Table 4 Evaluation of the quality of nonrandomized controlled trials by using the CLEAR-NPT checklist

Item	Practice; N (%)		
	Yes	No	Unclear
1. Was the generation of allocation sequences adequate?[a]	–	–	–
2. Was the treatment allocation concealed?[a]	–	–	–
3. Were details of the intervention administered to each group made available?[b]	17 (81.0%)	3 (14.3%)	1 (4.7%)
4. Were care providers' experience or skill[c] in each arm appropriate?[d]	7 (33.3%)	4 (19.1%)	10 (47.6%)
5. Was participant (ie, patients) adherence assessed quantitatively?[e]	6 (28.6%)	13 (61.9%)	2 (9.5%)
6. Were participants adequately blinded?	1 (4.8%)	19 (90.6%)	1 (4.8%)
6.1. If participants were not adequately blinded			
6.1.1. Were all other treatments and care (ie, cointerventions) the same in each randomized group?	5 (25.0%)	12 (60.0%)	3 (15.0%)
6.1.2. Were withdrawals and lost to follow-up the same in each randomized group?		14 (70.0%)	6 (30.0%)
7. Were care providers or persons caring for the participants adequately blinded?	2 (9.5%)	18 (85.8%)	1 (4.8%)
7.1. If care providers were not adequately blinded			
7.1.1. Were all other treatments and care (ie, cointerventions) the same in each randomized group?	4 (19.1%)	10 (52.6%)	5 (26.3%)
7.1.2. Were withdrawals and lost to follow-up the same in each randomized group?	0	11 (57.9%)	8 (42.1%)
8. Were outcome assessors adequately blinded to assess the primary outcomes?	2 (9.5%)	19 (90.5%)	0 (0.0%)
8.1. If outcome assessors were not adequately blinded, were specific methods used to avoid ascertainment bias (systematic differences in outcome assessment)?[f]	0	19 (100%)	0 (0%)
9. Was the follow-up schedule the same in each group?[g]	8 (38.1%)	7 (33.3%)	6 (28.6%)
10. Were the main outcomes analyzed according to the intention-to-treat principle?	3 (14.3%)	18 (85.7%)	0 (0.0%)

Notes: [a]First and second items were not described in order to RCT design; [b]The answer should be "yes" for this item if these data were either described in the report or made available for each arm (reference to a preliminary report, online addendum etc); [c]Care provider experience or skill will be assessed only for therapist-dependent interventions (ie, interventions where the success of the treatment are directly linked to care provider's technical skill). For other treatments, this item is not relevant and should be removed from the checklist or answered "unclear"; [d]Appropriate experience or skill should be determined according to published data, preliminary studies, guidelines, run-in period, or a group of experts and should be specified in the protocol for each study arm before the beginning of the survey; [e]Treatment adherence will be assessed only for treatments necessitating interventions (eg, physiotherapy that supposes several sessions, in contrast to a one-shot treatment such as surgery). For one-shot treatments, this item is not relevant and should be removed from the checklist or answered "unclear"; [f]The answer should be "yes" for this item, if the main outcome is objective or haed, or if outcomes were assessed by a blinded or at least an independent endpoint review committee, or if outcomes were assessed by an independent outcome assessor trained to perform the measurements in a standardized manner, or if the outcome assessor was blinded to the study purpose and hypothesis; [g]This item is not relevant for trials in which follow-up is part of the question. For example, this item is not relevant for a trial assessing frequent vs less frequent follow-up for cancer recurrence. In these situations, this item should be removed from the checklist or answered "unclear".
Abbreviation: RCT, randomized controlled trial.

conduct and reporting of the target articles. Our summaries detected omissions of description and nonfulfillments, including detailed information on participants, sample size, assessors, care (health care) providers, blinding, and analysis methods. Furthermore, the description of adverse events and withdrawals were generally insufficient. In the *Cochrane Review*,[1] there are strict eligibility criteria for a meta-analysis, and for each article, heterogeneity and low quality of reporting must first be excluded. Because there was insufficient evidence in studies of aquatic exercise, due to poor methodological and reporting quality and heterogeneity, we are unable to offer any conclusions about the effects of aquatic exercise based on an SR.

Characteristics of articles

The relevant articles represented several studies of locomotorium diseases (N = 4), compared with few studies of respiratory, circulatory, and psychiatric diseases. This characteristic was apparent in the review article[10] of SRs of RCTs. In that review, there were many articles (N = 15) that targeted the health enhancement effect instead of a specific disease, the primary and/or secondary outcome measurements and target participants varied, and a consistent trend was not detected.

We were interested in comparing not only nonintervention as the control, but also land exercise. There were five reports that defined land exercise as the control group, knee osteoarthritis[19,28] and rotater cuff tears[35] as the target disease; the remaining reports[22,31] were about healthy people. Two studies of knee osteoarthritis did not describe intervention effects. The recent meta-analysis[2] of RCTs showed no differences between aquatic exercise and land exercise for the pain-relieving effects on neurologic or musculoskeletal disease ($P = 0.56$; weighted standardized mean difference (SMD), 0.11; 95% confidence interval [CI]: –0.27–0.50; N = 103). Presently, we can not suggest that aquatic exercise is more effective than land exercise for pain relief in locomotorium diseases.

Future research agenda

There were no studies to clarify the effects on serum lipids, body composition, or blood pressure as the main outcome

for patients with metabolic syndrome (MS). A joint scientific statement[36] about MS was issued recently, and many studies based on those criteria or outcomes should be started soon. Studies of aquatic exercise using prevention or cure as the outcome are also expected.

Table 5 shows the future research agenda for aquatic exercise. In advanced nations and areas, it appears that there is interest in studies about mental health as well as MS. Researchers should use the respective checklists for research design and intervention method, which would lead to improvement in the quality of the study, and contribute to the accumulation of evidence. Suitable comparisons are necessary to explain why aquatic exercise is better than other types of dynamic exercise. Aquatic exercise needs a valuable resource (hot water pool), which can not be overlooked in the study feasibility. A recent study[37] suggested that public health is moving toward the goal of implementing evidence-based interventions, but the feasibility of possible interventions and determining whether comprehensive and multilevel evaluations should be justified to accomplish it.

Study limitations

This study was based on the PRISMA statement,[38] except for the meta-analysis. However, there were several limitations to the study. Some selection criteria were common to the studies, as described above; however, bias remained due to differences in eligibility for participation in each study. Publication bias was also a limitation. Since we did not limit our search to English, we found 11 articles (52%) published in Japanese. Furthermore, we did not check the references of hand-searches and did not contact institutions, societies, specialists known to have expertise in aquatic exercise, and authors of included studies to identify any additional published or unpublished data.

Table 5 Future research agenda on aquatic exercise intervention

Item	Concrete agenda
Target disease[a] or prevention	1. The prevention and curative effect of metabolic syndrome
	2. The prevention and the curative effect of mental diseases such as depression
Strengthening of quality	1. Set of research protocol, practice, description based on each respective checklist
	2. Description of adverse event and withdrawal
Feasibility and intrinsic characteristic	1. Comparison with land exercise and/or other dynamic intervention
	2. Description of intervention cost

Note: [a]The pain-relieving effect of chronic locomotorium diseases has already become clear from many randomized controlled trials.

In terms of quality assessment, disagreements and uncertainties were resolved by discussion between two authors; discussions with a third expert and contact with authors for the purpose of clarification were not allowed.

Conclusion

Because there was insufficient evidence on aquatic exercise due to poor methodological and reporting quality, and heterogeneity of nRCTs, we were unable to offer any conclusions about the effects of this type of intervention. However, we were able to identify the problems with current nRCTs of aquatic exercise, and propose a strategy of strengthening study quality and stressing the importance of study feasibility as a future research agenda objective.

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Disclosure

The authors report no conflicts of interest in this work.

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Appendix 1 References to studies excluded from this review

No.	Author. Journal (Year)	Title	Reason for exclusion
E1	Bar-Or. *Phys Sport Med* (2000)	Juvenile obesity, physical activity, and lifestyle changes	Review article
E2	Biering-Sørensen et al. *Spinal Cord* (2000)	Bacterial contamination of bath-water from spinal cord lesioned patients with pressure ulcers exercising in the water	No intervention by aquatic exercise
E3	Darby et al. *J Sports Med Phys Fitness* (2000)	Physiological responses during two types of exercise performed on land and in the water	Cross-over design
E4	Hsieh. *MAMM* (2000)	Aquatic exercise makes a splash	Program idea
E5	Jamison. *Rehab Management* (2000)	Long-term rehab. The healing properties of water	Review article
E6	Sugano et al. *J Physiol Anthropol Appl Hum Sci* (2000)	Influence of water exercise and land stretching on salivary cortisol concentrations and anxiety in chronic low back pain patients	Cross-over design
E7	Watanabe et al. *Percept Mot Skills* (2000)	Comparison of water- and land-based exercise in the reduction of state anxiety among older adults	RCT
E8	Alzugaray. *Midwifery Today* (2001)	American AquaNatal: a midwifery-based holistic prenatal water exercise and educational program	Program idea
E9	Hartmann et al. *Geburtsh Frauenheilk* (2001)	"Aqua-Fit" during pregnancy: Maternal and fetal hemodynamic responses during rest, immersion and exercise	No control group
E10	Piso et al. *Phys Med Rehabil Kuror* (2001)	Analgesic effects of sauna in fibromyalgia	RCT
E11	Postollec. *Back on Track* (2001)	Back on Track Aquatic therapy can help patients with back pain resume normal activity	Program idea
E12	Shono et al. *J Physiol Anthropol* (2001)	Physiological responses to water-walking in middle aged women	Physiological responses (regulatory experiment group versus the other group)
E13	Watanabe et al. *Percept Mot Skills* (2001)	Effects of increasing expenditure of energy during exercise on psychological well-being in older adults	No control group
E14	Seki et al. *Bul of Nurs College*, Wakayama Med Univ (2001)	The effects of maintaining health by exercising in the water in middle to old-aged women	No control group
E15	Belza et al. *Nus Res* (2002)	Does adherence make a difference	RCT
E16	Huey et al. *Best of Both Worlds* (2002)	Combining aquatics with land exercise effectively reduces back pain	Program idea
E17	V. Kendrick et al. *J Aquatic Phys Ther* (2002)	Effects of water exercise on improving muscular strength and endurance in suburban and inner city older adults	Cohort study
E18	Warden et al. *Sports Med* (2002)	Aetiology of rib stress fractures in rowers	Review article
E19	Weinsier et al. *An J Clin Nutr* (2002)	Free-living activity energy expenditure in women successful and unsuccessful at maintaining a normal body weight	No intervention by aquatic exercise
E20	Winter et al. *J Aquatic Phys Ther* (2002)	Effects of aquatic lumbar stabilization and strengthening exercise protocol on chronic low back pain patients	No control group
E21	Sudo et al. *Ann reports Health Phys Educ Sports Sci* (2002)	Effects of the underwater exercise on elderly with low-muscle strength	Cross-sectional study
E22	Tsushita et al. *J Aquatic Health Med* (2002)	Effect of aquatic exercise on lifestyle-related diseases in middle-aged women	No control group
E23	Campbell et al. *Med Sci Sports Exer* (2003)	Metabolic and cardiovascular response to shallow water exercise in young and older women	Physiological responses
E24	Charitopoulos et al. *J Human Mov Stud* (2003)	Application of an aqua exercise programme in children with exercise induced asthma	No control group
E25	Driver et al. *J Cognit Rehabil* (2003)	Effect of an aquatics program on psycho/social experiences of individuals with brain injuries: a pilot study	Case report
E26	Gyurcsik et al. *Arthritis Rheum* (2003)	Exercise-related goals and self-efficacy as correlates of aquatic exercise in individuals with arthritis	Cross-sectional study
E27	Mayo Clin. *Health Lett* (2003)	Water exercise for arthritis: low-impact fitness	Health letter
E28	Suomi et al. *Arch Phys Med Rehabil* (2003)	Effects of arthritis exercise programs on functional fitness and perceived activities of daily living measures in older adults with arthritis	RCT
E29	Weidner et al. *Aktuelle Rheumatoligie* (2003)	Rheumatism and Sports	Review article
E30	Yurtkuran et al. *Am J Phys Med Rehabil* (2003)	Evaluation of hormonal response and ultrasonic changes in heel bone by aquatic exercise in sedentary postmenopausal women	RCT

(Continued)

Appendix 1 *(Continued)*

No.	Author. Journal (Year)	Title	Reason for exclusion
E31	Sugano et al. *Bull Inst Health Sport Sci*, Univ of Tsukuba (2003)	Prescription of water exercise for low back pain patients. Influence of water exercise and land stretching on salivary cortisol concentrations and anxiety in chronic low back pain patients	Study report
E32	Matsumoto et al. *Ann Reports Health Physl Educ Sports Sci* (2003)	Blood chemical values in elderly persons performing habitual aquatic exercise	Cross-sectional study
E33	Benelli et al. *J Strength Cond Res* (2004)	Physiological responses to fitness activities: a comparison between land-based and water aerobics exercise	Cross-over design
E34	Booth. *Activ Adapt Aging* (2004)	Water exercise and its effect on balance and gait to reduce the risk of falling in older adults	Cross-sectional study
E35	Preis et al. *Fisioterapia em Movimento* (2004)	Análise de um programa de execução de saltos múltiplos verticais no meio líquido e no solo	Biomechanical trial
E36	Roebrs et al. *J Neurol Phys Ther* (2004)	Effects of an aquatics exercise program on quality of life measures for individuals with progressive multiple sclerosis	No control group
E37	Aoba et al. *Kokushikan Soc Sport Sci* (2004)	The effect of continuation term on BP at water exercise	No retrospective comparison between aquatic exercise group and drop out group of aquatic exercise
E38	Ashida et al. *Ann Reports Misasa Med Center*, Okayama Univ (2004)	Clinical study on reduction of costs of drugs for the treatment of asthma in relation to the administration method	Not intervention study
E39	Katayama et al. *Descente Sports Sci* (2004)	Effects of weight reduction through dietary restriction and exercise training on blood fluidity in obese middle-aged women	No intervention by aquatic exercise
E40	Higuma et al. *J Oita Med Assoc* (2004)	Rehabilitation after TKA in a hospital	Cross-sectional study
E41	Barry Dale et al. *Rehabil Management* (2005)	Aquatic therapy offers benefits to a wide range of clinical populations	Review article
E42	Cider et al. *Clin Physiol Funct Imaging* (2005)	Cardiorespiratory effects of warm water immersion in elderly patients with chronic heart failure	Comparison between patients on healthy people
E43	Kelly et al. *Development Med Child Neurol* (2005)	Aquatic exercise for children with cerebral palsy	Review article
E44	Kato et al. *Research Reports Suzuka Univ Med Sci Technol* (2005)	Influence of aquatic-exercise on arterial blood pressure and acceleration plethysmogram in middle-aged women	Case report
E45	Matsubara et al. *Ishikawa J Nurs* (2005)	Case-control study on long-term effect of programmed movement practice course combined with bathing in hot spring	Case-control study
E46	Gusi et al. *Arthritis Rheum* (2006)	Exercise in waist-high warm water decreases pain and improves health-related quality of life and strength in lower extremities in women with fibromyalgia	RCT
E47	Katia et al. *JAGS* (2006)	Older people involved in physical activity benefit from water exercise, showing longer total sleep time	Letter to the journal's editor
E48	Goto et al. *J Jpn Assoc Phys Med Balneol Climatol* (2006)	The effect of Spa-aqua therapy on lifestyle-related diseases in collaboration with public spa facility	No control group
E49	Kokubu et al. *Hip Joint* (2006)	Effect of underwater exercise for hip joint disease	Cross-sectional study
E50	Yano et al. *Jpn J Phys Fitness Sports Med* (2006)	Effect of fluid in ingestion on physiological response before walking in a pool	No intervention by aquatic exercise
E51	Brody. *J Aquatic Phys Ther* (2007)	Aquatic physical therapy practice analysis	Practice analysis
E52	Goodwin. *OT Practice* (2007)	Exploring the effects of a swim program for clients with down syndrome	No control group
E53	Kang et al. *J Gerontol Nurs* (2007)	Aquatic exercise in older Korean women with arthritis	No control group
E54	Kron. *Complementary Med* (2007)	Water therapies	Review article
E55	McManus B. *Pedia Phys Ther* (2007)	The effect of aquatic therapy on functional mobility of infants and toddlers in early intervention	RCT
E56	Magkos et al. *Clin J Sports Med* (2007)	The bone response to nonweight-bearing exercise is sport-, site-, and sex-specific	Cross-sectional study
E57	Schmid et al. *Heart* (2007)	Influence of water immersion, water gymnastics and swimming on cardiac output in patients with heart failure	Physiological responses of various performances in water
E58	Alpert. *Cardiology* (2008)	A water-based exercise program for patients with coronary artery disease	Editorial comment

(Continued)

Appendix 1 (*Continued*)

No.	Author. Journal (Year)	Title	Reason for exclusion
E59	Hujibregts et al. *Top Stroke Rehabil* (2008)	Implementation, process, and preliminary outcome evaluation of two community programs for persons with stroke and their care partners	Not intervention by aquatic exercise
E60	Kelley et al. *Therapeutic Recreation J* (2008)	Comparing the effects of aquatic and land-based exercise on the physiological stress response of women with fibromyalgia	A single-subject alternating treatment design
E61	Tokmakidis et al. *Cardiology* (2008)	Training, detraining and retraining effects after a water-based exercise program in patients with coronary artery disease	RCT
E62	Colado et al. *Eur J Appl Physiol* (2009)	Effects of aquatic resistance training on health and fitness in postmenopausal women	RCT
E63	Fragala-Pinkham et al. *Pedia Phys Ther* (2009)	An aquatic physical therapy program at a pediatric rehabilitation hospital: a case series	Case report
E64	Laurent et al. *Euro Soc Cardiol* (2009)	Training-induced increase in nitric oxide metabolites in chronic heart failure and coronary artery disease: an extra benefit of water-based exercises?	RCT
E65	Schmid et al. *Heart* (2009)	Influence of water immersion, water gymnastics and swimming on cardiac output in patients with heart failure	No intervention by aquatic exercise
E66	Souza Vale et al. *Arch Gerontol Geriatrics* (2009)	Effects of muscle strength and aerobic training on basal serum levels of IGF-1 and cortisol in elderly women	No intervention by aquatic exercise
E67	Tolomio et al. *Clin Ter* (2009)	Effects of a combined weight- and non weight-bearing (water) exercise program on bone mass and quality in postmenopausal women with low bone mineral density	No intervention by aquatic exercise

Abbreviations: IGF-1, insulin-like growth factor-1; RCT, randomized controlled trial.