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Review article

Effects of aquatic exercise on muscle strength and functional performance of individuals with osteoarthritis: a systematic review



Fernanda de Mattos^{a,*}, Neiva Leite^a, Arthur Pitta^b, Paulo Cesar Barauce Bento^a

^a Universidade Federal do Paraná (UFPR), Curitiba, PR, Brazil

^b Universidade Federal do Paraná (UFPR), Departamento de Educação Física, Programa de Pós-graduação em Educação Física, Curitiba, PR, Brazil

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ABSTRACT

Water-based exercises are recommended for people with osteoarthritis (OA), due to the beneficial effects on physical function, quality of life and symptom reduction. However, the effects on muscle strength are still controversial. The aim of this review was to assess and compare the effects of aquatic exercise programs on muscle strength and physical function in people with OA. A systematic search was performed at Pubmed, Scopus and Web of Science databases. Clinical trials with interventions involving aquatic exercises for individuals with OA were included. The methodological quality of the studies was evaluated using the PEDro scale. 296 studies were found and twelve were selected: six studies comparing water-based exercises with land-based exercise, and six comparing water-based exercise groups with the control group. Exercise programs included muscle strengthening, aerobic, balance, flexibility and stretching exercises. Duration of the program, weekly frequency, intensity and progression varied between studies. Beneficial effects of aquatic exercise were found on physical function. However, only two of five studies that assessed muscle strength observed positive effect of aquatic exercise. Although it is difficult to compare studies and establish guidelines for the standardized protocol formulation, it was observed that water-based exercises can be effective on improving physical function and increasing muscle strength, since they are well-structured, with exercise intensity and overload controlled.

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* Corresponding author.

E-mail: ferdymattos@hotmail.com (F. Mattos).

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Efeitos do exercício aquático na força muscular e no desempenho funcional de indivíduos com osteoartrite: uma revisão sistemática

R E S U M O

Palavras-chave:

Osteoartrite
Exercício aquático
Funcionalidade
Força muscular

Exercícios aquáticos são recomendados para pessoas com osteoartrite (OA), pois melhoram a funcionalidade, a qualidade de vida e reduzem os sintomas da doença. Entretanto, os efeitos na força muscular ainda são controversos. O objetivo desta revisão foi avaliar e comparar o efeito de programas de exercícios aquáticos na força muscular e na funcionalidade de pessoas com OA. Foi realizada uma busca bibliográfica nas bases de dados Pubmed, Scopus e Web of Science. Foram incluídos ensaios clínicos realizados com intervenções envolvendo exercícios aquáticos para indivíduos com OA. A qualidade metodológica dos estudos foi avaliada por meio da escala PEDro. Foram encontrados 296 estudos no total. Destes, doze foram selecionados, sendo seis estudos que compararam exercícios aquáticos com exercícios realizados em solo, e seis que compararam um grupo de exercícios aquáticos com grupo controle. Os programas contemplaram exercícios de fortalecimento muscular, aeróbios, de equilíbrio, de flexibilidade e alongamento. A duração do programa, a frequência semanal, a intensidade e a progressão variaram entre os estudos. Foram encontrados efeitos benéficos do exercício aquático na funcionalidade, porém, dos cinco estudos que avaliaram a força muscular, apenas dois verificaram efeito positivo dos exercícios aquáticos. Embora haja dificuldades para comparar os estudos e estabelecer diretrizes para a formulação de protocolos padronizados, observou-se que exercícios aquáticos podem ser eficientes na melhora da funcionalidade e no aumento da força muscular, desde que os programas sejam bem estruturados com intensidade e sobrecarga controlada e progressiva.

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Introduction

Osteoarthritis (OA) is a chronic degenerative disease of multifactorial origin, beginning usually between 50 and 60 years of age,¹ primarily affecting knee and hip joints.^{2,3} Pain is the main symptom of the disease and, when associated with joint stiffness, instability and weakness, can cause functional limitations and difficulties in performing activities of daily living.⁴

The treatment of OA includes drug therapy, manual therapy, and exercise.^{5,6} Exercise is a highly recommended conservative treatment, with easy application and low cost, and with little chance of adverse reactions.⁴ The types of exercises most recommended for people with OA are those causing a low-impact on the joints, for muscle strengthening, aerobics, or some combination thereof, carried out in water or on the floor.⁷

The strengthening of the muscles around the affected joint is a key part in the treatment of OA, because this contributes to the quality of cartilage, increases the neural activation and improves intra- and intermuscular coordination.⁸ In addition, muscles act as a load-absorbing mechanism during the gait. Therefore, stronger muscles can better absorb and distribute the impact on the hip and knee, which increases the stability⁸⁻¹⁰ and contributes to the improvement of the functionality and mobility.¹¹

When compared to land-based exercises, water exercises can offer some advantages to overweight patients, with mobility difficulties, since the body weight relief provided by the fluctuation reduces the impact on joints and the perception of pain intensity.^{12,13} The heated water and the hydrostatic

pressure promote muscle relaxation and stress relief, and also decrease muscle spasms,¹³⁻¹⁶ which facilitate the execution of movements. In addition, studies in healthy adults and older subjects have shown that water exercises are effective to increase muscle strength.^{13,17}

Previously conducted systematic reviews on the effects of aquatic exercise in people with osteoarthritis found benefits for pain, function and quality of life.^{12,13,15,18} However, there are no reviews to identify the effect of these interventions on the performance of function and muscle strength tests. Thus, the aim of this review was to evaluate and compare the effect of aquatic exercise programs on muscle strength and on the functionality of people with OA.

Methods

To develop this study, a literature search was performed in the following electronic databases: Pubmed, Scopus, and Web of Science. The selection of descriptors was based on terms indexed in Descriptors in Health Sciences (DeCS) and included the following keywords in English: osteoarthritis, aquatic, aqua, deep-water, water-based, exercise, motor activity, physical activity, and training. The keywords were combined using the Boolean operators "AND" and "OR", and were adapted for each database, as required.

There was no restriction on the publication year, considering the low number of studies found in this area. Two researchers surveyed all databases and, at the end of the application of inclusion and exclusion criteria, confronted the articles found. In the case of disagreement with the selected

Table 1 – Methodological quality of the studies analyzed.

Reference	1	2	3	4	5	6	7	8	9	10	11	Total
Wyatt et al. (2001)	1	1	0	0	0	0	1	1	1	1	1	7
Wang et al. (2007)	1	1	0	1	0	0	0	1	1	1	1	7
Hinman et al. (2007)	1	1	1	1	0	0	1	1	1	1	1	9
Silva et al. (2008)	1	1	1	1	0	0	1	1	1	1	1	9
Lund et al. (2008)	1	1	1	1	0	0	1	1	1	1	1	9
Lim et al. (2010)	1	1	1	1	0	0	1	1	1	1	1	9
Arnold and Faulkner (2010)	1	1	1	1	0	0	1	1	1	1	1	9
Wang et al. (2011)	1	1	0	1	0	0	1	1	1	1	1	8
Hale et al. (2012)	1	1	1	1	0	0	1	1	1	1	1	9
Wallis et al. (2014)	1	0	0	1	0	0	1	1	1	1	1	7
Bressel et al. (2014)	1	0	0	1	0	0	0	1	1	1	1	6
Fisken et al. (2015)	1	1	1	1	0	0	0	0	1	1	1	7

1, Eligibility criteria specified; 2, randomization or random assignment; 3, secret allocation; 4, similar groups at the beginning; 5, subjects blinded to participation; 6, treatment carried out by blinded researchers; 7, blinded evaluators; 8, evaluations carried out in at least 85% of the sample; 9, all evaluated subjects were submitted to the intervention; 10, results of the comparisons between groups were described; 11 the study shows precision and variability measurements for the results.

studies, the researchers conducted a pooled analysis of studies with the aim of reaching consensus.

The following inclusion criteria were adopted: articles published in English, Portuguese or Spanish; only original articles; controlled clinical trials or experimental studies with an experimental group versus control group or period; presenting an intervention with supervised aquatic exercises for people with osteoarthritis; describing intervention details, such as duration, frequency, type and intensity of exercise; with an evaluation and presentation, as primary or secondary outcomes, of muscle strength and/or functionality through physical performance tests.

Conference abstracts, monographs, dissertations and theses, case studies, non-controlled trials, systematic reviews, animal studies and also studies with mixed groups of subjects (osteoarthritis and other conditions influencing strength and/or functionality); interventional studies lasting less than six weeks, and those with a weekly frequency of the exercise program under two sessions/week, based on reviews of recommendations for the treatment of OA, were excluded from this review.^{4,19}

The selected studies were also analyzed for methodological quality, according to the evaluation protocol adapted for this study, based on the PEDro scale.²⁰ This evaluation included eleven criteria which, together, generated a score of 11 (Table 1). Criteria 5 and 6, which deal with the blinding of participants and therapists regarding the treatment applied, were not scored, due to the characteristics of the selected studies. In experimental studies including interventions with programs of physical activity, one cannot omit from participants and therapists the treatment carried out. Therefore, the maximum score achieved is 9 points. The higher the score on the scale, the better the quality of the study.

The analysis of the quality of the studies was performed independently by two researchers, and disagreements were discussed in consensus meetings. Methodological quality was assessed with the aim of identifying the internal validity (criteria 2-9) and the quality of statistical information for the interpretation of results (criteria 10-11).²⁰ After this step, the outcomes assessed and the results of the studies were analyzed and grouped into topics, for comparison and discussion.

Results

In the electronic search conducted, 296 studies in all three databases were found. After the exclusion of repeated titles, 170 articles remained for analysis. After the application of inclusion and exclusion criteria, 83 titles were excluded. In the abstract analysis stage, 48 articles and 8 systematic reviews were excluded, since these studies did not meet the objectives of this review. Of the 31 remaining articles for a full reading, 12 were included in this review: eight randomized controlled trials and four experimental studies (Fig. 1).

Methodological quality

The scoring of the selected studies in the evaluation of their methodological quality is described in Table 1. The mean score of the studies was 8 (6-9) points. The maximum score (9 points) was ascribed to six of the 12 studies assessed.^{14,21-25} Four criteria were covered by all studies selected: "eligibility criteria"; "all evaluated subjects received intervention"; "results of the comparisons between groups"; and "precision and variability measurements." In nine of the 12 studies, the evaluators were unaware of the group in which participants were allocated (single-blinded).^{14,21-28} Only those studies which used a single group with a double pre-test (with a four-week control period) had not a random allocation of participants.^{28,29}

Characteristics of studies

The characteristics of the studies (participants, measuring instruments, interventions, and main results) are summarized in Table 2. However, these features are presented and grouped in the following text.

Location and characteristics of the participants

The selected studies were performed in the United States,^{26,29,30} Australia,^{14,28} Brazil,²⁵ Denmark,²⁴ Korea,²³ Canada,²¹ Taiwan,²⁷ and New Zealand.^{22,31} The study participants were recruited from Orthopedic Clinics in local hospitals,^{14,23,25,28,31} medical offices and physiotherapy

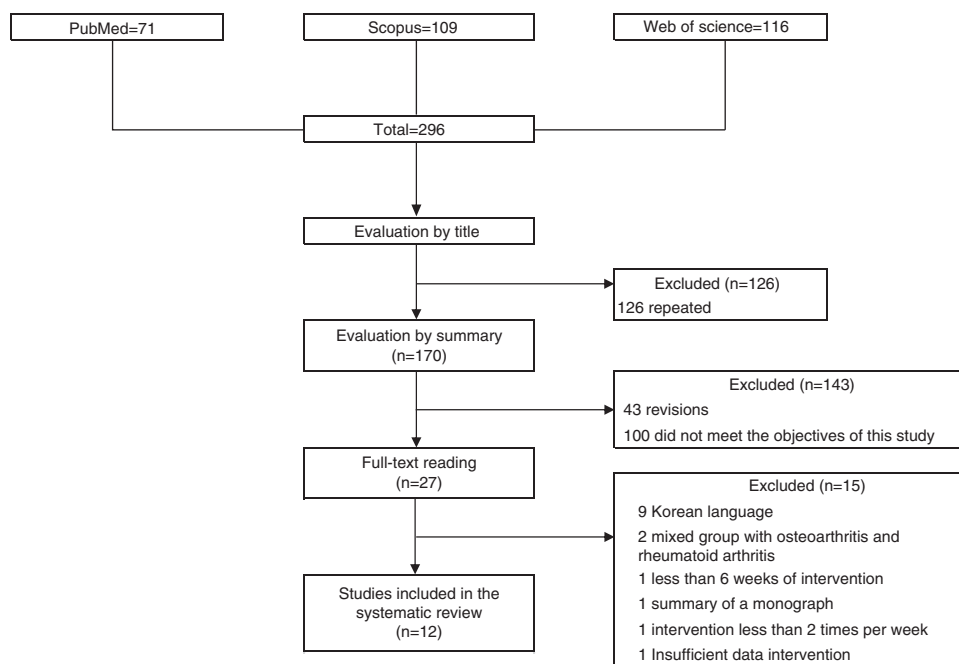


Fig. 1 – Schematic representation of the selection of the studies included in this review.

clinics,^{14,21,22,24,27,29} through dissemination in the local community and in community centers.^{14,21,22,24,27,29-31} All participants had a diagnosis of knee and/or hip OA,^{14,22,28-31} only hip OA,²¹ and only knee OA,²³⁻²⁷ were aged between 60 and 75 years, and most were female (72% of total participants).

Characteristics of interventions

The protocols of exercise programs differ among studies, but one can identify the main components of each program. Six studies conducted interventions with a group that participated in aquatic exercise and another group that performed land-based exercise,^{21,23-27} and six other studies only conducted interventions with aquatic exercise.^{14,22,28-31}

The programs' duration ranged from six^{14,26,28,29} to 18 weeks.²⁵ Two studies conducted 8-week interventions,^{23,24} Arnold and Faulkner²¹ did 11 weeks of exercise, and other 4 studies used 12 weeks in their protocol.^{22,27,30,31} The weekly frequency of exercise programs varied from two^{14,21,22,24,28,31} to three^{23,25-27,29,30} weekly sessions.

Aquatic exercise protocols were composed primarily of muscle strengthening exercises for upper and lower limbs and trunk,^{14,21,28,30,31} aerobic walking exercises and shifts in water,^{14,22,28-30} and High-Intensity Training (HIT) in an aquatic treadmill,²⁹ balance disturbance exercises,²⁹ one-foot shifts and movements,^{21,22} flexibility,^{27,30} and stretching.^{24,25}

Studies comparing programs of water versus land-based exercises sought to follow similar protocols in both media, with strengthening exercises of upper and lower limb muscles, stretching,²³⁻²⁷ aerobic walking exercises²⁴⁻²⁷ and water bike and on the floor,²³ as detailed in Table 2.

Five of the 12 studies used a control group without intervention for comparison with the groups that performed the exercise.^{14,21,24,27,30} In studies where the control group received some kind of intervention, exercises were performed

at home,²³ hydrotherapy exercises were performed in immersion in a sitting position in the water,³¹ and computer-assisted activities.²²

The applied intensity also varied among protocols. Only one study used heart rate as a reference, from a basal value of 65% HR for aquatic exercise and 40-60% of one-repetition maximum (1RM) for land-based exercise.²³ In other studies, the intensity was controlled on the basis of perceived exertion scales (0-10, Borg CR10 or 6-20),^{27,29,30} cadence of music,^{24,31} and the number of sets and repetitions.^{14,25} Only two studies did not control or describe the intensity,^{21,26} and some studies did not offer in-depth information on the progression of intensity.^{22,28}

Outcomes

To be included in this review, the studies should indicate the functionality and/or muscle strength as a primary or secondary outcome, assessed by physical performance tests. Only two studies pointed out functionality as a primary endpoint.^{21,31} Of the five studies that evaluated muscle strength, three presented this variable as the primary outcome,^{23,24,30} and two as a secondary outcome.^{14,31} Pain was assessed in all studies; however, it was considered as the primary outcome in three of them.^{4,24,25}

Of the 12 studies included, only the work by Lim et al. (2010) evaluated the functionality without performing physical performance tests. In this study, the authors used only questionnaires. The physical tests most used in other studies to evaluate the functionality were walking tests that measure the distance covered in a given time in a usual speed,^{14,21,27,28,30} tests that measure the time to cover a certain distance at different speeds,^{25,26,29,31} and the Timed Up and Go Test (TUG), which was used in 4 of the 12 studies.^{14,21,22,31}

Table 2 – Summary of the characteristics of the articles included in the review.

Authors, year/country, type of study	Sample (N), mean age (years), number of women, site of OA	Groups	Assessments outcomes	Intervention	Results
Wyatt et al., 2001/USA Experimental study	N = 42	AG = *	Initial (s0) and final (s6) assessment	AG: 3 × wk/6 wk	Increase in ROM and thigh thickness, and reduction of pain and in 1-mile travel time in both groups A difference between groups only in pain; AG with greater reduction in pain
	45–70 years OA knee	GG = *	ROM (goniometer), thigh thickness, pain (VAS) and speed (1-mile walk time)	Manual resistance + strengthening exercises LLMs + 244-meter walk GG: 3x wk/6 wk Manual resistance exercises + LLMs + 244-meter walk	
Wang et al. 2007/USA	N = 42	AG = 20	Initial (s0), medium (s6), and final (s12) assessment	AG: 3 × wk/50 min/12 wk	Increased hip and knee flexibility, muscle strength and distance covered in 6 min walk
Randomized clinical trial	66 years	CG = 18	ROM flexibility of knee and hip (goniometer), maximal isometric strength of hip and knee extension and flexion, and hip abduction and adduction (hand dynamometer), gait (6-min walk test), functionality and ADLs (MDHAQ) and pain (VAS)	Flexibility + aerobic + strengthening exercises for LLMs, ULMs and trunk (AFAP Protocol) Progressive intensity (scale 0–10): s0-s4 (2–3), s5-s8 (3–4), and s9-s12 (4) CG: activities of daily living	No difference in self-reported function and in pain between groups
	32 women				
OA knee and hip					
Hinman et al. 2007/Australia Randomized clinical trial	N = 71	AG = 36	Initial (s0), final (s6), and follow-up (s12) assessment	AG: 2 × /45–60 min/6 wk	Hip muscle strength and QOL improved in AG after 6 weeks. AG had a 33% reduction in pain and 72% of the group reported improvement throughout the intervention

Table 2 – (Continued)					
Authors, year/country, type of study	Sample (N), mean age (years), number of women, site of OA	Groups	Assessments outcomes	Intervention	Results
Silva et al., 2008/Brazil Randomized clinical trial	62 years	CG = 35	Pain (VAS), change in pain and functionality (5-point scale), osteoarthritis (WOMAC), QOL (15-item scale), physical activity level (PASE), isometric strength of hip abduction and knee extension (hand dynamometer), the Step test, TUG and 6-min walk test	Strengthening exercises for LLMs: 2 × 10 reps + 6–10 min walk on water Water depth decreased throughout the intervention CG: activities of daily living	At follow-up (s12) the benefits were maintained
	48 women				
	OA knee and hip				
	N = 64	AG = 31	Initial (s0), medium (s9), and final (s18) assessment	AG: 3 × wk/50 min/18 wk	The 15-m test in a comfortable speed ↓ in both groups, but at high-speed GG improved between s1 and s9, and AG between s9 and s18A
	59 years	GG = 26	Pain (VAS), osteoarthritis (Lequesne and WOMAC), speed (two-speed 15-meter walk test) and pain during the walk test (VAS) and NSAIDs	Stretching: 2 × 20 s + Strengthening exercise for LLMs: 7–10 reps of 6 s (isometric contractions) and 20–40 reps Increased resistance to the use of elastic or of a 1-kg weight GG: 3 × wk/50 min/18 wk Stretching 2 × 20 s + strengthening exercise for lower limbs: 7–10 6-s reps (isometric contractions) and 20–40 reps Floater to ↑ speed (isotonic exercises)	Pain ↓ in both groups. LEQUESNE and WOMAC ↓ in both groups until S9; from S9 to S18 a decrease occurred only in AG
	59 women OA knee				

Table 2 – (Continued)

Authors, year/country, type of study	Sample (N), mean age (years), number of women, site of OA	Groups	Assessments outcomes	Intervention	Results
Lund et al., 2008/Denmark Randomized clinical trial	N = 79	AG = 27	Initial (s0), final (s8), and follow-up (s20) assessment	AG and GG: 2× wk/50 min/8 wk	Muscle strength ↑ in GG and ↓ in AG versus CG both at the end of the intervention and at follow-up. The aquatic exercise showed a better effect on balance versus ground exercise. Pain ↓ in GG versus CG in follow-up
	68 years	GG = 25	Pain (VAS), osteoarthritis (KOOS), body sway (static equilibrium – Balance Master Pro) and isokinetic strength at 30, 60 and 90°/s (isokinetic dynamometer – Biodex)	Resisted exercises + balance and stability + stretching of LLMs Intensity control: music CG: activities of daily living	
	62 women OA knee	CG = 27			
Lim et al., 2010/Korea Randomized clinical trial	N = 75	AG = 26	Initial (s0) and final (s8) assessment	AG: 3× wk/40 min/8 wk	AG showed improved functionality, pain and quality of life. Both groups improved the functionality of lower limbs. There was no change in knee flexor and extensor strength in both groups. The physical component scale improved slightly in both groups
	65 years	GG = 25	Pain (BPI), osteoarthritis (WOMAC), QOL (SF-36 version 2.0), isokinetic strength of knee extensors and flexors at 60°/s (isokinetic dynamometer – Biodex)	Heating + Walk + strength + resistance + force – aerobic exercises Intensity >65% of CF GG: 3× wk/40 min/8 wk Joint mobilization + strengthening Intensity of 40–60% of 1RM CG: home exercises: isometrics (quadriceps) and partial squats	
	65 women OA knee	CG = 24			
Arnold and Faulkner, 2010/Canada Randomized clinical trial	N = 83	AG = 28	Initial (s0) and final (s11) assessment	AG: 2× wk/45 min/11 wk	In physical performance, AEG has improved versus CG and AG. Similar trends were found for TUG and for the 6-min walk test. An improvement was found in efficacy of falls in AEG versus CG
	75 years	AEG = 26	Balance (Berg Balance Scale), gait (6-min walk test), falls (ABC), functionality (STS and TUG), osteoarthritis (AIMS-2), and physical activity level (PASE)	Heating + strengthening exercises of LLMs and ULMs + trunk control + balance and practical posture	

Table 2 – (Continued)					
Authors, year/country, type of study	Sample (N), mean age (years), number of women, site of OA	Groups	Assessments outcomes	Intervention	Results
Wang et al., 2011/Taiwan Randomized clinical trial	56 women OA hip	CG = 27	Initial (s0), medium (s6), and final (s12) assessment Osteoarthritis (KOOS), ROM (goniometer) and gait (6-min walk test)	AEG: 2× wk/45 min/11 wk Same program of AG + 30-min educational session before water training (functional tasks) CG: activities of daily living	Significant improvement in KOOS, ROM, 6-min walk test and pain in AG and GG versus control group; no significant change was found between AG and GG
	N = 78	AG = 26		AG: 3× wk/60 min/12 wk	
	67 years	GG = 26		Flexibility + aerobic exercises (AFAP protocol) Intensity 3–4 (Borg CR10 Scale) GG: 3× wk/60 min/12 wk Flexibility + aerobic exercises (PACE Protocol) Intensity 3–4 (Borg CR10 Scale) CG: activities of daily living	
Hale et al., 2012/New Zealand Randomized clinical trial	67 women OA knee	CG = 26	Initial (s0) and final (s12) assessment Falls (PPA and ABC), dynamic balance (Step Test), functionality (TUG), and osteoarthritis (WOMAC andAIMS-2)	AG: 2× wk/20–60 min/12 wk Heating + balance exercises ↑ difficulty Water depth ↓ throughout the intervention CG: 2× wk/60 min/12 wk SeniorNet (computer skills' training offered by the elderly for the elderly)	In both groups there was a significant improvement in Step test and also improvement in two items of PPA (reaction time and contrast sensitivity) in CG. There was no significant improvement in TUG
	N = 39	AG = 23		AG: 2× wk/20–60 min/12 wk	
	74 years	CG = 16		Heating + balance exercises ↑ difficulty	
	29 women OA knee and hip				

Table 2 – (Continued)

Authors, year/country, type of study	Sample (N), mean age (years), number of women, site of OA	Groups	Assessments outcomes	Intervention	Results
Wallis et al., 2014/Australia Experimental study	N = 20 71 years 9 women OA knee and hip	AG = 20	Pre (s-0), initial (s0), and final (s6) assessment Self-efficacy (Arthritis Self-efficacy Scale), osteoarthritis (WOMAC), gait (10-min walk test), functionality (STS), and QOL (EQ-5D and EQ-VAS)	AG: 2× wk/105 min/6 wk Educational sessions (60 min) + water exercises (45 min): Functional, aerobic, ROM, strengthening exercises of LLMs and exercises at home (counseling) Moderate intensity and individual progression	An increase of 12% was found for the fast walk test. There was no significant improvement in STS
Bressel et al., 2014/USA Single group posttest, double pretest design	N = 18 64 years 16 women OA knee and hip	AG = 18	Pre- (s4), initial (s0), and final (s6) assessment Osteoarthritis (KOSS), pain (VAS), balance and motor function (SMART EquiTest system), and functionality (STS, FLT and 10-min walk test)	SG: 2-3x wk/18–30 min/6 wk Balance exercises + HIT components (aquatic mat)/water jets to balance disorder Intensity of 14–19 over RPE	There was significant improvement in functionality, mobility and balance, and reduction in knee pain
Fisken et al., 2015/New Zealand Experimental study	N = 35 70 years 23 women OA knee, hip, spine and hands	AG = 19 CG = 16	Initial (s0) and final (s12) assessment Functionality (TUG and STS), dynamic balance (15-sec Step Test), muscle strength (hand dynamometer), grip strength (Jamar dynamometer), gait (400-m walk test), osteoarthritis (AIMS2-SF), falls (FES-I), physical activity level (RAPA)	AG: 2× wk/45–60 min/12 wk Strength + aerobic exercise Intensity control: music CG: 1× wk/35–40 min/12 wk HT-type exercise + hydrotherapy exercises (AFAP) wk progression	In both groups, ↓ in time in the 400-m walk test. AG improved on Step test and AIMS-2. AG improved in FES-I versus CG. There was no significant change in TUG, STS and grip strength in both groups

OA, osteoarthritis; CG, control group; AG, Aquatic Exercise Group; AEG, Aquatic Exercise + Education Group; GG, Ground Exercise Group; SG, Single Group; ROM, range of motion; VAS, Visual Analogic Scale; ADL, Activities of Daily Living; QOL, quality of life; MDHAQ, Multidimensional Health Assessment questionnaire; AFAP, Arthritis Foundation Aquatics Program; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; PASE, Physical Activity Scale for the Elderly; TUG, Timed “Up & Go” test; NSAIDs, Nonsteroidal Anti-inflammatory Drugs; KOOS, Knee Injury and Osteoarthritis Outcome Score; BPI, Brief Pain Inventory; SF-36, Short Form 36-item Health Survey; ABC, Activities and Balance Confidence; STS, Sit-to-stand; AIMS-2, Arthritis Impact Scale measurement; PPA, Physiological Profile Assessment; EQ-5D, EuroQo-5D; EQ-VAS, EuroQol-VAS; FLT, Forward Lunge Test; FES-I, Falls Efficacy Scale-International; RAPA, Rapid Assessment of Physical Activity; RPE, Rating of Perceived Exertion; LLMs, Lower limb muscles; ULMs, Upper Limb Muscles; †, increase; ↓, reduction or decrease. * Not informed.

The evaluation of muscle strength of lower limbs was performed by indirect tests (Chair Stand Test) in four studies.^{21,28,29,31} Only two studies conducted muscle strength tests using an isokinetic dynamometer.^{23,24} Three other studies assessed muscle strength through isometric testing of lower limbs with a dynamometer^{14,30} and handgrip strength test.³¹

Pain is the only outcome present in all studies and was assessed by a visual analog scale (VAS) of pain perception,^{14,24-26,29,30} or through questionnaires.^{21-23,27,28,31} Although not an inclusion criterion in this study, the outcome "pain" was added to the results, considering that this factor was present in all analyzed studies. Additionally, pain is one of the most common symptoms of OA and is associated with functional limitations caused by the disease^{32,33} and by the impact of OA on the patients' quality of life.^{34,35}

Effects of interventions

Water × land-based exercises

All studies comparing aquatic exercise programs and land-based exercise found some beneficial effect on the functionality, for example, an increase in the distance covered²⁷ and a decrease in the time to perform walking tests.²⁵ However, the aquatic exercise proved to be more efficient *versus* land-based exercise to improve balance in the study by Lund et al. (2008).

The results of muscle strength are controversial.^{14,30} Only two of the five studies that evaluated muscle strength found improvement after the practice of aquatic exercise. None of the studies comparing muscle strength between the groups who underwent aquatic *versus* land-based exercise^{14,23,24,30,31} found some effect of aquatic exercise in increasing strength. Lim et al. (2010) could not observe changes in muscle strength in none of their groups. However, Lund et al. (2008) found improvement in muscle strength only in the group that performed floor exercise, while the group that underwent aquatic exercise showed a decreased strength in the isokinetic test.

In all articles comparing the two interventions, significant reductions were observed in pain, regardless of the environment where the exercise was held,^{24,25} but only Wyatt et al. (2001), Silva et al. (2008) and Lim et al. (2010) reported a greater effect in the group that performed aquatic exercises.

Water exercises × control

The studies that compared a group of aquatic exercises and a control group found benefits of aquatic exercise, in terms of functionality, with physical performance tests. However, Hale et al. (2012) found no difference between the group that received the intervention with aquatic exercise and the control group, as both showed improved functionality. Of the studies that performed the 30-Second Chair Stand Test,^{21,28,31,36} only Arnold and Faulkner (2010) found a significant improvement after the intervention. The group that performed aquatic exercises and participated in educational sessions for the prevention of falls increased by 12% the number of repetitions *versus* the other two groups.

Significant effects of aquatic exercise were found in muscle strength compared to the group without intervention in two

studies, which reported an increase of 5–10% of the isometric strength of the hip abductor muscles,¹⁴ 45% in the knee extensors, 11.5% in the hip extensors, and 14.3% in the hip abductors.³⁰ On the other hand, Fiskens et al. (2015) found no effect of aquatic exercise in the evaluation through manometry. Pain levels also showed controversial results. Three studies reported reduced pain after the intervention.^{14,29,31} However, in the study by Fiskens et al. (2015) both groups had a reduction in pain, but with no difference between them. On the other hand, Wang et al. (2007) and Wallis et al. (2014) found no significant effects of aquatic exercise in reducing pain.

Discussion

The objective of this review was to evaluate and compare the effect of aquatic exercise programs on muscle strength and function of people with hip or knee osteoarthritis. Interventions with exercises that can slow or stop the progression of the disease are important to the health system, considering that they can reduce the cost of treatments, surgeries, and hospitalizations; moreover, these interventions can improve the quality of life of participants.¹²

The aquatic exercise, a procedure highly recommended in the treatment of OA, may have advantages compared to land-based exercise, because, due to the physical properties of water, the execution of the movements can become easier, decreasing also the sensation of pain.^{12,13} Strengthening the muscles surrounding the affected joint is an important part of the treatment of OA.⁸⁻¹⁰ Therefore, the resistance of the water is used as an overloading factor for muscle strengthening exercises. The use of resistive materials promotes an increased area of contact with water, and will also increase the exercise overload.^{17,37} However, there is no consensus yet on the effects of aquatic exercise on muscle strength.

In this review, only two of the five studies that evaluated muscle strength showed significant effects.^{14,30} Wang et al. (2007) conducted a 12-week program with three weekly sessions with a standardized protocol of muscle strengthening, aerobic and flexibility exercises (AFAP protocol)³⁸ with controlled and progressive intensity, and achieved significant improvement in isometric muscle strength of knee extensors and flexors and hip abductors, adductors, extensors and flexors. Similar results were found by Hinman et al. (2007), who prescribed two weekly sessions of aquatic exercise for six weeks, with the progression of the volume and degree of difficulty of the exercises; these authors reported significant improvement in isometric muscle strength of the hip, as assessed with hand dynamometry. The progression of the intensity and the specificity of exercise are crucial factors. Both studies performed specific exercises of muscle strengthening, whose strength and volume increased over the program, which may have resulted in neuromuscular adaptations throughout the exercise program.

On the other hand, studies by Lund et al. (2008), Lim et al. (2010) and Fiskens et al. (2015) found no improvement in muscle strength. While one study reported a significant reduction in muscle strength of knee extensors and flexors in an isokinetic evaluation at 60°/s in the group that underwent aquatic exercise,²⁴ other studies found no differences among groups

(water exercise, land-based exercise, and control) in the isokinetic evaluation²³ or in handgrip strength in the group that performed aquatic exercises.³¹ These results may be associated with the choice of exercises, the progression of the program, exercise intensity, and tests used. Perhaps the handgrip strength test does not properly identify strength gains in lower limbs.^{39,40}

Interventions of these studies have examined aquatic exercises without using resistive materials to increase overload; this was done with the progression of the volume of exercise, increases in the number of repetitions,²⁴ or in the degree of difficulty of movements²³ and also in the speed and magnitude of implementation of exercises³¹ throughout the program. Lund et al. (2008) suggested that there was no improvement in muscle strength due to the small resistance imposed in the exercises. The use of materials that increase the contact area with the water and the practice of high-speed movements promote an increased exercise overload and consequent increase in force production.^{17,37,41}

Additionally, Lund et al. (2008) and Fiskén et al. (2015) used the rhythm of the music to determine exercise intensity. Perhaps this is not an effective strategy because it does not respect the individuality of the participants. By using the same rate for all participants, the absolute effort is the same, but the relative effort may differ depending on the participant's physical fitness. In the study of Fiskén et al. (2015), the increase in the speed of execution of exercises, according to the rhythm of the music, was not enough to promote improvement in muscle strength. The music cadence progressed every two weeks, ranging from 92 to 162 bpm in the first four weeks, and from 92 to 220 bpm for the remaining period.

Studies comparing aquatic exercise programs versus land-based exercises²³⁻²⁷ found similar effects in both groups in terms of functionality and in reducing the pain; however, land-based exercise programs were more effective in increasing muscle strength.²⁴ Similar results were observed in previous experimental studies^{4,42} and in systematic reviews.^{43,44} The land-based exercise can be more effective versus water exercise, as the control and increase in overload can be performed more objectively.

However, when properly known, the hydrodynamic properties of water can be used to increase efficiently the exercise overload.⁴⁵ Bento et al. (2014) reported an increase in muscle strength in healthy older subjects when comparing a protocol of aquatic versus land-based exercises. The strategy used was the gradual increase in the intensity of exercise at every four weeks, increasing the projected area of the lower limbs and the speed of execution of movements, which increases the resistance offered by the water.

The results found by Wyatt et al. (2001), Silva et al. (2007), Wang et al. (2007; 2011), Wallis et al. (2014), Bressel et al. (2014) and Fiskén et al. (2015) for functionality and mobility indicate that aquatic exercise programs lasting six weeks or more and with two to three weekly sessions of 45-60 min can be effective in improving mobility and gait speed. The similarity between the movements performed in aquatic exercise and daily tasks evaluated in functional tests can facilitate the transfer of the gains from the exercise.^{46,47}

Hinman et al. (2007) and Hale et al. (2012) found no improvement in mobility tests, due to some characteristics of the

interventions. In the study by Hinman et al. (2007), the sample was more physically active and had a lower functional impairment, as the participants were aged under 65 and with only a slight degree of involvement of OA, which may have influenced the results.¹⁴ Physical exercise promotes more significant benefits in older people with greater functional impairment.^{47,48} Even using balance-specific exercises, Hale et al. (2012) found no difference between experimental and control groups in terms of balance, due to the intervention performed in the control group. According to these authors, the increase in daily physical activity and in social interaction resulting from the intervention with computer games promoted benefits similar to those in the experimental group.

Some limitations of this review were observed. The specific goal of this study restricted the number of articles that met the inclusion and review quality criteria. However, the studies found represent the literature on the subject. It was not possible to pool the data to perform a meta-analysis, due to the methodological diversity of the studies and the lack of detail in the description of interventions, which also made it difficult to identify a standardized protocol for exercise programs.

Conclusion

This review study suggests that well-designed and controlled interventions with aquatic exercise lasting at least six weeks, contemplating muscle strengthening exercises and aerobic exercises, can be effective in increasing muscle strength of lower limbs and in improving the functionality of patients with OA.

Although there is difficulty in comparing different exercise programs due to methodological differences, it seems important an individualized control of intensity and overload, as well as of their progression. However, there is no way to establish safe guidelines to formulate protocols. Therefore, it is suggested greater standardization/control and also a greater level of detail of the programs in future experimental studies.

Conflicts of interest

The authors declare no conflicts of interest.

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