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ORIGINAL ARTICLE

The Effectiveness of Aquatic Exercises in Improving Balance and Gait in Patients with Knee Osteoarthritis: A Systematic Review

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ABSTRACT

Aim: Knee osteoarthritis is a degenerative joint disease that primarily affects older persons. The second most common disease among adults living in communities is osteoarthritis, which also has the second-highest overall medical cost aggregate.

Objective: This review aimed to synthesize evidence for the effectiveness of aquatic exercises on the mobility, balance, gait, and posture of patients with knee osteoarthritis.

Method: The databases utilized for literature searching were Embase, PubMed, PEDro, Cochrane library, and web of science. The search was conducted for literature selection on electronic databases up to November 2022. The selected studies were randomized controlled trials conducted in the past 12 years and published in English. To assess the methodological quality of the selected studies, the PEDro scale for quality assessment was applied**.**

Results: Out of 366 obtained studies from the initial search, 10 trials met the inclusion criteria and were selected for review. All the included studies were found to have good methodological quality when assessed by the PEDro scale. A total of 531 participants, 74 males, and 457 females were evaluated with ages above 40 years. The aquatic exercise sessions for 3 to 12 weeks, 2 to 5 times a week for 30 to 90 minutes were administered across the studies. Although the method, duration, and frequency of aquatic interventions varied widely regarding mobility and balance in the studies, most of the studies found significant improvement in balance, postural control, and mobility. No convincing evidence can be provided for the improvement of gait and reduction of postural sway for both genders.

Conclusion: Aquatic exercises are generally effective for the management and treatment of elderly patients suffering from knee osteoarthritis and should be used as an initial treatment option. Aquatic exercises with proper protocols of warm-up, specific aquatic exercise sessions, and cool-down are effective for the improvement of mobility, balance, and postural control in patients with knee osteoarthritis.

Keywords: knee osteoarthritis, osteoarthritis of the knee, knee osteoarthritides, aquatic exercise, hydrotherapy, and water exercise

INTRODUCTION

The most prevalent progressive degenerative musculoskeletal condition that can affect joints is osteoarthritis (OA), which primarily affects the hips and knees since they bear most of the body's weight (Bortoluzzi, Furini, & Scirè, 2018; Nelson, 2018). Around 10% of men and 18% of women over 60 years old worldwide are affected by OA, putting this population at risk of significant morbidity, including disability, lower quality of life, and eventually mortality (Hawker, 2019). In accordance with a study by Disease and Injury Incidence and Prevalence Collaborators, knee OA accounts for around 85% of the burden of OA globally, with an estimated prevalence of 10% in men and 13% in women aged 60 and over (Vos et al., 2016). This systematic analysis also demonstrated a surge in the prevalence of knee OA, which has increased by 32.7% between 2005 and 2015 additionally, in the computation of Disability Adjusted Life Years (DALYs) for the older population, osteoarthritis ranks second behind low-back pain as the most common musculoskeletal illness (Prince et al., 2015; Vos et al., 2016). In affluent countries, OA accounts for an annual economic burden of at least USD 89.1 billion, or between 1% and 2.5% of GDP and the majority of this expense is attributable to knee and hip joint replacements (Hunter, Schofield, & Callander, 2014).

Osteoarthritis in the knee is associated with structural changes to the articular cartilage and subchondral bone, synovial lining, ligaments, and muscles, leading to the idea that OA is regarded as a disease affecting the entire joint (Loeser, Goldring, Scanzello, & Goldring, 2012). It is acknowledged that knee OA has a complex aetiology, where the entire joint is impacted by the pathology of knee OA, which results in bone remodelling, synovial inflammation, cartilage degradation, and the growth of osteophytes (Alshami, 2014). The clinical presentation includes; joint pain, muscular weakness, transient morning joint stiffness, unstable joints, reduced quality of life, crepitus and functional difficulties (Bennell & Hinman, 2011). These impairments, which are primarily pain-related, frequently appear as difficulties walking, climbing stairs, doing domestic tasks, and sitting erect. They also have a detrimental psychological impact, which can all contribute to a worse quality of life (Mahir et al., 2016).

Patients with knee OA have decreased joint proprioception, which compromises their static and dynamic balance and raises their risk of falling. (Khalaj, Abu Osman, Mokhtar, Mehdikhani, & Wan Abas, 2014). Knee OA also results in changes in gait patterns in terms of reduced walking speed which is presumably the result of adjustments made to the neuromuscular strategy of the lower extremity kinetic chain in reaction to joint discomfort, muscle weakness (Zeni & Higginson, 2011).

There are certain contributing risk factors associated with rising incidence of knee OA are age, prior knee injuries, obesity, joint malalignment, and instability that lead to increased mechanical stress (Anderson & Loeser, 2010; Felson, 2013; Vina & Kwoh, 2018). Physical Inactivity is another significant factor in the disease development, which increases the risk of knee injury since weaker and less stable joints are more prone to instability (Berenbaum, Wallace, Lieberman, & Felson, 2018). Sex is also one of the risk variables linked to the development of OA since males are less likely to develop it than women are (Srikanth et al., 2005) because women's knee anatomy differs from men's due to narrower femurs, thinner patellae, larger quadriceps angles, and variations in the size of tibial condyles (Hame & Alexander, 2013).

Clinical practice guidelines recommend the use of medication, education, weight loss, and exercise as conservative treatment choices (UK, 2014) and therapeutic exercise is recognized as a fundamental treatment for people with OA and should include both strength and aerobic components, regardless of age, comorbidities, pain level, or disability (Fernandes et al., 2013). There are distinct properties of water such as buoyancy, resistance to motions in all directions (due to the water's viscosity),

turbulence caused by the person's movements, and the hydrostatic pressure that make exercise performed while submerged in water fundamentally different from land-based exercises (Meredith-Jones, Waters, Legge, & Jones, 2011; Sato, Kaneda, Wakabayashi, & Nomura, 2009). Exercise in water reduces the likelihood of unfavourable outcomes minimizes the fear of falling, reduces stress on weight-bearing joints, and motivates obese people to exercise without exposing their complete body which potentially leads to greater exercise adherence (Lund et al., 2008; Takeshima et al., 2002).

There are numerous studies available that looked at the effectiveness of water-based exercises on reducing pain, improving quality of life, enhancing cardiovascular fitness, and reducing disability but only limited studies about aquatic exercise utilization for mobility, gait, posture, and improvement of balance. Therefore, our systematic review will focus on filling in the gaps in the literature and give a summary of recent research that may be used in a therapeutic setting as well as help guide suggestions for future studies.

METHODOLOGY

This systematic review was designed to synthesis high-quality evidence from the current literature to assess the efficacy of aquatic exercises for enhancing balance, gait, posture, and mobility in patients of older ages with knee osteoarthritis by considering both genders. The method and design of the study were following the guidance of the Cochrane handbook of systematic reviews (Higgins et al., 2019) and the recommendations of PRISMA 2020 (preferred reporting items of a systematic review and meta-analysis). The selection of studies was done by using EndNote software.

Inclusion and exclusion criteria: The inclusion criteria for the selection of studies were as follows: (1) Patients having osteoarthritis of the knee joint, without the involvement of any other joint of the body. (2) Participants of the studies having an age of more than 40 years. (3) The study design was RCT (randomized controlled trials). (3) Participants have no other chronic health condition that affects their participation in the study. (4) Studies were published in the past 12 years. (5) At least one of the groups in the study was getting aquatic exercise interventions. (6) At least one of the outcome measures of the study was mobility, balance, gait, and postural control and sway. The studies were excluded if; (1) Articles had study designs other than randomized controlled trials. (2) Articles were not published in the English language. (3) Studies included Hip osteoarthritis or another joint osteoarthritis along with knee osteoarthritis. (4) Studies whose full text was not available. (5) Studies having PEDro score <3.

Search strategy: The electronic databases utilized for literature searching were Embase, PubMed, PEDro, Cochrane library, and web of science. The search was conducted for study selection in November 2022. The literature was searched around the search terms for knee osteoarthritis and aquatic exercises with the use of MeSH terms and Boolean operators. Different search limits were utilized for different databases because of the difference in the interface provided by the databases. The search strategy for PubMed was as follows; (osteoarthritis, knee [MeSH Terms] OR knee osteoarthritides [All Fields] OR knee osteoarthritis [All Fields] OR osteoarthritis of knee [All Fields]) AND (aquatic exercise [MeSH Terms] OR aquatic exercise [All Fields] OR hydrotherapy [All fields] OR water exercise [All Fields]). Further, the limits were applied for only randomized controlled trials, the English language, and Articles from the past 12 years.

Selection of studies and quality assessment: The studies were obtained from databases by using certain limits and filters under the predetermined inclusion and exclusion criteria. The obtained studies were then managed using EndNote software. Initially, duplicate studies were removed by using EndNote and then manually rechecked for further assurance of accuracy. The title of the articles, after the removal of duplications, were reviewed and only those articles were selected which were seemed to meet the scope of the study. The next step was taken to explore the full text of the selected articles and excluded those articles which were not per the eligibility criteria, to come up with more relevant and eligible studies for the systematic review. PRISMA flow chart for the selection of studies is presented in figure 1.

The quality assessment of the eligible and included trials, finalized by EndNote software, was done by using the PEDro scale of methodological assessment of quality and critical appraisal, which includes items such as eligibility criteria, randomization of participants recruited, concealed allocation of subjects into groups, baseline similarity of participants' characteristics of the experimental and control groups, blinding of subjects, therapists, and assessors, dropouts of subjects from the study, availability of treatment and control condition to the allocated subjects and their outcome measurement, reporting of results of statistical comparison between groups, and provision of point measure and variability of outcomes. The PEDro scores of selected studies are shown in table 1. According to the measurement properties of the PEDro scale by Cashing AG, et al. 2020, one out of ten selected studies (Khruakhorn & Chiwarakranon, 2021) was an excellent quality study, eight studies were good quality (Assar, Gandomi, Mozafari, & Sohaili, 2020; Azizi et al., 2020; Garbi et al., 2021; Kuptniratsaikul, Kittichaikarn, Suntornpiyapan, Kovintaset, & Inthibal, 2019; Taglietti et al., 2018; Wang et al., 2011; Yennan, Suputtitada, & Yuktanandana, 2010; Zamanian et al., 2012) have PEDro scores of 6-8. The one selected trial (Kunduracilar, Sahin, Sonmezer, & Sozay, 2018) had a PEDro score of 5 and was considered fair quality.

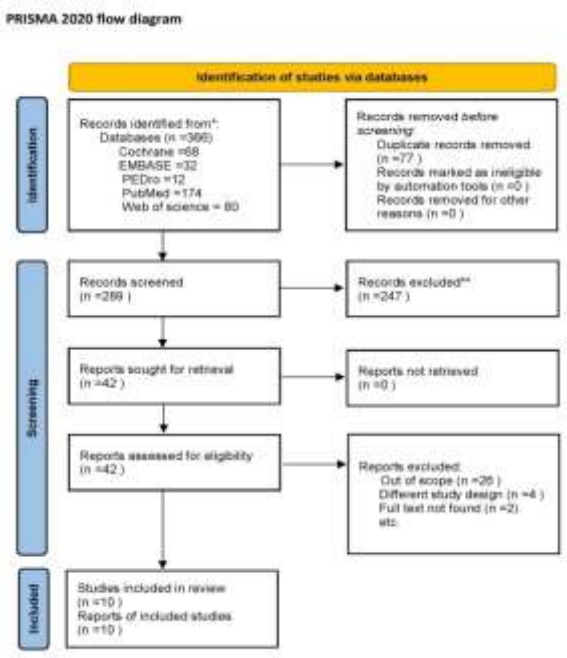

Figure 1: PRISMA flow chart

Data Extraction: The selected studies were reviewed thoroughly for data extraction. The extraction of required data and information of interest from the eligible studies, after their quality assessment, was done twice to ensure preciseness. The extracted information was author, year of publication, sample size, gender of participants, intervention and control groups, frequency and duration of treatment sessions, type of intervention to the participants, outcome measures of interest, and result or conclusion of the study. The information was then presented in tabulated form (table 2) for utilization in the synthesis of results to come up with an evident conclusion for the systematic review.

RESULTS

A total of 366 studies were obtained while searching from the electronic databases, and at the end of the eligibility assessment process, 10 studies were found eligible and selected to obtain results for this systematic review. A total of 531 participants were evaluated across the selected studies, of which 74 were male participants and 457 were female participants, so the ratio of female participants was high as compared to male subjects. The age of all the patients was above 40 years. With regards to the interventional and control groups; 272 participants were recruited in the aquatic therapy groups and 259 were in the non-aquatic groups. The duration of sessions ranged from 3 to 12 weeks and frequency of 30 to 90 minutes, 2 to 5 times a week across all the studies. All the included studies were published in the English language and published in years from 2012 to 2022.

Outcome Measures: The main outcome measures that were evaluated for the systematic review included mobility and balance, along with other secondary outcomes that were postural sway and control, and gait of patients suffering from knee osteoarthritis. Across the studies, the outcomes measurement tools utilized were; a 6-minute walk test (6MWT), Time up and go test (TUG), 5 times sit to stand (5STS) and stair climbing test (SCT) for assessment of mobility; Step length(cm), Step time(s), Step width(cm), Stride length(cm), Cadence(step/min) for assessment of gait; Romberg test, Balance error scoring system, Berg balance scale, Single leg stance test with eyes open and close to examine the static and dynamic balance, and postural control; and Medio-lateral amplitude, Anterior-posterior amplitude, Total sway area using force platform for assessment of postural sway.

Table 1: Extracted data from studies

Studies	Sample size	Gender of participants	Intervention and control group	Duration and frequency	Intervention	Outcome measures of interest	Results
Azizi, S. et al. 2020	N=32	Only male	IG: n=16, aquatic exercise CG: n=16, acetaminophen + usual lifestyle	Three sessions per week for 8 weeks, per session 60 minutes.	10–15 min warm-up, 35 min strength training, and 10 min cool-down exercises.	(Gait and balance) Romberg test Balance error scoring system. Step length(cm) Step time(s) Step width(cm) Stride length(cm) Cadence(step/min)	Significant improvement in static and dynamic balance, step length, stride length, and cadence.
Garbi, F. P.et al. 2021	N= 29	4 Male, 25 female	IG : n=17, aquatic program CG: n=12, no physiotherapy	Total Sixteen sessions, 60 minutes each for 2 months	Aquatic physiotherapy program and stretching	Mobility 6MWT TUG	Significant improvement in mobility and functional capacity.
Kunduracilar, Z. et al. 2018	N=89	Females only	IG: Group 1(n=30), electrotherapy (hot pack, ultrasound, TENS)+ lower extremity aquatic program. Group 2(n=30), electro + lower and upper extremity and trunk aquatic exercise program. CG: (n=29) only electrotherapy	45 minutes standard therapy, 45-60 min aquatic (for IG), Five times a week for 3 weeks.	Warm-up Stretching Strengthening (isometric exercises for knee, elastic resistance exercises, stretching exercises for lower extremity)	Standing Balance: Single-leg stance test	A significant difference between groups for balance-related parameters, group 2 was found superior to group 1, and group 1 was better than the control.
Taglietti, M. et al. 2018	N= 60	19 male, 41 female	IG: Aquatic exercise group: n=31 Educational group: n=29 No control group	AEG= total of 16 sessions, twice a week for eight weeks, per session 60 min. EG= 2 hours, once a week 3 month follow up	AEG: Warm-up Aquatic Exercises (knee and hip isometric and dynamic exercises with elastic bands, aerobic exercises, step training, and proprioceptive exercises. Cool down.	Functional mobility: TUG test	No significant difference between groups for mobility.
Yennan, P. et al. 2010	N=50	Females only	IG: Aquatic exercise group: n=25 Land-based exercise group: n=25 No control group	warm-up 10 minutes exercise 45 minutes and cool-down 10 minutes for 6 weeks	Double-leg squat, double-leg calf raise, stand stretch and bend the knee, standing kick leg-to-side, standing kick leg-to-front, sitting stretch knee, sit spin bike, and fast walking forward and backward, single-leg squat and single calf raise	Postural sway: Medio-lateral amplitude Anterior-posterior amplitude, Total sway area using a force platform. (30-sec test for each position)	Improvement in balance and reduction in postural sway were significantly better in the aquatic exercise group.
Zamanian, F. et al. 2012	N=43	Female only	IG: Shallow water exercise group: n=14 Deep water exercise group: n=14 CG: n=15	1-hour session, three sessions per week for 12 weeks	Aquatic exercises (no specific exercise mentioned)	Postural control and balance: One leg balance with eyes open (Romberg test)	Significant improvement of balance and posture control in the shallow water group more than deep water group.
Kuptniratsaikul, V. et al. 2019	N=80	75 female 5 male	IG: Under water group(UWG): n=40 CG: Home exercise group (HEG): n= 40 No control group	UWG: 30 min per session, three times a week for 4 weeks. HEG: Daily 30 min for 4 weeks.	IG: Underwater treadmill CG: Isometric quadriceps exercises	Mobility: 6MWT	Both groups show improvement in function. More improvement in UWG but not statistically significant.
Wang, T. J. et al. 2011	N=78	67 female, 11 male	IG: Aquatic group: n=26 Land Group: n=26 CG: N= 26	60 minutes, 3 times a week for 12 weeks	Warm-up Flexibility training Aerobic training Upper and lower body training Cool down	Mobility: 6MWT	Improvement in both the group compared to the control group. No significant difference between the intervention groups.
Khraukhorn, S. & Chiwarakranon, S. 2020	N=34	3 males, 31 females	IG: Hydrotherapy group (n = 17) Land-based group (n=17) No control group	45-60 minutes, 3 sessions per week for 6 weeks. 6 months follow up	Strengthening, stretching, and aerobic exercises in the lower limb, Forward and backward single-leg swings, Forward marching, Medial diagonal single leg swing etc.	Functional mobility: Time up and go (TUG) 5 times sit to stand (5STS) Stair climbing test (SCT)	Both exercises equally improve mobility.
Assar, S. et al. 2020	N= 36	Females only	IG: Aquatic exercise group (n=12) Total resistance exercise group (n=12) CG: (n=12)	90 minutes session, 3 times a week for 8 weeks.	Warm up, Walking, Stretching exercises of lower extremity muscles, strengthening exercises, step training, proprioceptive exercises, core exercises and cool down.	Balance: Berg balance scale	Significant improvement of balance in aquatic exercises group compared to control group.

Critical Appraisal: The critical appraisal of ten selected studies was done by using the PEDro scale of quality assessment of Randomized controlled trials (shown in table 1). All the selected trials had their eligibility criteria for the selection of participants with

nine of the ten trials had random allocation into groups, out of which seven trials (Assar et al., 2020; Azizi et al., 2020; Garbi et al., 2021; Khruakhorn & Chiwarakranon, 2021; Kuptniratsaikul et al., 2019; Taglietti et al., 2018; Wang et al., 2011) had shown the process of concealed allocation. The remaining had not cleared the procedure of randomization. None of the studies had baseline characteristics differences between participants of groups. Participants were blinded in just one study (Khruakhorn & Chiwarakranon, 2021), and measurement assessors were blinded in six studies (Assar et al., 2020; Azizi et al., 2020; Khruakhorn & Chiwarakranon, 2021; Kuptniratsaikul et al., 2019; Taglietti et al., 2018; Wang et al., 2011). None of the trials had blind therapists and participants as the blinding was not possible because of the nature of the intervention of the studies. All the studies provided the treatment and control conditions as allocated and analysed their participants at the end of trials for all outcome measures. All the trials reported between group statistical comparisons and presented the data with their means and standard deviations.

Table 2 PEDro scoring

PEDro questions	Azizi, S. et al. 2020	Garbi, F. P. et al. 2021	Kunduracilar, Z. et al. 2018	Taglietti, M. et al. 2018	Yennan, P. et al. 2010	Zamanian, F. et al. 2012	Kuptniratsaikul, V. et al. 2019	Wang, T. J. et al. 2011	Khruakhorn, S. & Chiwarakranon, S. 2020	Assar, S. et al 2020
Q # 1*	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Q # 2	yes	yes	no	yes	yes	yes	yes	yes	yes	yes
Q # 3	yes	yes	no	yes	no	no	yes	yes	yes	yes
Q # 4	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Q # 5	no	no	no	no	no	no	no	no	yes	no
Q # 6	no	no	no	no	no	no	no	no	no	no
Q # 7	yes	no	no	yes	no	no	yes	yes	yes	yes
Q # 8	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Q # 9	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Q # 10	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Q # 11	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Total score	8	7	5	8	6	6	8	8	9	8

1 Eligibility criteria were specified.2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received). 3. Allocation was concealed. 4. The groups were similar at baseline regarding the most important prognostic indicators. 5. There was blinding of all subjects. 6. There was blinding of all therapists who administered the therapy. 7. There was blinding of all assessors who measured at least one key outcome. 8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups. 9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat". 10. The results of between-group statistical comparisons are reported for at least one key outcome. 11. The study provides both point measures and measures of variability for at least one key outcome.

Effects of interventions: Balance (Static and dynamic) and postural control: Four studies in the selected literature (Assar et al., 2020; Azizi et al., 2020; Kunduracilar et al., 2018; Zamanian et al., 2012) examined the balance and postural control in patients before and after the interventions. The outcome measurement scales that they used were the Romberg test, the Balance error scoring system, the Berg balance scale, and the single-leg stance test. All the included trials provide significant improvement of balance in the aquatic intervention groups for particular scales; however, there were variety of aquatic exercises administration with different frequencies and durations. Across the trials, aquatic exercises had found to be effective in improving both static and dynamic balance and controlling posture in a patient with knee osteoarthritis.

Mobility: Five of the studies (Garbi et al., 2021; Khruakhorn & Chiwarakranon, 2021; Kuptniratsaikul et al., 2019; Taglietti et al., 2018; Wang et al., 2011) from the selected trails had examined the mobility of patients with knee osteoarthritis. Outcome measures for assessment were TUG test and 6MWT along with 5 times Sit to stand tests (5 STS) and stair climbing tests (SCT). Across the trails, a significant improvement in mobility of patients were found while comparing aquatic exercise group with no intervention, except for one trial (Taglietti et al., 2018) that shown minimal improvement on TUG test. But, based on other included trials that also analyzed mobility by the TUG test (Garbi et al., 2021; Khruakhorn & Chiwarakranon, 2021) and are quality trails, there is a significant change in the mobility of knee OA patients after aquatic exercise interventions. Hence, Exercising in water is effective in patients of knee osteoarthritis for improvement of mobility.

Gait: One study (Azizi et al., 2020) from the selected trails that examined the gait of patients utilized the measurement scales of Step length(cm), Step time(s), Step width(cm), Stride length(cm), and Cadence (step/min). After administering aquatic strengthening exercises on male subjects, the study provided significant improvement in step length, stride length, and cadence whereas step time and step width improvement were minimal. Gait improves significantly in patients with knee osteoarthritis after administration of aquatic exercises.

Postural sway: One of the trials from the ten selected studies for the review examined the postural sway of patients with knee osteoarthritis. (Yennan et al., 2010) conducted the study by including only female participants and outcome measurement tools used before and after the interventions were Mediolateral amplitude, Anterior-posterior amplitude, and Total sway area using a force platform (30-sec test for each position). After the intervention of aquatic exercises there was a significant reduction in the postural sway of patients suffering with knee osteoarthritis.

DISCUSSION

This systematic review aimed to determine the effectiveness of aquatic exercises in elderly patients with knee osteoarthritis, on outcomes of balance, mobility, postural control, postural sway, and gait. Studies had been shown that the severity of osteoarthritis is related to the loss of stabilization of gait and balance in patients with knee OA (Serkan, Guneri, Kaymak, & Erden, 2015), which in turn increases the fair and risk of falling in patients. The knee osteoarthritis of the medial compartment of the knee also acts to change the posture of the patient's foot (Levinger et al., 2010) which also affects the mobility and gait of the patient. So, this study aims to find out an effective treatment approach to reduce these kinds of issues related to knee OA. An intervention of aquatic exercises was brought into debate for the sake of this purpose.

From the previous reviews (Silva, Serrão, Driusso, & Mattiello, 2012), balance effectively improved in patients with knee osteoarthritis and therapeutic exercises were found to improve outcomes in women suffering from osteoarthritis of the knee. It is also congruent with the systematic review by (Song & Oh, 2022), which confirmed that the exercise programs are effective and safe for patients with knee OA. A comparison of the effectiveness of aquatic and land-based exercises favoured aquatic exercises as more satisfactory for patients with knee OA (Dong et al., 2018) .Aquatic exercises had also been found to improve functional capacity and fitness when administered in older adults (Lopez et al., 2021). The properties of water like waves, water temperature, and hydrostatic pressure provide relaxation of muscles and soothing effects to the joints to help alleviate pressure from joints and reduce the pain caused by compression on the joint (Bender et al., 2005). This reduction of pain and other properties of water like buoyancy supports the weight of the body and helps patients to move their joint in water and make exercising in the watery environment easy for the patients (Bento, Pereira, Ugrinowitsch, & Rodacki, 2012; Yázigi et al., 2013). Hence, this weight reduction effect in aquatic environment is a good treatment option for patients with osteoarthritis and also enhance their quality of life (Zeng, Zhang, Tang, & Hua, 2021).

Analysis of the ten studies critically analysed by the PEDro scale, all were found good quality trials with a PEDro score above 5. In most of the trials, the diagnosis of osteoarthritis was based upon the clinical and radiological evaluations, which were following the Kellgren and Lawrence scale (1 to 4 Grade). Based on the selected randomized controlled trials (n=3) for postural control and static balance, Romberg's test with eyes open and eyes closed, Berg balance scale, and single leg stance test had provided evidence of significant improvement of the balance in knee OA patients. For dynamic balance, it is also found that aquatic exercises are associated with significant improvement in the balance error scoring system. This is strengthened by (Kim, Vakula, Waller, & Bressel, 2020) that presented aquatic exercises as more effective in improvement of dynamic balance on different scales, including berg-balance scale, when compared to land-based exercises. (Cugusi et al., 2019) also supported this outcome

and concluded for improvement of balance disorders with aquatic exercise interventions and showed improvement in berg-balance scale values.

From the studies concerning the mobility of patients (n=5), it is found that aquatic exercises had caused a significant change in the 6-minute walk test (6MWT), 5 times sit-to-stand test (5STS), and stair climbing test (SCT) which is contrary to the study of (Ma et al., 2022), which concluded that 6MWT does not provide a significant change of measurement after administration of aquatic exercises. This may be due to the difference of randomized controlled trials that this systematic review utilized, as it utilized studies concerning both knee and hip OA patients. Nevertheless, meta-analysis by (Jurado-Castro, Muñoz-López, Ledesma, & Ranchal-Sanchez, 2022) showed a significant improvement in 6MWT after intervention of therapeutic exercises. On the Time Up and Go test (TUG), the review shown significant improvement of mobility of Knee OA patients after aquatic exercises that also heighten the evidence of the previous systematic review (Ma et al., 2022) which favored the improvement of TUG test for mobility. Moreover, a meta-a nalysis by (Zampogna et al., 2020) also strengthens this evidence by providing significant improvement in dynamic balance by TUG test after aquatic exercise interventions. For gait assessment (n=1), the included trial had shown significant improvement after aquatic exercise programs in step length, stride length, and cadence of patients but not a significant change in step time and step width (Azizi et al., 2020). This study had recruited only male participants and there was no other eligible study found with the gait parameters as their outcome measure. The results of systematic review (Khan et al., 2022) that administered total resistance aquatic exercise in Knee OA patient and found improvement in walking speed supported our study outcome. Aquatic exercises had also been found to improve walking speed when compared with land-based exercises (Nascimento, Flores, de Menezes, & Teixeira-Salmela, 2020). For the assessment of postural sway (n=1), aquatic exercises are also associated with significant improvement in the measurements of Medio-lateral amplitude, Anterior-posterior amplitude, and Total sway area using a force platform and concluded to be the evidence of the effectiveness of aquatic exercises for the reduction of postural sway in knee OA patients. This study recruited only female participants and there was only one study included with postural sway as an outcome. There is no other systematic review conducted so far for this outcome measure.

There was a variety of aquatic physical therapy protocols and exercises that the included trials utilized and had included broad ranges of strengthening exercises, stretching exercises, aerobic exercises, isometric, proprioceptive training, flexibility exercises, etc. One of the studies compared deep water exercises from shallow water (Zamanian et al., 2012) and one trial compared lower extremity water-based exercises from the upper extremity and trunk exercises along with the lower extremity (Kunduracilar et al., 2018). Also, there were different temperatures of water utilized in the trails. There were a variety of other comparisons as well but as the objective of this study concerns which aimed to focus on the effectiveness of aquatic exercises in general and not specified for a particular exercise protocol and procedure.

The literature was very short of studies that have talked about the effect of aquatic exercises on the balance, posture, and improvement of gait of patients with knee OA. Most of the participants across all the studies, except for one (Azizi et al., 2020), were females which renders the requirement of more trials with the recruitment of equal male participants. The clinical implications of this systematic review are that it provided the conclusion in favour of aquatic exercises for improvement of mobility, and balance but as there were few studies related to the outcomes of interest, a provision of a strong evident conclusion is hindered. For secondary outcomes with more conduction of studies related to the improvement of gait and postural sway is recommended. However, based on this review, aquatic exercises with a proper protocol of warm-up, aquatic exercise session, and cool-down are effective in controlling posture and enhancing the balance and mobility of patients with knee osteoarthritis. There is a greater need for further research on the effectiveness of aquatic exercises for balance, postural control, postural sway, and gait outcomes for further provision of incontrovertible evidence to use in clinical settings for the betterment of patients suffering from knee osteoarthritis. There is also a need for more randomized controlled trials for providing evidence about the more effective protocols and procedures of aquatic exercises. This systematic review gives testimony for the conduction of evidence-based practice in clinical settings as well as provides recommendations for future research.

This systematic review demonstrates the significant improvement in primary outcome measures of balance, postural control, and mobility after the administration of aquatic therapy programs in patients with knee osteoarthritis. However, for secondary outcome measures of gait and postural sway the generality of improvement of results to both genders are controversial because of limited and gender-specific studies.

Limitations of the study: There are various limitations to this systematic review. Firstly, the eligible and selected trials, which were following the inclusion criteria for this review, were very short in numbers which impede the ability to depict the definitive conclusion. In addition, the sample size of most of the included trials was also small which hinder conclusive decisions. Secondly, a variety of aquatic exercise modes, duration, and frequencies are utilized in all the included trials and that variation in aquatic exercises may affect the efficiency and outcome of different studies. Thirdly, most of the trials had not blinded the participants and therapists because of the nature of the intervention that impedes it. The ratio of female participants was greater than male participants across the studies which also acts as a limitation of the study while generalization of conclusion for both genders.

CONCLUSION

Overall, based on the synthesis of results, the systematic review concluded in the favour of aquatic exercises and found that aquatic exercises are generally effective for the management and treatment of elderly patients suffering from knee osteoarthritis and should be used as an initial treatment option in rehabilitation systems. Hydrostatic pressure, buoyancy, temperature, and other properties of water help alleviate the pain of patients and make them able and comfortable to perform exercises in water that were otherwise difficult for them to conduct in land-based environments. Aquatic exercises with proper protocols of warm-up, specific exercise sessions, and cool-down are effective for the improvement of balance and mobility in patients when compared to any control. We are unable to provide a convincing conclusion for improvement of postural sway and gait in patients, after following aquatic exercise protocols, because of a short number of appropriate search results for trials and gender-specific studies of these outcome measures. The literature was limited for the studies in accordance with the predetermined inclusion criteria, and most of the selected studies had not provided long-term follow-up.

Based on this systematic review, aquatic exercises in a shallow water environment are more effective, the exercise program for 30 minutes to 1-hour sessions, 3 times a week, for 4 to 12 weeks is recommended for improvement of balance, postural control, sway, gait, and mobility. The recommended exercises are aerobic training, muscular stretching exercises, strengthening, proprioceptive exercises, flexibility training, and other posture-related pieces of training in a watery environment.

More research is required on the outcome measures of patients' posture, balance, mobility, and gait because of its limited number for knee OA patients. There should also be more research for further extension of evidence by maximizing the properties of the aquatic environment and for the determination of more effective aquatic exercise protocols. There is also a need for more good quality randomized controlled trials for the provision of more evidence for the betterment of patients.

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