental Health") OR ("blue space".ti,ab AND anxiety.ti,ab) OR ("blue space".ti,ab AND Anxiety) OR ("blue space".ti,ab AND depression.ti,ab) OR ("blue space".ti,ab AND Depression) OR ("blue space".ti,ab AND mood.ti,ab) OR ("blue space".ti,ab AND "mood disorders") OR ("blue space".ti,ab AND well-being.ti,ab) OR ("blue space".ti,ab AND self-esteem.ti,ab) OR (aquatic*.ti,ab AND "mental health".ti,ab) OR (aquatic*.ti,ab AND "Mental Health") OR (aquatic*.ti,ab AND anxiety.ti,ab) OR (aquatic*.ti,ab AND Anxiety) OR (aquatic*.ti,ab AND depression.ti,ab) OR (aquatic*.ti,ab AND Depression) OR (aquatic*.ti,ab AND mood.ti,ab) OR (aquatic*.ti,ab AND "mood disorders") OR (aquatic*.ti,ab AND self-esteem.ti,ab)	435
SPORTDiscus	09/10/2020	((TI swim* OR AB swim*) AND (TI "mental health" OR AB "mental health")) OR ((TI swim* OR AB swim*) AND (MH "Mental Health+")) OR ((TI swim* OR AB swim*) AND (TI anxiety OR AB anxiety)) OR ((TI swim* OR AB swim*) AND (MH "Anxiety+")) OR ((TI swim* OR AB swim*) AND (TI depression OR AB depression)) OR ((TI swim* OR AB swim*) AND (MH "Depression+")) OR ((TI swim* OR AB swim*) AND (TI mood OR AB mood)) OR ((TI swim* OR AB swim*) AND (MH "mood disorders+")) OR ((TI swim* OR AB swim*) AND (TI well-being OR AB well-being)) OR ((TI swim* OR AB swim*) AND (TI self-esteem OR AB self-esteem)) OR ((TI "blue space" OR AB "blue space") AND (TI "mental health" OR AB "mental health")) OR ((TI "blue space" OR AB "blue space") AND (MH "Mental Health+")) OR ((TI "blue space" OR AB "blue space") AND (TI anxiety OR AB anxiety)) OR ((TI "blue space" OR AB "blue space") AND (MH "Anxiety+")) OR ((TI "blue space" OR AB "blue space") AND (TI depression OR AB depression)) OR ((TI "blue space" OR AB "blue space") AND (MH "Depression+")) OR ((TI "blue space" OR AB "blue space") AND (TI mood OR AB mood)) OR ((TI "blue space" OR AB "blue space") AND (MH "mood disorders+")) OR ((TI "blue space" OR AB "blue space") AND (TI well-being OR AB well-being)) OR ((TI "blue space" OR AB "blue space") AND (TI self-esteem OR AB self-esteem)) OR ((TI aquatic* OR AB aquatic*) AND (TI "mental health" OR AB "mental health")) OR ((TI aquatic* OR AB aquatic*) AND (MH "Mental Health+")) OR ((TI aquatic* OR AB aquatic*) AND (TI anxiety OR AB anxiety)) OR ((TI aquatic* OR AB aquatic*) AND (MH "Anxiety+")) OR ((TI aquatic* OR AB aquatic*) AND (TI depression OR AB depression)) OR ((TI aquatic* OR AB aquatic*) AND (MH "Depression+")) OR ((TI aquatic* OR AB aquatic*) AND (TI mood OR AB mood)) OR ((TI aquatic* OR AB aquatic*) AND (MH "mood disorders+")) OR ((TI aquatic* OR AB aquatic*) AND (TI well-being OR AB well-being)) OR ((TI aquatic* OR AB aquatic*) AND (TI self-esteem OR AB self-esteem))	357
Google Scholar	13/10/2020	swimming and swimmers and swim and aquatic (mental health or depression or anxiety or mood or well-being or mood disorders)	12/452 (only the first 100 hits assessed)

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