Complementary Therapies in Clinical Practice 34 (2019) 195–200

Contents lists available at ScienceDirect

Complementary Therapies in Clinical Practice

journal homepage: www.elsevier.com/locate/ctcp

Aquatic exercise for persons with haemophilia: A review of literature

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ARTICLE INFO

Keywords:
Bleeding disorders
Haemophilic arthropathy
Hydrotherapy
Underwater exercise

ABSTRACT

Background: and purpose: Aquatic exercise exerts low contact stresses on the joints and may expedite an efficient recovery in persons with haemophilia. The objective of this review is to provide a qualitative summary of the interventional trials on the effects of aquatic exercise for haemophilia.

Methods: The literature search was carried out in the databases PubMed, CINAHL, CENTRAL, and PEDro to identify the interventional trials published in the English language from their inception to December 2017. Studies must deliver and report the effectiveness of the aquatic intervention in participants with haemophilia. Quality assessment of the studies was performed using the Down and Black Quality index.

Results: Four studies of moderate methodological quality were identified. Overall, the studies reported positive effects of aquatic exercise, some in comparison with no treatment and land-based exercise. Two trials reported improvements in range of motion of the elbow, knee, ankle joints, and knee muscle strength. Low-level evidence noticed an increase in aerobic capacity and prothrombin time.

Conclusion: The present review identified preliminary supportive research for aquatic intervention in persons with haemophilia. However, more robust interventional trials are required to conclude the effectiveness of the aquatic intervention in haemophilia.

1. Introduction

Haemophilia is a congenital genetic coagulopathy due to deficiency of coagulation factors VIII (FVIII) or IX (FIX), causing haemophilia A or B respectively. Globally, the second highest number of recorded cases (11,456) of haemophilia A have been reported in India [1]. The characteristic features of haemophilia are recurrent long-lasting bleeding episodes that occur either spontaneously or after trauma due to hampered clotting mechanisms. Recurrent hemarthrosis eventually produces synovial hypertrophy and cartilage destruction with joint space narrowing, and incongruence of articular surfaces [2,3]. The subsequent periods of immobilization after the joint bleeds promotes muscular atrophy, weakness, and restriction of joint range of motion [2,3]. These articular changes are collectively described as 'haemophilic arthropathy' which is associated with 65–85% of the bleeding episodes [4].

Prevention of acute bleeds and chronic haemophilic arthropathy are the two primary goals of the management of persons with haemophilia (PWH) [5]. The risk of bleeding reduces the prescription of physical activity for PWH [6,7]. However, studies have shown that exercise can provide various benefits for PWH [5]. Exercise programs are usually designed and implemented to help manage recovery after a joint or muscle bleed, to maintain or improve function in the presence of chronic arthropathy, or as a tool to prevent frequent bleeding episodes, obesity, and cardiovascular disease [8,9]. Regular exercise has been demonstrated to improve the joint range of motion, muscle strength, endurance, proprioception, and aerobic function [10,11]. However, strenuous exercise may exacerbate the bleeding and might further compromise the joint health. Therefore, special care is advocated during exercise to minimize the impact related to loading stress on the joints [5].

Though exercise appears to be beneficial, safe modes of exercise must be identified. The clinical application of underwater exercise in the rehabilitation settings has been increasing over the past few decades. The benefits of aquatic exercise arise from the biomechanical effects of immersion with effects derived from two main physical properties, i.e., buoyancy and viscosity [12,13]. Buoyancy decreases the compressive weight-bearing stresses on joints and allows functional exercise with lessened gravitational load [14]. The immersion of the human body up to the xiphoid process reduces the load on the articulations up to 60% of the body weight [14]. PWH could benefit from the decrease in intra-articular pressure and better articular mobility in water. The potential of aquatic exercise to build muscle strength due to viscosity and drag forces without any accompanying compressive force

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https://doi.org/10.1016/j.ctcp.2018.12.004
Received 3 July 2018; Received in revised form 7 December 2018; Accepted 13 December 2018

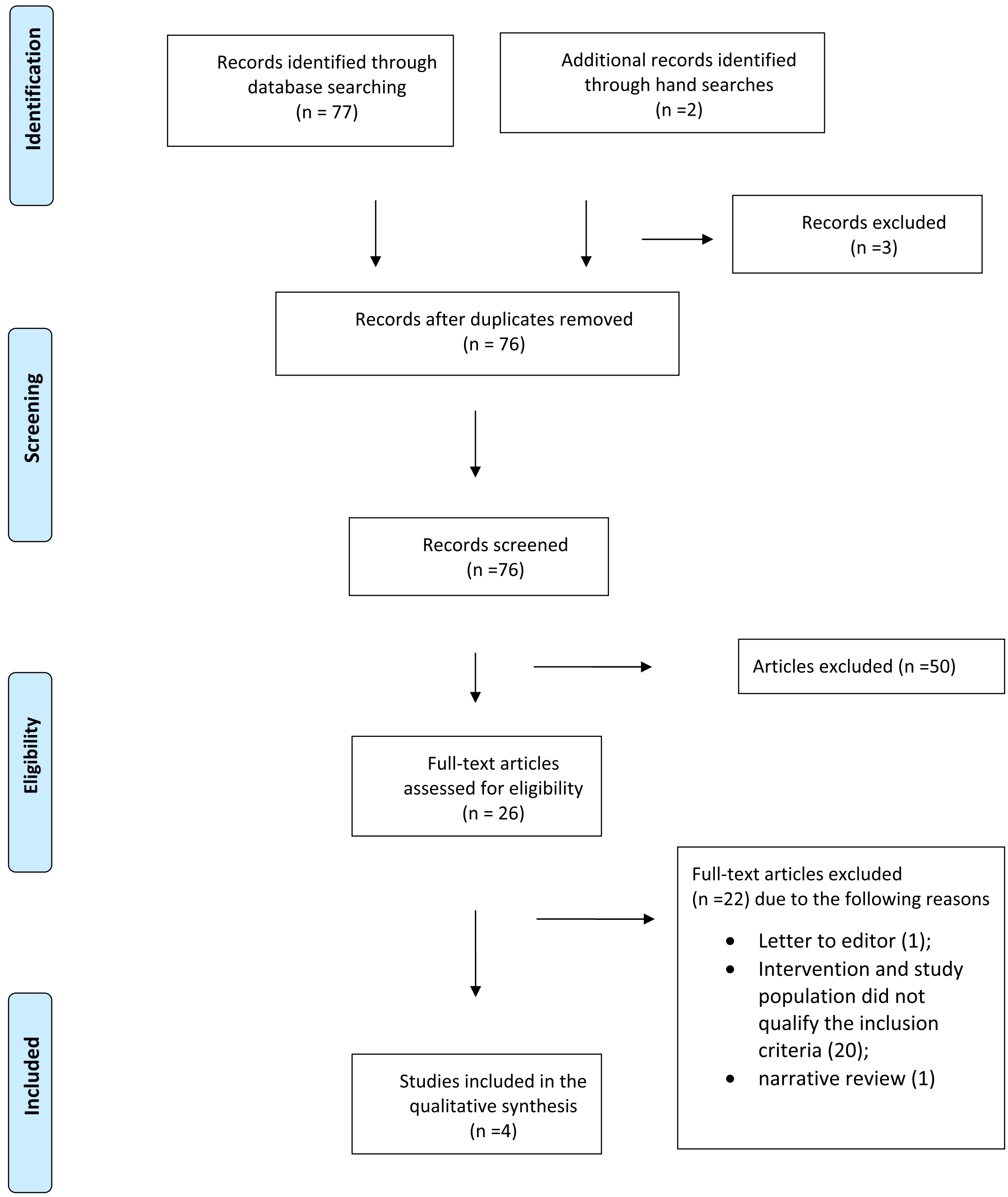

Fig. 1. PRISMA flow diagram.

is another advantage [15]. Exercise in thermoneutral water reduces the activity of sympathetic nervous, and together with the compressive effects of hydrostatic pressure reduces swelling and pain [14]. Due to these mentioned reasons, aquatic therapy can potentially be an ideal exercise environment for PWH.

High-quality evidence exists in favour of aquatic exercise for several musculoskeletal conditions such as osteoarthritis, rheumatoid arthritis, and fibromyalgia [16]. Although there is early literature on the benefits of aquatic exercise for haemophiliacs, no reviews are available that synthesized the research evidence in this topic. Thus, this review investigated the effectiveness of aquatic exercise in persons with haemophilia on various outcomes measures.

2. Methods

2.1. Literature search

The electronic databases PubMed, PEDro, CINAHL, and CENTRAL were searched systematically to identify interventional trials on the effectiveness of aquatic exercise in haemophiliacs. Additionally, hand searching of the relevant references of the retrieved articles and the journal "Haemophilia," was conducted. The search was performed using a combination of the following keywords: "Haemophilia" OR "Haemophiliacs" OR "Haemophilic Arthropathy" AND "Aquatic therapy" OR "Hydrotherapy" OR "Aquatic exercise" OR "Aquatic rehabilitation" OR "Water exercise" OR "Aquatic physical therapy." After the initial search and removal of duplicates, two authors independently screened the titles and abstracts of the resulted articles. The abstracts of the relevant studies were reviewed, and full-text articles of the studies that met the below-stated inclusion criteria were retrieved. Related articles were included in the review after arriving at a consensus. The reporting of the selection of studies has been done according to PRISMA guidelines [17].

2.2. Inclusion and exclusion criteria

Studies published in the English language between their inception to December 2017 were considered for the review. Intervention trials of any study design (randomized, non-randomized and quasi-experimental) that studied the effect of aquatic exercise in haemophilia participants (any type, age group, and severity) on various clinical and physiological outcomes were included in the review. Other reviews (systematic, narrative) and articles which are published conference papers were excluded.

2.3. Data extraction and quality assessment

The primary author did the extraction of data from the included studies with assistance from the second authors on a spreadsheet. Details of the authors, study setting, demographic data, sample size, characteristics of the included participants, intervention characteristics and outcome measures were recorded. The quality of the included trials was assessed using the Downs and Black quality index which is considered to evaluate the quality of both randomized and non-randomized controlled trials [18,19]. This scale rates the studies on five subdomains: reporting, external validity, bias, confounding, power, and the maximum score obtained will be 32. The studies were graded as poor (< 18), moderate (18–23), good (24–29), excellent (> 30) based on the proposed scoring criteria from the 27-item checklist [19].

3. Results

3.1. Search results and selection

The initial search through electronic databases resulted in a total of 77 articles, and two articles were found additionally through the journal “Haemophilia.” After the removal of duplicates, these articles were screened for relevance and following which four studies [20–23] were included in the final review. The review included two randomized trials [22,23], one pre-post study design [23] and one cross-sectional study [20]. Fig. 1 shows the study selection process.

3.2. Study characteristics

Table 1 outlines the features of the individual studies.

*Participants***:** The studies included adults [20–22] and children [23] with one study on haemophilia type A and type B [20]. However, none of the studies reported the diagnostic criteria. The total number of participants in all the studies was 79. Only one study reported the severity of haemophilia as moderate [21].

Interventions and Comparison groups: The effects of various aquatic exercises were compared with no treatment [21], and land-based exercise [22]. The details of the intervention were provided in Table 1.

Outcomes: The effects of aquatic exercise were measured on intensity of pain [22], range of motion of the knee [21,22], ankle [21], and elbow [21], maximum and relative oxygen uptake [23], isokinetic strength of flexors and extensors of knee [21], and clotting variables (factor VIII prothrombin time (PT), activated partial thromboplastin time (APTT) and fibrinogen) [20].

3.3. Quality assessment of the studies

The quality of the included studies was found to be moderate, according to the Downs and Black quality index (Table 2). The studies lacked external validity and had a significant bias due to the absence of outcome assessor blinding and randomization. Further, there is an inadequate reporting of the characteristics of the study population such as the type of haemophilia [21–23] and severity (mild, moderate, or severe) of the disease [20,22,23].

3.4. Qualitative analysis/effects of intervention

3.4.1. Aquatic exercise vs. No treatment

The results of the study by Kargarfard et al. [21] state that aquatic exercise for eight weeks can significantly improve the range of motion of elbow, knee, and ankle joints in comparison with no treatment. The isokinetic strength of knee flexors and extensors was also increased.

3.4.2. Aquatic exercise vs. land-based exercise

While the prescription of exercise is same for land and water, aquatic exercise for four weeks was found to be slightly superior to land-based exercise in improving pain (mean difference: 0.5 cm) [22]. No statistical differences were found between aquatic and land-based exercise for knee range of motion.

3.4.3. Effect on aerobic capacity

Aquatic therapy for three weeks (3 h per week) was found to improve oxygen uptake by 51.5% ($p < 0.05$), and distance covered in 12 min by 14.6% ($p < 0.05$) in a study by Vallejo et al. [23].

3.4.4. Effect on clotting variables

An acute session of moderate intensity aquatic exercise for a short 5-min duration may have a beneficial impact on prothrombin time (Effect size (ES):0.6). However, there was no effect on factor VIII (ES:0.3), fibrinogen (ES:0.03), and APTT (0.2) [20].

4. Discussion

The current review found that aquatic exercise improves pain, muscle strength, joint range of motion, clotting factors, aerobic function in persons with haemophilia. However, the number of studies were less, the level of evidence is low, and the overall quality of evidence is moderate. The common methodological limitations were the absence of a control group, lack of randomization of the participants, and blinding of the outcome assessor (Table 2).

Pain is a frequent musculoskeletal complaint in PWH which is usually due to acute bleeds or chronic hemarthropathy [24,25]. However, there are no standard recommendations on the management of chronic pain in haemophilia [26]. The aquatic exercise was shown to produce a small, but the clinically insignificant reduction of pain scores when compared with land-based exercise [22,27]. Two studies measured and reported improvements in range of motion of the ankle, knee, and elbow joints post aquatic exercise [21,22]. The reasons cited for improvements in pain and range of movement are the hypoalgesic effect of the temperature of water in the pool and its influence on the circulatory system and reduction of edema [22,28]. Buoyancy is another physiological effect that unloads the joints and probably helps to achieve maximum range of motion stretching the periarticular structures [24]. However, both the studies included a cooling down phase consisting of flexibility exercise following the aquatic intervention. Therefore, it may be difficult to differentiate and conclude whether the improvements in range of motion were due to aquatic therapy alone.

Isokinetic muscle strength of knee flexors and extensors increased in the study by Kargarfard et al. [21]. Though positive effects were noticed, firm conclusions on the effect of aquatic exercise on muscle strength could not be ascertained. It is unclear whether the principles of strength training were applied during the exercise sessions and the main exercise program involved simple active movements of the lower limb. A recent meta-analysis identified that principles of resistance exercise (such as overload principle etc.) were implemented poorly in trials that studied the effect of the aquatic intervention on muscle strength [29]. Hence, the clinical translation of the biomechanical

Table 1
Description of the included studies (mean and SD).

Authors	Study design Level of evidence	Participants	Intervention	Outcomes	Results
Vallejo et al., 2010 [23]	Pretest post-test 4	Nine children with haemophilia between 5 and 13 years of age. Nine children with no pathology	Muscular endurance Two sets of 20 repetitions of shoulder and elbow movements Muscle strengthening Horizontal and vertical traction movements at their maximum speed The exercises were performed with various flotation devices (alter-gim, hydro bells) Three times/week for three weeks	Max and relative oxygen uptake Heart rate Respiratory quotient	Twenty-seven aquatic therapy sessions (1 h) were found to improve oxygen uptake by 51.5% ($p < 0.05$) and distance covered in 12 min by 14.6% ($p < 0.05$) No significant differences were found for heart rate
Kargarfard et al., 2013 [21]	Non- randomized trial 2b	20 males with moderate haemophilia (Mean age (SD): 22(7.5))	Ten simple active movements in the water - 5 for the upper limb and 5 for the lower limb. **Control group: No treatment** Three times/week for eight weeks	Isokinetic strength of the extensors and flexors of knee Range of motion of the knee, ankle, and elbow joints	Aquatic therapy can significantly improve (p value < 0.05) range of motion of elbow, knee and ankle joints and strength of the knee joint muscles when compared to no treatment.
Mazloum et al., 2014 [22]	Randomized trial 2b	40 adult haemophiliacs (Mean age (SD): 33(10))	Hamstring stretching Quadriceps strengthening **Control group: Similar exercise on the land** Three times/week for four weeks	Pain severity (VAS), knee joint range of motion	The aquatic exercise was found to be slightly superior to land-based exercise in improving pain (Mean difference: 0.5 cms) No statistical differences were found between aquatic and land-based exercise for the range of motion ($p. > 0.05$)
Beltrame et al., 2014 [20]	Cross-sectional 4	Ten adult haemophiliacs (8 type A, 2 type B) (Mean age: 22)	Back leg strokes with plantar flexions, forward leg strokes with plantar extensions, hip abductions with plantar extension and aquatic running One session for 20 min with 56–88% of HR max	Factor VIII prothrombin time (PT), activated partial thromboplastin time (APTT) and fibrinogen.	An acute session of a moderate aquatic exercise of short duration may have a beneficial effect on prothrombin time (Effect size (ES):0.6) and no effect on factor VIII (ES:0.3) and fibrinogen (ES:0.03) and APTT (0.2)

SD: standard deviation; VAS; visual analog scale; HR max: heart rate maximum; PT: prothrombin; APTT: activated partial thromboplastin time; ES: effect size; cm: centimeter.

Table 2
Quality index of studies included in the review.

Author (year)	Reporting (11)	External validity (3)	Bias (7)	Confounding (6)	Power (5)	Total Quality score(32)
Mazloum et al., 2014 [22]	8	0	3	3	5	19 (Moderate)
Kargarfard et al., 2013 [21]	8	0	4	4	5	21 (Moderate)
Beltrame et al., 2014 [20]	8	0	3	3	5	19 (Moderate)
Vallejo et al., 2010 [23]	8	0	4	2	5	19 (Moderate)

effects of aquatic exercise such as buoyancy and viscosity in haemophiliacs could not be confirmed based on these two trials [21,22].

An acute increase in blood clotting factors after the aquatic exercise session was another therapeutic effect identified [20]. This finding suggests the potential benefits on long-term factor replacement which must be explored further. Though the underlying physiological reasons remain unclear, this is the only study that measured the clotting variables. Recent data indicate an increasing prevalence of obesity in haemophiliacs and associated healthcare costs burden related to clotting factor replacement therapy, which is generally dependent on the body weight of the person [30–32]. The aquatic exercise was shown to have positive effects on parameters of aerobic capacity [23]. As aerobic exercise influences body mass [33], the corresponding translation of the increased aerobic capacity on the body fat measures may lead to clinically oriented therapeutic implications.

The therapy needs of the haemophilia individuals are persistent and long-term. Therefore, treatment models need to consider long-term compliance and active participation of the individuals. The therapy sessions can be made more acceptable by allowing the participants to choose the preferred mode of exercise [34]. As the land-based training and aquatic exercise were shown to have similar benefits, the preferences of the participants might direct the choice of the exercise intervention. Aquatic therapy being a recreational mode of exercise may be the preferred mode of treatment. However, the preferences of the participants and compliance with treatment were not studied in the previous studies.

Another meta-analysis identified 26 studies that delivered aquatic exercise in various musculoskeletal conditions such as osteoarthritis, rheumatoid arthritis, fibromyalgia, and low back pain with positive effects on the associated pain and function [16]. In contrast to our results, the studies on the above musculoskeletal conditions were of higher quality and larger sample sizes, possibly due to a higher prevalence of those diseases.

4.1. Study limitations

Though this is the first review that summarized the available studies on the effects of aquatic intervention in haemophilia individuals, it has the following limitations. (1) A narrative synthesis of the current literature was performed as the review identified studies with varying study designs. (2) Further, the variability in the parameters of the intervention among the included studies prevented a quantitative meta-analysis of the data. (3) Two studies published in the Persian language were not included in the review. (4) Besides, the strength of the current review is influenced by the limitations identified in the individual studies. The sample size of the studies was low, ranging from 9 to 40 and the duration of intervention in the studies was less and varied from 3 to 8 weeks. The adherence rate and outcomes after a long-term follow up were not reported. None of the studies reported the adverse events such as the number of bleeds (if any) during the period of intervention, or self-reported or objective measurements of activity and participation.

4.2. Clinical implications

There is inadequate high-quality research to strongly recommend aquatic exercise for PWH. However, existing studies showed benefits for various musculoskeletal symptoms of haemophilia. These improvements in musculoskeletal function could enhance their activity and participation and may improve quality of life.

5. Conclusion

This review of the literature on the effectiveness of aquatic exercise for haemophilia population identified very few trials of low-level evidence. However, studies support aquatic exercise to improve muscle strength, the range of motion and aerobic capacity and clotting variables. Firm conclusions could not be drawn based on the limited available literature, and lack of robust study designs and the aquatic interventions. This review highlights the need for large-scale trials to develop a verified consensual statement for guidelines of aquatic intervention in haemophilia. Future studies need to identify the specific parameters of aquatic exercise for PWH, informing the precise benefits of standardized aquatic exercise on outcomes related to function, activity, participation, and quality of life. Further high-quality studies need to be conducted to determine the most effective exercise parameters and benefits of aquatic exercise in people with haemophilia concerning these recommended outcome measures.

Declaration of interest

All the authors report no conflicts of interest.

Funding

None.

Acknowledgment

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ctcp.2018.12.004.

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