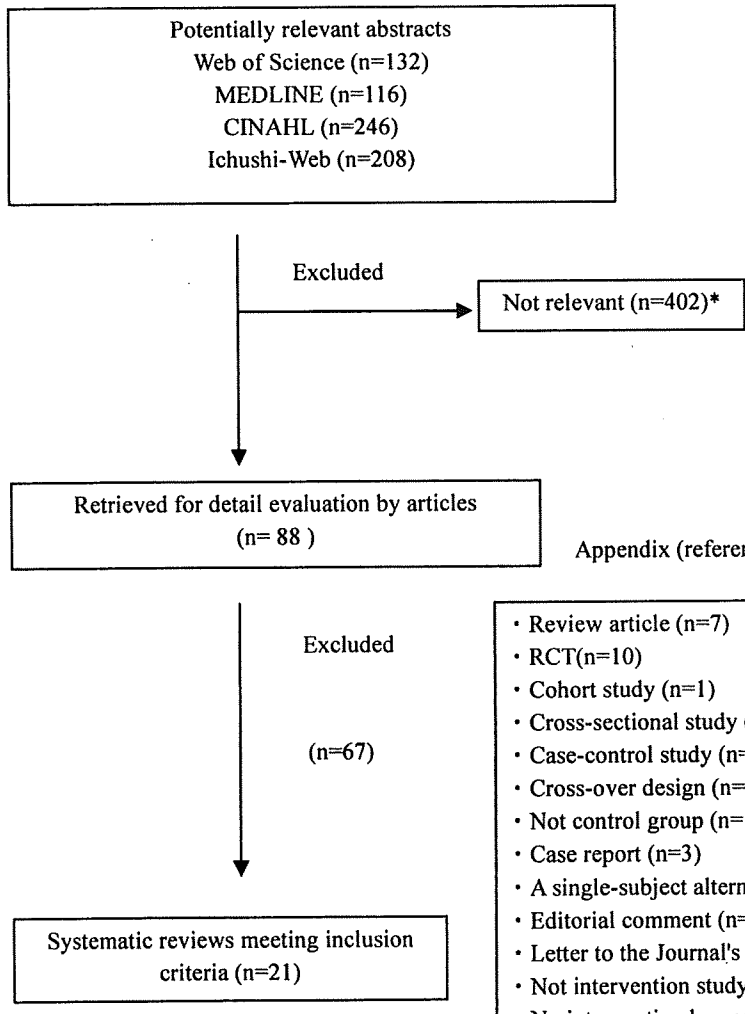

Figure 1. Flowchart of trial process

*redupulication

Appendix (references to studies excluded)

- Review article (n=7)
- RCT(n=10)
- Cohort study (n=1)
- Cross-sectional study (n=7)
- Case-control study (n=1)
- Cross-over design (n=3)
- Not control group (n=10)
- Case report (n=3)
- A single-subject alternating treatment design (n=1)
- Editorial comment (n=1)
- Letter to the Journal's editor (n=1)
- Not intervention study (n=1)
- No intervention by aquatic exercise (n=8)
- Not retrospective comparison between aquatic exercise group and drop out group of aquatic exercise (n=1)
- Study report (n=1)
- Physiological responses (regulary experiment group vs. the other group) (n=1)
- Physiological responses (n=1)
- Comparison between patients and health people (n=1)
- Physioloical responses of various performances in water (n=1)
- Practice analysis (n=1)
- Biomechanical trial (n=1)
- Health letter (n=1)
- Program idea (n=4)

Table 1. Summary of articles based on structured abstracts

No.	Author	Journal Year;Vol.;Page.	Title	Aim/Objective	Setting/Place	Participants	Detail and period of intervention	Main and secondary outcomes	Main results	Conclusion
9	Willén C, et al.	Arch Phys Med Rehabil 2001;82:66-72.	Dynamic water exercise in individuals with late poliomyelitis	To evaluate the specific effects of general dynamic water exercise on individuals with late effects of poliomyelitis.	A university hospital department.	Twenty-eight individuals with late effects of polio, 15 (7 men, 8 women) assigned to the training group (TG) and 13 (9 men, 6 women) to the control group (CG). The mean age was 51 years (range, 22-65 yrs) for the TG and 49 years (range, 28-59 yrs) for the CG.	A 40-minute general fitness training session in warm (33° C) water twice a week. The average training period was 5 months.	Peak load, peak work load, peak oxygen uptake, peak heart rate (HR), muscle function in knee extensors and flexors, and pain dimension of the Nottingham Health Profile (NHP).	The exercise did not influence the peak work load, peak oxygen uptake, or muscle fnction in knee extensors compared with the controls. However, a decreased HR at the same individual work load was seen, as well as a significantly lower distress in the dimension pain of the NHP.	A program of nonswimming dynamic exercises in heated water has a positive impact on individuals with late effects of polio, with a decreased HR at exercise, less pain, and a subjective positive experience. The program was well tolerated (no adverse effects were reported) and can be recommended for this group of individuals.
10	Ebisu T, et al.	Health Care 2001;43:981-984. (in Japanese)	Effectiveness of serum lipids on spa-walking	To examine the effect of spa walking on serum lipids.	A spa pool	Spa walking group consisted of 5 healthy female students who did not have exercise habit (21.3±0.7 yrs). Non-walking group consisted of 5 females who did not have exercise habit (22.1±0.2 yrs).	Walking in a spa pool three times a week (30 min for once) for 10 weeks.	Serum lipids (TC, HDL-C, LDL-C, TG) and energy intake.	In the exercise group, significant increment of HDL-C was seen. Group comparison was not conducted.	Spa walking can improve HDL-C value, though the detailed mechanism for HDL-C increment is unclear.
11	Aoba T, et al.	Ann Reports Health Phys Educ Sports Sci 2001;20: 99-104. (in Japanese with English abstract)	The effects of enforcement water exercise class on hypotensive to blood pressure at elderly subjects.	To examine the effect of 8 weeks of water exercise on blood pressure at 133 elderly subjects.	A heated pool	One hundred elderly people (29 males and 71 females, aged 59.1±10.0yrs) who participated the water exercise program and 30 elderly people (17 men and 13 women, aged 57.0±12.5yrs) who didn't have fitness habits.	The exercise group trained for 8 weeks with two 90 minitues programs per week. Each program was consisted of stretches and cool down on land, and walking, stretcheng, resistance training and aerobic exercise in water.	Blood pressure	In elderly subjects, significant improvement of SBP or DBP were shown among the subjects in elder group and high blood pressure level. However, obesity subjects showed no significant change.	The present study suggested that blood pressure value would improve with water exercise and recognition of health was for elderly subjects who participated in the water exercise program.
12	Yamada T et al.	Jpn J Phys Anthropol 2002; 7: 35-41. (in Japanese with English abstract)	Effects of water-based well-rounded exercise on vital age and physical fitness in older adults	To determine the effects of water-based exercise training on vital age (VA) in older adults.	No description.	Thirty-nine volunteers were randomly divided into an exercise group (8 males and 13 females aged 69±4 yrs) and control group (5 males and 11 females aged 68±4 yrs).	The exercise group participated in a 12-week water-based exercise program, 70 min/d, and 3 d/wk; the control group continued their normal lives.	The vital age (VA) based on age and varios physical fitness tests.	Significant lowering in VA was noted in the exercise group, and no significant changes was observed in the control group.	Water-based exercise is an effective measure to lower the VA, thus improving the overall physical fitness in the elderly.
13	Murai, E	J Jpn Soc Clin Sports Med 2002; 10: 54-60. (in Japanese with English abstract)	Exercise therapy for osteoarthritis of the knee -preliminarily study of water exercise-	To compare the effects of aquatic exercise training and land exercise on slight knee osteoarthritis (OA) patients.	No description.	Aquatic exercise group consisted of 16 females aged 49.7yrs on average. Land exercise group consisted of 6 felames aged 53.5 yrs on average.	Once per week for 10 weeks on average. A voluntary exercise was permitted. Aquatic exercise was walking in the water, balancing exercise, cool down. Land exercise was stretching, resistance training, balancing exercise, ergometer exercise, icinig.	Body fat, VAS, JOA knee score, and isometric knee extension force.	There was no significant difference of weight and body fat. VAS, JOA score and COP sway was significantly decreased or improved by aquatic exercise. They improved by land exercise although not significant. Knee extension force was improved in both groups. Significance level was higher in aquatic exercise	Knee pain, JOA, muscle force and COP were significantly improved in aquatic exercise group. Only muscle force was improved in land exercise group. Aquatic exercise was more effective than land exercise on slight OA patients.
14	Igarashi Y, et al.	Sick Body Phys 2002;36:11-14. (in Japanese)	Health effect of aquatic exercise therapy using a hot spring.	To examine the health effect of aquatic exercise therapy with a hot spring for the citizens not for atheletes.	A city hot spring pool	Aquatic exercise group consisted of aquatic exercise class participating 13 females for 2 years (56-70 yrs). Non-aquatic exercise group consisted of 7 females who did not have exercise habit (60-75 yrs).	Stretching and balance training was mainly included. 45 minits a week for 4 months.	Physical characteristics (height, weight, body fat, blood pressure), muscle volume, VO2max, physical flexibility were examined at the biginning and end of the intervention.	In the exercise group, significant reduction of weight and minimum blood pressure were seen. Group comparison was not conducted.	the intervention period (4 months) and frequency (once a week) might not enough to improve the health.
15	Pechter U et al.	Int J Rehabil Res 2003; 26: 153-156.	Beneficial effects of water-based exercise in patients with chronic kidney disease	To ascertain whether water-based, 12-week, regular, low-intensity aerobic exercise conditioning may provide beneficial effects for individuals with moderate chronic kidney disease (CRF) and to compare the outcome with data of a sedentary control group.	No description.	Twenty-six patients with modarate CRF: an exercise group (7 male and 10 females aged 31 to 72 yrs) and a control group men and 3 women aged 35 to 65 yrs).	The exercise group did low-intensity aerobic exercise in the pool during a period of 12 weeks, (6 twice a week, with sessons lasting for 30 min; the control group remained sedentary.	Cardiorespiratory parameters (peak VO2 and peak ventilation), renal functional parameters (serum creatinine, cystain-c [Cys-C], glomerular filtration rate [GFR], and protein/cratinine ratio [U-prot]), systolic [SBP] and diastolic [DBP] blood pressure, and oxidative stress indices (products of lipid peroxidation and reduced glutathione [GSH].	Only in the exercise group, all cardiorespiratory functinal parameters, SBP, and DBP lowered significantly. U-prot and U-prot were diminished significantly and GFR was enhanced. LPO was reduced significantly and GSH showed significant improvement.	Regular water-based exercise has beneficial effects on the cardiorespiratory, renal functional parameters and oxidative stress status in patients with moderate renal failure, and can be used in the complex rehabilitation of chronic renal failure patients, together with blood pressure control, dietary consultation, encouragement and education to prevent physical worsening and to postpone cardiovascular and renal atherosclerotic complications.
16	Douris P, et al.	J of Geriat Phys Ther 2003;26:3-6.	The effect of land and aquatic exercise on balance scores in older adults.	To determine if aquatic exercise was more effective than land-based exercise when training balance.	Aquatic;Inground Custom Therapy Pool(Longmont, Colo).Land;assisted living recreation area.	Subjects were healthy elderly aged 65 and older who were independent ambulators with or without an assiative device and independent in activities of daily living. Land group; 83.2±8.14 (73-91) yrs (5 subjects). Aquatic group; 75.0 ±3.63 (68-78) yrs (6 subjects).	Exercise was comparable for both land and water and was administered twice a week for 6 weeks. Walking activities (Done 3 times each); 1.Warking forward 11 feet, 2.Marching forward 11 feet, 3.Sidestepping without crossing legs 11 feet, 4.Tandem walking 11 feet. Exercise activities (One set of 15 repetitions); 1.Marching in place, 2Hip flexion/extension, 3.Hip abduction/adduction, 4.Toe raises/heel raises, 5.Shallow knee bends, 6a.Sit to stand from chair in land group, 6b.Sit to stand from pool shelf in aquatic group.	Berg Blance Scale score.	There was a significant main effect of time ($p < .001$) but not group on BBS scores. There was no significant interaction between group and time.	The utilization of lower body exercise, whether in water or on land, was accompanied by improved balance.
17	Liquori A, et al.	J Section Women's Health 2003;27:11-19.	Effects of a 6-week Prenatal Water Exercise Program on Physiological Parameters and Well-being in Women with Pregnancies in the 2nd-3rd Trimesters: A Pilot Study	To evaluate an established prenatal water aerobics program for its impact on the physiological function and well-being of female with low risk pregnancies in the 2nd and early 3rd trimesters.	A pool in a rehabilitation center	Seven healthy females with uncomplicated singleton pregnancies participated in the exercise group (mean age 32.8yrs). Six women having the same characteristics participated in the control group (mean age 30.5yrs).	Participating in the 1 hour water aerobic exercise class using a pool in a rehabilitation center, 2 or 3 times a week for 6 weeks.	Cooper 6-minute walk test, muscle force in the quadriceps, shoulder abductors, biceps, and triceps, and the health promoting lifestyle profile II questionnaire.	Post-test measures of strength in the quadriceps and biceps, as well as the subscale of physical activity within the HPLP II questionnaire were greater in the exercise group.	This study outcome supported the effect of prenatal water aerobic exercise but further research with greater number of subjects is necessary to establish the most effective protocols.
18	Lin YC, et al.	Clin Rehabil 2004;18:92-101.	Community rehabilitation for older adults with osteoarthritis of the lower limb: a controlled clinical trial	To examine the effectiveness of a 12-month community-based water exercise programme on measures of self-reported health and physical function in people aged over 60 years old with knee-hip osteoarthritis (OA).	Public community swimming pool in Sheffield, UK.	One hundred and six community-dwelling sedentary older people (aged 60>yrs), with conformed knee-hip osteoarthritis, enrolled in an experimental controlled trial for 12 months. Sixty-six subjects in the exercise group were offered a water-exercise programme. Forty age-matched, nonexercising, 'control' subjects received monthly education material and quarterly telephone calls.	Participants in the exercise group were asked to attend two exercise sessions a week of 1 hour for 12 months led by specially trained swimming instructors.	The disease-specific Western Ontario. McMaster University Osteoarthritis Index (WOMAC), a battery of performance-based physical function tests.	After one year, participants in the exercise group experienced a significant improvement in physical function (4.0 ± 9.1 versus -0.4 ± 7.3 units; 95% confidence interval (CI) 0.96-7.98, $p < 0.05$) and reduction in the perception of pain (1.3 ± 3.7 versus 0.2 ± 2.5 units; 95% CI -0.19 -2.52, $p < 0.05$) compared with the control group, as measured by the WOMAC Osteoarthritis Index. In addition, the exercise group performed significantly better in the ascending and descending stairs tests ($p < 0.05$), had significantly greater improvements in knee range of movement ($p < 0.01$) and hip range of movements ($p < 0.005$). There were no signi-cant differences in the two groups for quadriceps muscle strength and psychosocial well-being (Arthritis Impact Measurement Scales 2 questionnaire).	Older people with knee/hip osteoarthritis gained modest improvements in measures of physical function, pain, general mobility and flexibility after participating in 12 months of community-based water exercise.
19	Akamine T, et al.	Kyushu Yamaguchi Sports Sci J 2005;17:7-12. (in Japanese with English abstract)	Effects of underwater exercise with hot spring bathing on middle aged people	To investigate the effects of underwater exercise with hot spring bathing on the middle aged people.	No description	Three males and 22 females (59.6±8.9 yrs) without serious systemic complication.	Group A (one-day intervention): underwater exercise (70min) and hot spring bathing (20min) Group B (one-day intervention): underwater exercise (70min) and fresh water bathing (20min) Group C : no exercise, no bathing	Blood pressure, total cholesterol, CD4, red blood cells, hematocrit, total protain, and Profile of Mood States (POMS) .	After exercise with bathing, significantly lower values of diastolic blood pressure, total cholesterol, CD4, red blood cells, hematocrit and total protain when compared with before exercise with bathing ($p<0.05$). After exercise with bathing, significantly lower levels of depression-dejection, anger-hostility and confusion in POMS test when compared with control group.	Underwater exercise with hot spring bathing has good effects on the health of middle aged people.

20	Takumi Y,et al	Jpn J Biometeor 2005;42:17-27. (in Japanese with English abstract)	Participation in an aquatic exercise class twice a week for 12 weeks improved physical fitness for good walking, walking self-efficacy on winter roads, mental health and QOL in elderly woman	This study investigated whether the level of good walking, walking self-efficacy (SE) on winter roads, mental health and quality of life (QOL) improved through participation in an aquatic exercise class (twice a week, for twelve weeks) in elderly women.	a pool with Water temperature 34 degree centigrade.	The subjects were 15 females who took part in the aquatic exercise class and 16 females in the control group (over 60 yrs).	The duration of each class was 60 minutes (twice a week, for 12 weeks) and was conducted under the guidance of a skilled instructor.	Good walking tests (standing on one leg with eyes open, BOSU balance score) , walking self-efficacy (SE) , mental health pattern(MHP), and quality of life (QOL)	good walking tests of the final class were improved compared to the first class (P<0.05). walking SE on winter roads did not change in either group, but the SE scores for general falling were significantly increased at the last class compared to the first class in the exercise group (P=0.032). The stress scores of MHP did not increase in the exercise group, which indicates that participating in the aquatic exercise class was not stressful. In QOL measures, the scores of physical symptoms (P<0.001) and the mean of QOL (P=0.028) was significantly improved at the last class compared to the first class in the exercise group.	Participation in an aquatic exercise class is suggested to be effective for promoting good walking, QOL and an active lifestyle.
21	Takumi Y,et al	Jpn J Biometeor 2005;42:5-15. (in Japanese with English abstract)	Participation in an aquatic exercise class for 12 weeks improved physical fitness for good walking, walking self-efficacy on winter roads, mental health and QOL in elderly women.	This study investigated whether participation in an aquatic walking class (once a week, for twelve weeks) had an effect on middle-aged and elderly women, compared to no participation.	a pool with Water temperature 29 degree centigrade.	The subjects were 35 women (58.5± 8.3yrs) who took part in the aquatic exercise class and 24 women (61.0y± 7.4yrs) in the control group .	The duration of the class exercise was 50 minutes (once a week, for 12 weeks) under the guidance of a skilled instructor. Averages of % heart rate reserve (HRR) during exercise were 24-34%, so that the intensity of exercise was lowor middle level.	Mood Check List-Short Form 1, good walking tests (maximal one step distance, one leg squat, BOSU balance test, 10m walk time), walking self-efficacy (SE).	Mood Check List-Short Form 1 for pleasantness and relaxation significantly increased post-compared to pre-exercise every time (P<0.001).good walking tests in the 12th week improved compared to those from first week.The scores of walking self-efficacy in strong wind and on an icy surface in the 12th week were increased compared to the scores from the first week.No changes were observed in the control women group.	No changes were observed in the control group.
22	Lee HY.	J Korean Acad Nurs 2006;36(3):571-580. (in Korean with English abstract)	Comparison of effects among Tai-chi exercise, Aquatic Exercise, and a self- help program for patients with knee osteoarthritis	To compare the effects among Tai-chi exercise, aquatic exercise, and self-help program for knee osteoarthritis patients on symptoms of arthritis, muscle strength, balance, and difficulty of programing activities.	Tai-chi exercise and self-help program: public health center. aquatic exercise: a pool	Tai-chi exercise group (N=18: 61.3±9.5 yrs), aquatic exercise group (N=16: 66.4± 6.7 yrs) and self-help program group (N=16: 61.6±7.6 yrs) were enrolled for this study. All subjects had knee osteoarthritis and did not have exercise habit during past six months.	Tai-chi exercise and aquatic exersice group exercised twice a week (one hour) for two months. In self-help program group, they exercised once a week (two hours) for two months.	Muscle strength, balance and difficulty of performing activities (K-WOMAC Index).	The Tai-Chi group was significantly different from the self-help group for knee extensor peak torque, knee flexor and stiftness. In addition, the Tai-Chi group or aquatic group were significantly different from the self-help group for difficulty of performing activities.	The Tai-Chi group or aquatic group were significantly different from the self-help group. However, it seems that Tai-Chi exercise may be more suitable than aquatic exercise in osteoarthritis exercise program.
23	Lord SR, et al.	Australasian J Ageing 2006;25:36-41.	The effects of water exercise on physical functioning in older people	To determine whether a 22-week water exercise program can improve physical functioning in older people.	All participants in central and eastern Sydney. The exercises were undertaken in heated pools with water temperatures that ranged between 25 and 29° C.	Eighty-five persons (18 males and 67 females, mean age 71.8 yrs) participated in a water-exercise program and 44 control subjects (7 males and 37 females, mean age 76.5 yrs) participated in the study.	The exercisers participated in approximately 1-hour exercise sessions once a week for two 10 weeks (with 2-week inter-term break). The intervention comprised the 'WAVES' water exercise program specifically designed for older people.	Leaning balance, quadriceps strength, reaction time and shoulder range of motion.	The 48 exercise subjects who were available for retest showed significantly improved leaning balance (as measured by tests of maximal balance range and coordinated stability) and shoulder range of motion compared with the controls. The groups did not differ in tests of quadriceps strength and reaction time.	These findings show that water exercise can produce benefits with regard to improving balance and flexibility in older people.
24	Smith SA et al.	J Obstat Gynecol Neonatal Nurs 2006; 35: 315-323.	A pilot study on the effects of aquatic exercises on discomforts of pregnancy	To estimate the impact of an aquatic exercise program on perception of body image, participation in health-promoting behaviors, barriers to health-promoting participation, level of physical discomfort, and mobility.	No description.	Forty nonexercising pregnant women with more than 19 weeks gestation. Based on self-selection, participants were assigned to either aquatic exercise group (N=20: 25.1±4.9 yrs) or control group (N=20: 24.8±5.6 yrs).	The aquatic exercise group participated in a 60-minute, 6-week aquatic exercise program three sessions per week. The control group was instructed to continue their normal activities of daily living.	The Pregnancy Body Shape Questionnaire, the Health Promotion Lifestyle Prifile, the Timed Get Up and Go Test, and the Discomfort Intensity Index.	Women in the aquatic exercise group reported significantly less physical discomfort, improved mobility, and improved body image and health-promoting behaviors as compared to control subjects.	Aquatic exercise during pregnancy may enhance physical functioning, decreasing maternal discomfort, improving maternal body image, and improving health-promoting behaviors.
25	Chishaki A, et al.	Memoirs of Dep Health Sci Sch of Med Kyushu Univ 2006;7:23-32. (in Japanese with English abstract)	Comparison of usefulness between water exercise and gymnastic exercise, Jōkyojutsu, in maintaining physical ability for the elderly.	To compare physical ability and physical characteristics of elderly woman between water exercise and gymnastic exercise.	No description.	Aquatic group consisted of 21 healthy females (60±5.2yrs). Land group consisted of 10 healthy females (60± 3.2yrs).	Aquatic group; Aquatic walking, swimming (twice or more (60-minutes/times) a week for 1 year). Land group; Gymnastic (Soulder raise/lower, Arm raise/lower, Push-up, Lower back twist, Straddle stretching, Head shake, Tumble, etc.) (every day (20-minutes in the morning and the afternoon respectively) of the week for 1 year)	Physical carastaristics (Body Mass Index, Waist size, Hip size, %fat), and Physical fitness (10m walking, 10m maximal walking, 10m obstacle walking, Single-leg standing with eyes open, Grip strength, Sit up, Side steps, Sitting-toe-touch test, VO2max).	The mean percentage of fat mass was reduced in the gymnastic exercise group without change of weight. The average estimated maximal oxygen uptake increased in the gymnastic exercise more than in the water exercise. Sitting trunk flexion was decreased in both groups after one year.	The results of this study suggested that water exercise could be more benefical by adding flexibility exercise in the gymnastic exercise, and could maintain and promote physical fitness of elder people.
26	Kawasaki T, et al.	Jpn J Clin Experimental Med 2007;84:402-411. (in Japanese)	The effect of aquatic exercise on preventing falls and life-style related disease among middle-aged and elderly people.	To evaluate the effects of water exercise on blood pressure, carbohydrate and lipid metabolism, arterial sclerosis, and stability of center of mass in middle- and old-ages.	A swimming club in Kyushu Sangyou University.	Eleven healthy males and 24 healthy females aged were assigned to the training group (N=35, 61.5 ±0.8yrs) and control group (N=22. 62.6±0.9yrs).	A 2-hour program consisted of stretching, bicycling, walking in warm (30.5° C) water stream, and swimming twice weekly. The training period was 6 months.	Anthropometric variables, blood pressure, heart rate, work load, blood biochemical values, urine testing, blood pressure pulse wave, and stability of center of mass.	Weight, body mass index, amount of body fat, blood pressure, and pulse wave velocity decreased and lipid and carbohydrate metabolism and index of arterial scrolosis significantly improved in the training group.	Water exercise might be useful for controlling metabolic syndrome and preventing falls in middle-aged and elderly.
27	Nishikawa A, et al.	JJCR 2008;13:135-138.	Effect of aquatic walking on the cardiovascular patients in our hospital and health-related QOL – in comparison with indoor exercise therapy-.	To compare the effectiveness of a programme of aquatic exercise therapy and land exercise therapy in patient with herat disease.	Rehabilitation pool.	Aquatic group consisted of 11 meles and 3 females 66±7yrs. Land group consisted of 8 males and 2 females 63± 9years. Patient characteristic (aquatic/land); Angina pectoris (7/5)、Myocardial infarction (4/5), Valve replacement (2/0), Dilatative cardiomyopathy (1/0).	Aquatic exercise therapy; Stretching, Aquatic walking, Resistance training. Land exercise therapy; Stretching, Resistance training, Aerobic exercise (ergometer). Each therapies were conducted 2 times (60-minutes/times) a week for 3 months.	VO2 at anaerobic threshold (ATVO2), Peak VO2, and health-related QOL.	ATVO2, Peak VO2 and Health-related QOL were significantly improved in both groups.	The improvement of aerobic fitness was similar in both groups.The difference of improved effect in QOL was due to the influence that the content and the environment of each exercise were different.
28	Rotstein A, et al.	J Sports Med Phys Fitness 2008;48:352-359.	The effect of a water exercise program on bone density of postmenopausal women	To examine the effect of a seven-month program of water exercise, on bone mineral density(BMD) in postmenopausal females.	A heated pool	Thirty-five postmenopausal females aged 50 to 65 (twenty in the experimental group and 10 in the control).	The exerrcise group trained for seven months with three one-hour sessions per week. Each session was divided into four different segments; warm-up, aerobic set, strengthening muscles and loading the bones, and cool down and stretches.	Bone density by DEXA (lunar) for Vertebrae L2-L4 and femoral neck of the legs.	DEXA test findings for femoral neck density indicated no significant differences between the groups pre and post treatment. However a significant interaction was found for BMC in the right leg indicating an increase trend in BMC in the experimental group and a trend towards decrease for the control group.	It is possible to plan and execute a water exercise program that has a positive effect on bone status of postmenopausal women.
29	Brady B	Physiotherapy Res Int 2008;13:153-161.	The addition of aquatic therapy to rehabilitation following surgical rotator cuff repair: a feasibility study	To determine the feasibility of implementing and investigating the effect of a combined aquatic and land-based rehabilitation programme in the post-operative rehabilitation of rotator cuff tears.	University of Sydney and Delmer Private Hospital	Eighteen subjects undergoing rotator cuff repair. Aquatic and land group (N=12, 56.3 ±9.1yrs) and land group (N=53.5± 16.0yrs).	Twice per week for 12 weeks combined aquatic- and land-based programme: Standard protocol: passive range of motion (ROM), active-assisted ROM, resistive phase standard land-based programme: Standard protocol, adding that 10 days post-operativly three primary stages: buoyancy assisted ROM, buoyancy supported ROM, resistive phase	Passive ROM (forward flexion, external rotation), Western Ontario Rotator Cuff (WORC) Index, health-related QOL, and 11-point VAS.	Both subjects improved passive ROM and WORC. Participation in aquatic therapy significantly improved passive flexion range of motion measurerd at three and six weeks. No significant differences in the attenndance rate and patients perceptions of the programmes.	The implementation of a combined aquatic and land-based physiotherapy programme following surgical repair of the rotator cuff is feasible and presents a potential viable alternative to conventional land-based exercise with comparable outcomes.

* Description of study design was omitted.

Table 2. Brief summary of 21 articles

No.	Author	Year of publication	Object disease	Effects noted	Withdrawals	Adverse event	Cost of intervention
9	Willén C, et al.	2001	Poliomyelitis	Significant effect	No withdrawal	Nothing	No description
10	Ebisu T, et al.	2001	No specific disease	Significant effect*	No description	No description	No description
11	Aoba T, et al.	2001	No specific disease	Significant effect	No description	No description	No description
12	Yamada T et al.	2002	No specific disease	Significant effect	No description	No description	No description
13	Murai, E	2002	Knee osteoarthritis (OA)	Significant effect	No description	Nothing	No description
14	Igarashi Y, et al.	2002	No specific disease	Significant effect*	No description	No description	No description
15	Pechter U et al.	2003	Moderate chronic kidney disease	Significant effect	No description	No description	Not description
16	Douris P, et al.	2003	No specific disease	Significant effect	No description	No description	Not description
17	Liquori A, et al.	2003	No specific disease	Significant effect	No description	No description	No description
18	Lin YC, et al.	2004	Knee-hip osteoarthritis (OA)	Significant effect	N=9 Reason was not described.	No description	No description
19	Akamine T, et al.	2005	No specific disease	Significant effect	No description	No description	No description
20	Takumi Y,et al	2005	No specific disease	Significant effect	No description	No description	No description
21	Takumi Y,et al	2005	No specific disease	Significant effect	No description	No description	No description
22	Lee HY.	2006	Knee osteoarthritis (OA)	Significant effect	N=3 Slipping on poolside, having a cold, low height.	N=1 Slipping on poolside.	No description
23	Lord SR, et al.	2006	No specific disease	Significant effect	N=37 Reasons were shown in Table 1 in detail.	No description	No description
24	Smith SA et al.	2006	Discomforts of pregnancy	Significant effect	No description	No description	After pretests were completed, each participant received a $10 grocery store gift certificate, and each one in the aquatic exercise group were given the bus tickets or parking passes to assist partisipants' attendance. Other cost was not described.
25	Chishaki A, et al.	2006	No specific disease	Significant effect	No description	No description	No description
26	Kawasaki T, et al.	2007	No specific disease	Significant effect	N=8 Low compliance.	No description	No description
27	Nishikawa A, et al.	2008	Cardiovascular disease	Significant effect	No withdrawal	No description	No description
28	Rotstein A, et al.	2008	No specific disease	Significant effect	N=5 Reason was not described.	No description	No description
29	Brady B	2008	Rotator cuff tears	Significant effect	No description	Nothing	No description

* Group comparison was not conducted.

Table 3. Evaluation of the quality of non-randomized controlled trials by using the TREND checklist

Paper Section / Topic	Item No.	Descriptor	N of yes	%
Title and abstract	1	• Information on how units were allocated to interventions	5/21	23.8
		• Structured abstract recommended	8/21	38.1
		• Information on target population or study sample	12/21	57.1
Introduction				
Background	2	• Scientific background and explanation of rationale	18/21	85.7
		• Theories used in designing behavioral interventions	8/21	38.1
Methods				
participants	3	• Eligibility criteria for participants, including criteria at different levels in recruitment / sampling plan (e.g., cities, clinics, subjects)	14/21	66.7
		• Method of recruitment (e.g., referral, self-selection), including the sampling method if a systematic sampling plan was implemented	10/21	47.6
		• Recruitment setting Settings and locations where the data were collected	7/21	33.3
Interventions	4	• Details of the interventions intended for each study condition and how and when they were actually administered, specifically including:	11/21	52.4
		• Content: what was given?	19/21	90.5
		• Delivery method: how was the content given?	19/21	90.5
		• Unit of delivery: how were subjects grouped during delivery?	13/21	61.9
		• Deliverer: who delivered the intervention?	10/21	47.6
		• Setting: where was the intervention delivered?	16/21	76.2
		• Exposure quantity and duration: how many sessions or episodes or events were intended to be delivered? How long were they intended to last?	20/21	95.2
		• Time span: how long was it intended to deliver the intervention to each unit?	21/21	100.0
		• Activities to increase compliance or adherence (e.g., incentives)	7/21	33.3
Objectives	5	• Specific objectives and hypotheses	15/21	71.4
Outcomes	6	• Clearly defined primary and secondary outcome measures	17/21	81.0
		• Methods used to collect data and any methods used to enhance the quality of measurements	17/21	81.0

		• Information validated instruments such as psychometric and biometric properties	8/21	38.1
Sample size	7	• How sample size was determined and, when applicable, explanation of any interim analyses and stopping rules	5/21	23.8
Assignment method	8	• Unit of assignment (the unit being assigned to study condition, e.g., individual, group, community)	16/21	76.2
		• Method used to assign units to study conditions, including details of any restriction (e.g., blocking, stratification, minimization)	4/21	19.0
		• Inclusion of aspects employed to help minimize potential bias induced due to nonrandomization (e.g., matching)	1/21	4.8
Blinding (masking)	9	• Whether or not participants, those administering the interventions, and those assessing the outcomes were blinded to study condition assignment; if so, statement regarding how the blinding was accomplished and how it was assessed	3/21	14.3
Unit of analysis	10	• Description of the smallest unit that is being analyzed to assess intervention effects (e.g., individual, group, or community)	15/21	71.4
		• If the unit of analysis differs from the unit of assignment, the analytical method used to account for this (e.g., adjusting the standard error estimates by the design effect or using multilevel analysis)	2/21	9.5
Statistical methods	11	• Statistical methods used to compare study groups for primary outcome(s), including complex methods for correlated data	20/21	95.2
		• Statistical methods used for additional analyses, such as subgroup analyses and adjusted analysis	2/21	9.5
		• Methods for imputing missing data, if used	3/21	14.3
		• Statistical software or programs used	10/21	47.6
Result				

Participants flow	12	• Flow of participants through each stage of the study: enrollment, assignment, allocation and intervention exposure, follow-up, analysis (a diagram is strongly recommended)	4/21	19.0
		• Enrollment: the numbers of participants screened for eligibility, found to be eligible or not eligible, declined to be enrolled, and enrolled in the study	8/21	38.1
		• Assignment: the numbers of participants assigned to a study condition	20/21	95.2
		• Allocation and intervention exposure: the number of participants assigned to each study condition and the number of participants who received each intervention	21/21	95.2
		• Follow-up: the number of participants who completed the follow-up or did not complete the follow-up (i.e., lost to follow up), by study condition	10/21	47.6
		• Analysis: the number of participants included in or excluded from the analysis, by study condition	13/21	61.9
		• Description of protocol deviations from study as planned, along with reasons	9/21	42.9
Recruitment	13	• Dates defining the periods of recruitment and follow-up	3/21	14.3
Baseline data	14	• Baseline demographic and clinical characteristics of participants in each study condition	15/21	71.4
		• Baseline characteristics for each study condition relevant to specific disease prevention research	7/21	33.3
		• Baseline comparisons of those lost to follow-up and those retained, overall and by study condition	2/21	9.5
		• Comparison between study population at baseline and target population of interest	1/21	4.8
Baseline equivalence	15	• Data on study group equivalence at baseline and statistical methods used to control for baseline differences	10/21	47.6
Numbers analyzed	16	• Number of participants (denominator) included in each analysis for each study condition, particularly when the denominators change for different outcomes; statement of the results in absolute numbers when feasible	18/21	85.7
		• Indication of whether the analysis strategy was "intention to treat" or, if not, description of how noncompliers were treated in the analyses	2/21	9.5
Outcomes and estimation	17	• For each primary and secondary outcome, a summary of results for each study condition, and the estimated effect	2/21	9.5

		size and a confidence interval to indicate the precision		
		• Inclusion of null and negative findings	9/21	42.9
		• Inclusion of results from testing prespecified causal pathways through which the intervention was intended to operate, if any	3/21	14.3
Ancillary analyses	18	• Summary of other analyses performed, including subgroup or restricted analyses, indicating which are prespecified or exploratory	1/21	4.8
Adverse events	19	• Summary of all important adverse events or unintended effects in each study condition (including summary measures, effect size estimates, and confidence intervals)	4/21	19.0
Discussion				
Interpretation	20	• Interpretation of the results, taking into account study hypotheses, sources of potential bias, imprecision of measures, multiplicative analyses, and other limitations or weaknesses of the study	10/21	47.6
		• Discussion of results taking into account the mechanism by which the intervention was intended to work (causal pathways) or alternative mechanisms or explanations	15/21	71.4
		• Discussion of the success of and barriers to implementing the intervention, fidelity if implementation	9/21	42.9
		• Discussion of research, programmatic, or policy implications	9/21	42.9
Generalizability	21	• Generalizability (external validity) of the trial findings, taking into account the study population, the characteristics of the intervention, length of follow-up, incentives, compliance rates, specific sites/settings involved in the study, and other contextual issues	7/21	33.3
Overall evidence	22	• General interpretation of the results in the context of evidence and current theory	12/21	57.1

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

Items	Practice; N(%)		
	Yes	No	Unclear
1. Was the generation of allocation sequences adequate?*	-	-	-
2. Was the treatment allocation concealed?*	-	-	-
3. Were details of the intervention administered to each group made available?[a]	17 (81.0%)	3 (14.3%)	1 (4.7%)
4. Were care providers' experience or skill[b] in each arm appropriate?[c]	7 (33.3%)	4 (19.1%)	10 (47.6%)
5. Was participant (i.e., patients) adherence assesed quantitatively?[d]	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 (i.e., 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 (i.e., 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)?[e]	0	19(100%)	0(0%)
9. Was thefollow-up schdule the same in each group?[f]	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%)

* First and second items were not described in order to RCT design.

[a] 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.)

[b] Care provider experience or skill will be assesed only for therapist-dependent interventions (i.e., interventions where the succcess of the treatment are directly linked to care provider's technical skill). For other treatment, this item is not relevant and should be removed from the checklist or answered "unclear."

[c] 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.

[d] Treatment adherence will be assessed only for treatments necessitating interventions (e.g., 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."

[e] 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 assesed by an independent outcome assessor traind to perform the measurements in a standardized manner, or if the outcome assessor was blinded to the study purpose and hypothesis

[f] 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."

Table 5 Future research agenda on aquatic exercise intervention

Item	Concrete agenda
Target disease* 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 the other dynamic intervention 2.Description of intervention cost

* The pain-relieving effect of chronic locomotorium diseases has already become clear from many RCTs.

Appendix

References to studies excluded in this review

No.	Author. Journal (Year)	Title	Reason of exclusion
E1	Bar-Or O. Phys Sport Med (2000)	Juvenile obesity, physical activity, and lifestyle changes	Review article
E2	Biering-Sørensen F, et al. Spinal Cord (2000)	Bacterial contamination of bath-water from spinal cord lesioned patients with pressure ulcers exercising in the water	Not intervention by aquatic exercise
E3	Darby LA, 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 E. MAMM (2000)	Aquatic exercise makes a splash	Program idea
E5	Jamison LJ. Rehab Management (2000)	Long-term rehab. The healing properties of water	Review article
E6	Sugano A, et al. J Physiol Anthropol Appl Hum Sci (2000)	Influence of water exercise and land stretching on salivary cortisol concentrations and anxiety in choronic low back pain patients	Cross-over design
E7	Watanabe E, 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 M. Midwifery Today (2001)	American AquaNatal: a midwifery-based holistic prenatal water exercise and educational program	Program idea
E9	Hartmann S, et al. Geburtsh Frauenheilk (2001)	"Aqua-Fit" during pregnancy: Maternal and fetal hemodynamic responses during rest, immersion and exercise	No control group
E10	Piso U, et al. Phys Med Rehabil Kuror (2001)	Analgesic effects of sauna in fibromyalgia	RCT
E11	Postollec ML. Back on Track (2001)	Back on Track Aquatic therapy can help patients with back pain resume normal activity	Program idea
E12	Shono T, et al. J Physiol Anthropol (2001)	Physiological responses to water-walking in middle aged women	Physiological responses (regulary experiment group vs. the other group)
E13	Watanabe E, 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 M, et al. Bul of Nurs College, Wakayama Med Univ	The effects of maintaining health by exercising in the water in middle to old-aged women	No control group
E15	Belza B, et al. Nus Res (2002)	Does adherence make a difference	RCT
E16	Huey L, et al. Best of Both Worlds (2002)	Combining aquatics with land exerciseeffectively reduces back pain	Program idea
E17	V.Kendrick Z, 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 SJ, et al. Sports Med (2002)	Aetiology of rib stress fractures in rowers	Review article
E19	Weinsier RL, et al. An J Clin Nutr (2002)	Free-living activity energy expenditure in women successful and un successful at maintaining a normal body weight	Not intervention by aquatic exercise
E20	Winter SV, 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 A, 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 K, et al. J Aquatic Health Med (2002)	Effect of aquatic exercise on lifestyle-related diseases in middle-aged women	No control group
E23	Campbell JA, et al. Med Sci Sports Exer (2003)	Metabolic and cardiovascular response to shallow water exercise in young and older women	Physiological responses
E24	Charitopoulos K, et al. J Human Mov Stud (2003)	Application of an aqua exercise programme in children with exercise induced asthma	No control group
E25	Driver S, 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 NC,et al. Arthritis Rheumatism (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 R, et al. Arch Phys Med Rehabil (2003)	Effects of arthritis exercise programs on functional fitness and percieved activities of daily living measures in older adults with arthritis	RCT
E29 Weidner S, et al. Aktuelle Rheumatoligie (2003)	Rheumatism and Sports	Review article
E30 Yurtkuran AA, 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
E31 Sugano A, 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	Study report
E32 Matsumoto T, et al. The Ann Reports Health Physl Educ sports Sci (2003)	Blood chemical values in elderly persons performing habitual aquatic exerxise	Cross-sectional study
E33 Benelli P, 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 CE. Activities Adaptation Aging (2004)	Water exerecise and its effect on balance and gait to reduce the risk of fallling in older	Cross-sectional study
E35 Preis C, et al.Fisioterapia em Movimento (2004)	Análise de um programa de execução de saltos múltiplos verticais no meio líquido e no	Biomechanical trial
E36 Roebrs TG, 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 T,et al. Kokushikan Soc Sport Sci(2004)	The effect of continuation term on BP at water exercise	Not retrospective comparison between aquatic exercise group and drop out group of aquatic exercise
E38 Ashida K, 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 Y, et al. Descente Sports Sci(2004)	Effects of weight reduction through dietary restriction and exercise training on blood fluidity in obese middle-aged women	Not intervention by aquatic exercise
E40 Higuma Y, et al. J Oita Med Assoc(2004)	Rehabolitation after TKA in a hospital	Cross-sectional study
E41 Barry Dale R, et al. RehabIL Manegement (2005)	Aquatic therapy offers benefits to a wide range of clinical populations	Review article
E42 CiderA, et al. Clin Physiol Funct Imaging (2005)	Cardiorespiratory effects of warm water immersion in elderly patients with chronic heart failure	Comparison between patients on health people
E43 Kelly M, et al. Development Med Child Neurol (2005)	Aquatic exercise for chirdren with cerebral palsy	Review article
E44 Kato T, 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 I, 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 N, et al. Arthritis Rheumatism (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 L, 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 S, 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 T, et al. Hip joint (2006)	Effect of underwater exercise for hip joint disease	Cross-sectional study
E50 Yano T, et al. Jpn J Phys Fitness Sports Med (2006)	Effect of fluid in ingestion on physiological response before walking in a pool	Not intervention by aquatic exercise
E51 Brody LT. J Aquatic Phys Ther (2007)	Aquatic physical therapy practice analysis	Practice Analysis
E52 Goodwin C. OT Practice (2007)	Exploring the effects of a swim program for clients with down syndrome	No control group
E53 Kang HS, et al. J Gerontol Nurs (2007)	Aquatic exercise in older Korean women with arthritis	No control group
E54 Kron J. Complementary Med (2007)	Water therapies	Review article

E55 M.McManus B. Pedia Phys Ther (2007)	The effect of aquatic therapy on functional mobility of infants and toddlers in early	RCT
E56 Magkos F, et al. Clin J Sports Med (2007)	The bone response to non-weight-bearing exercise is sport-, site-, and sex-specific	Cross-sectional study
E57 Schmid JP, 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 JS. Cardiol (2008)	A water-based exercise program for patients with coronary artery disease	Editorial comment
E59 Hujibregts MPJ, 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 C, 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 SP, et al. Cardiol (2008)	Training, detraining and retraining effects after a water-based exercise program in patients with coronary artery disease	RCT
E62 Colado JC, et al. Eur J Appl Physiol (2009)	Effects of aquatic resistance training on health and fitness in postmenopausal women	RCT
E63 Fragala-Pinkham MA, et al. Pedia Phys Ther(2009)	An aquatic physical therapy program at a pediatric rehabilitation hospital: a case series	Case report
E64 Laurent M, 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 JP, et al. Heart (2009)	Influence of water immersion, water gymnastics and swimming on cardiac output in patients with heart failure	Not intervention by aquatic exercise
E66 Souza Vale RG, 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	Not intervention by aquatic exercise
E67 Tolomio S, 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	Not intervention by aquatic exercise

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F.健康危険情報

なし。

G.研究発表

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H.知的財産権の出願・登録状況

なし。

厚生労働科学研究費補助金（健康安全・危機管理対策総合研究事業）
分担研究報告書

水中運動の効果と運動特性に関する研究

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研究要旨

【目的】安全かつ有効な健康増進・リハビリテーションの手段の一つとして普及している水中運動の中で、知見が示されていない水中での側方歩行の特性について、前方歩行と比較しながら、特に普及・啓発の対象である中高年の生理学的応答に着目して明らかにすることを目的とした。

【方法】対象は、55 歳～76 歳までの中高年成人女性 14 名であった。実験は、室内の 25m プールで室温、湿度、水温などが一定の条件に保たれた環境下で実施した。水中での前方歩行と側方歩行の運動特性を比較するために、それぞれの歩行方向について、3 段階の主観的運動強度（11「楽である」、13「ややきつい」、15「きつい」）で 4 分間ずつの歩行（各強度の間に 1 分間の休憩）を行った。前方歩行と側方歩行のどちらを先に行うかは被検者ごとにランダムに設定し、先に行った歩行の後に 30 分以上の十分な休憩時間を設けて、心拍数と乳酸で疲労回復の状況を確認した後に、次の歩行を実施した。測定項目のうち、酸素摂取量、心拍数は実験中常時モニタリングを行い、各強度での 4 分間の歩行の最後の 1 分間を分析対象データとした。血圧、乳酸は、各強度の歩行直後の休憩時に計測を行った。歩行時間と歩数は、各強度での 4 分間の歩行の最後の 1 分の中での 15m の歩行について計測した。得られたデータのクリーンアップを行ったところ、欠損なく全てのデータが揃った分析対象は 6 名となった。各項目で繰り返しのある二元配置分散分析により、水中歩行の方向と運動強度の関係を検証した。また、前年度に同様のプロトコールで行った若年男性のデータとも比較した。本研究実施にあたっては十分な倫理的配慮を行った。

【結果】水中での前方歩行、側方歩行それぞれにおける 3 段階の主観的運動強度での、酸素摂取量、体重あたり酸素摂取量、心拍数、血圧、乳酸、15mに要した歩行時間、15mに要した歩数の平均値を比較した結果、歩行方向による差は、体重あたり酸素摂取量、15m に要した歩行時間と 15m に要した歩数であった。前年度に実施した若年男性のデータとの比較では、拡張期血圧（前方、側方とも）と乳酸（前方のみ）で中高年女性との間に統計学的に有意な差が認められた。

【結論】中高年女性の水中での前方歩行と側方歩行で、若年男性と同様の運動学的な特性の違いがみられた。一方、主観的運動強度による同一の指示に対する生理学的な応答は、若年男性と異なる傾向がみられた。

キーワード：水中歩行、側方、主観的運動強度、中高年

A. 研究目的

安全かつ有効な健康増進・リハビリテーションの手段の一つとして普及している水中運動について、その効果と限界、運動特性に関して、実験による新たな知見を得ることで、より適性で安全な水中運動の運動処方と合理的指導の普及に役立て、今後の健康づくり運動の実践内容等の充実に結びつけることは重要である。

水中運動の中でも、中高年者を対象に最も普及している形態が水中歩行である。水中歩行は前方・後方・側方が基本となり、後方歩行に関する知見は先行研究(Masumotoら2007,2009)で得られているが、側方は明らかではない。

そこで、初年度の研究では健常な若年成人男性を対象とした水中運動実験を行い、水中での側方歩行の特性を、前方歩行との比較により明らかにした。今年度の研究では、初年度の知見をふまえて、普及・啓発の対象である中高年の生理学的反応に着目して、水中での側方歩行の特性を、前方歩行との比較により明らかにすることを目的とする。

B. 研究方法

【対象】

55歳～76歳までの中高年成人女性で、実験への協力に同意が得られた14名を対象とした。

被検者は、定期的に水中運動を行っており、喫煙歴がないこと、BMI でやせや高度肥満にでないこと（BMI 21.0～28.6, 平均23.7)、水深 1m が胸部水位の身長であること（身長144.4～162.7 cm, 平均153.6 cm)、を条件とした（表1)。

【実験環境】

一般に開放している室内温水プール（ケアポートみまき温泉アクティブセンター）内の25m プール（水深 1.0m、水温 31℃）で実験を行った。実験時の環境は、館内平均温度28.5℃（27.0～32.0) 、館内平均湿度 39.3%（33.0～42.0)、平均水温 30.9℃（30.8～31.0)であった。

【測定手順】

本研究は、水中での前方歩行と側方歩行の運動特性を比較するために、それぞれの歩行方向について、3段階の主観的運動強度（11「楽である」、13「ややきつい」、15「きつい」）で4分間ずつの歩行（各強度の間に1分間の休憩）を行った。前方歩行と側方歩行のどちらを先に行うかは被検者ごとにランダムに設定するとともに、先に行った歩行の後に、30 分以上の十分な休憩時間を設け、心拍数と乳酸で疲労回復の状況を確認した後に、次の歩行を実施した（図1)。

水中歩行は、片道25m のコースのうち15mの区間を往復する方法で行った（図2、3)。そして、歩行特性の比較の観点から、上半身に運動負荷をかけないようにするために、前方歩行時、側方歩行時ともに、上肢で極力水を掻かないように指示した。また、側方歩行時は足を交差させないようにした。全被検者はいずれの歩行時も、滑り止めのためにアクアシューズを装着した。

なお、本研究は主観的運動強度を用いて被検者に対する指示を出すために、実験当日を迎える前に練習の機会を設けて、主観的運動強度の指示による水中歩行の練習を行った。なお、疲労の影響も考慮して、練習日は実験当日の 2日以上前とした。また、実験協力の注意事項として、測定日2日前から激しい運動と飲酒を控えこと、実験実施3時間前から実験中は水以外の摂取を避けること、を条件とした。

【測定項目】

測定項目は、酸素摂取量（エアロソニックAT-1100、アニマ社、図4)、心拍数（バンテージNV、Polar社)、乳酸(Lactate Pro LT-1710、ARKRAY社）による、血圧、15mに要する歩行時間、歩数であった。

酸素摂取量、心拍数は実験中常時モニタリングを行い（図５）、各強度での４分間の歩行の最後の１分間の平均値を分析対象データとした。血圧、乳酸、は、各強度の歩行直後の休憩時に計測を行った。歩行時間と歩数は、各強度での４分間の歩行の最後の１分の中での15mの歩行について計測した。

【分析】

前方及び側方の３段階の運動強度での水中歩行をプロトコールとしたが、指示通りに実施できなかった４名は分析から除外した（表２）。さらに、酸素摂取量はノイズ処理（極端な変動数値の除外）を行うなどのクリーンアップを行ったところ、さらに４名が除外され、分析可能なデータ項目が全て揃う対象は６名となった（表１）。なお、乳酸測定値は実験機器の特性から、0.8mmol/l未満の数値は測定値の信頼性の観点から「Lo」と表示されるが、これについては全て「0.7mmol/l」に読み替えて分析した。

各測定項目の、３段階の運動強度による前方歩行と側方歩行の間での６名及び10名の平均値を、繰り返しのある二元配置の分散分析によって比較し、歩行方向による差、運動強度による差、歩行方向と運動強度の交互作用を検証した。

また、中高年女性の水中歩行時の生理学的応答の特徴を明らかにするために、前年度の同様の方法で実施した若年男性の水中歩行時の生理学的応答との比較を、二元配置分散分析により行い、対象間による差を検証した。

【倫理的配慮】

本研究実施にあたっては、身体教育医学研究所倫理審査委員会の承認を受けるとともに、大学病院医療情報ネットワークの臨床試験登録（UMIN-CTR）を行った（ID000001506）。

被検者に対して、途中で辞めたい場合には、いつでも可能であることや考えられるデメリットを含む研究計画を文書と口頭で十分に説明し、参加の承諾を文書で受けた。

C. 研究結果

中高年女性の水中での前方歩行、側方歩行それぞれにおける３段階の主観的運動強度（11「楽である」、13「ややきつい」、15「きつい」）での、酸素摂取量（mi/分）、体重あたり酸素摂取量（ml/分/kg）、心拍数（拍）、収縮期血圧（mmHg）、拡張期血圧（mmHg）、乳酸（mmol/l）、15mに要した歩行時間（秒）、15mに要した歩数（歩）の結果を表３（全データが揃った６名の分析）、表４（一部のデータがない10名の分析）に示した。

全測定項目のデータが揃う６名について、繰り返しのある二元配置分散分析の結果、歩行方向によって統計学的に有意な差が認められたのは、体重あたり酸素摂取量（$p=0.045$）、15mに要した歩行時間（$p<0.001$）と15mに要した歩数（$p=0.004$）の３項目であった。一方、主観的運動強度による差は、収縮期と拡張期血圧及び15mに要した歩数を除く全ての項目で認められた。歩行方向と主観的運動強度で交互作用が認められたのは、15mに要した歩行時間のみであった。10名のデータでの分析が可能であった測定項目で６名での分析結果と検定の結果が異なったのは、収縮期血圧で主観的運動強度による差が認められたことのみであった。

また、今年度の中高年女性６名と前年度の若年男性10名について繰り返しのある二元配置分散分析を行った結果、拡張期血圧（前方、側方とも）を除く全ての測定項目で主観的運動強度による差が認められたが、中高年女性と若年男性間では、拡張期血圧（前方、側方とも）、乳酸（前方のみ）で統計学的に有意な差が認められ、体重当たり酸素摂取量（前方のみ）、収縮期血圧（前方のみ）、15mに要した歩数（前

方のみ）には有意水準 10%未満の傾向差を認めた。

D. 考察

中高年女性を対象として、主観的運動強度により、3段階の強度に規定した水中での前方歩行と側方歩行を比較したところ、各運動の特性の違いが明らかになった。

まず、両者の明らかな違いは運動学的特性であり、歩数は、側方歩行の方が前方歩行よりも少なく、歩行速度は、側方で運動強度の上昇による速度の上がり方が大きかった。

また、体重当たりの酸素摂取量が側方よりも前方歩行時に統計学的に有意に高い結果であり、前方歩行で主観的運動強度が高くなるほど全身運動としての負荷が強くなる、と推測された。

次に、同様のプロトコールで実施した前年度の若年男性と今年度の中高年女性の生理学的応答を比較したところ、最も顕著な違いは拡張期血圧であった。血圧値が若年男性に比べて中高年女性で高く、また運動強度の上昇に伴う変化が、若年男性で微減、中高年女性で微増の傾向を示した。また、前方歩行時において、乳酸値が統計学的に有意に高く、体重当たり酸素摂取量と収縮期血圧も高い傾向であった。

これらの結果のうち、中高年女性の拡張期血圧が高かった原因は、加齢に伴う身体特性の変化（動脈壁進展性の低下や自律神経系の働きなど）が考えられた。一方、前方歩行時に中高年女性で運動負荷（体重当たり最大酸素摂取量、乳酸）が高いことは、主観的運動強度と実際にかかっている運動負荷との乖離とも捉えられ、加齢による感覚の鈍化や、熟練者の慣れによる影響なども考えられた。

本実験から、中高年女性の水中歩行は、若年男性と同様に、歩行方向によって運動学的な歩行パターンが明らかに異なることが示された。一方、年齢によって水中歩行時の呼吸循環系の応答が異なる傾向が示され、今後、安全で効果的な水中運動を普及・啓発していくうえで有用な知見を得たと言える。

E. 結論

中高年女性の水中での前方歩行と側方歩行で、若年男性と同様の運動学的な特性の違いがみられた。一方、主観的運動強度による同一の指示に対する生理学的な応答は、若年男性と異なる傾向がみられた。

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F. 健康危険情報

該当せず。

G. 研究発表

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H. 知的財産権の出願・登録状況

なし

表１　被検者と分析対象者の属性

	被検者（14名）	全データ分析対象者（6名）
年齢（歳）	65.1 ± 5.8 (55 - 76)	64.2 ± 7.0 (56 - 76)
身長（cm）	154.0 ± 5.8 (144.4 - 162.7)	153.8 ± 5.9 (149.3 - 162.0)
体重（kg）	56.5 ± 7.8 (45.4 - 73.8)	57.6 ± 8.8 (47.2 - 73.8)
BMI	23.8 ± 2.2 (21.0 - 28.6)	24.3 ± 2.8 (21.2 - 28.6)

平均値±標準偏差（最小値-最大値）

表２　分析除外の理由

【プロトコール通りに実施できなかったケース】

No. 01：前方歩行時のＲＰＥ13で、心拍数が150拍を超えたため、ＲＰＥ15を行わなかった。

No. 03：前方歩行時のＲＰＥ11で、4分の中で段階的に速度を上げた（一定ではなかった）。

No. 06：時間的な都合により、側方歩行が実施できなかった。

No. 10：前方歩行時に疲労感が強かったため、途中で中止した。

【プロトコール通りに実施したが、ノイズのためデータが使用できなかったケース】

No. 02, 04, 05, 14

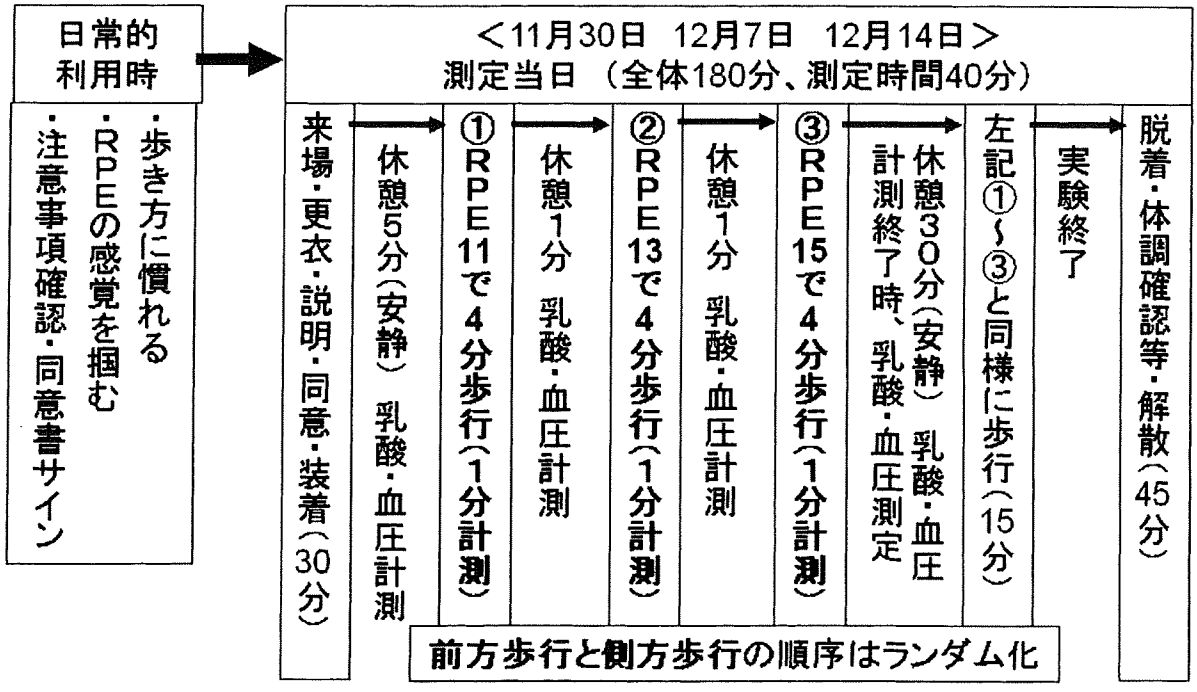

図１　実験のプロトコール

図２　水中歩行中の測定の様子

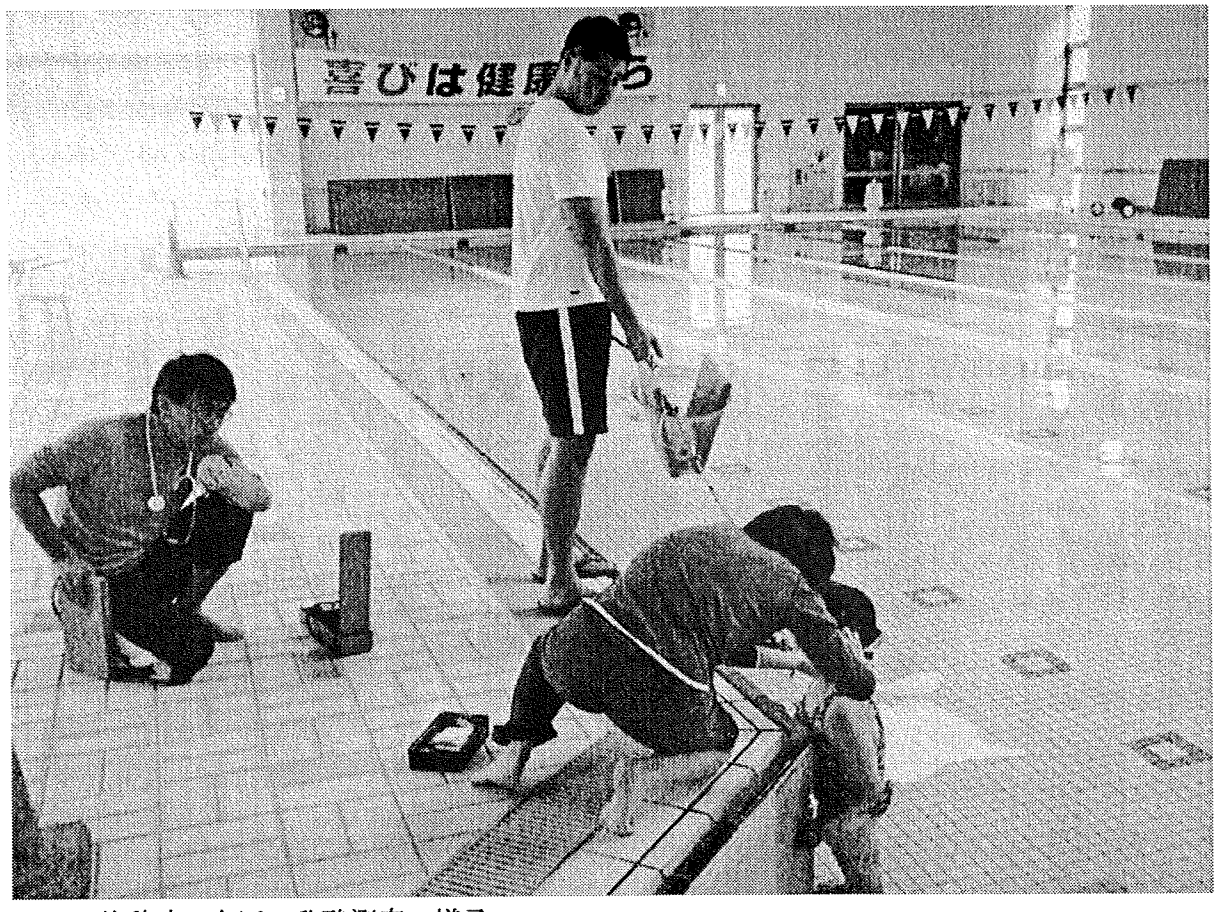

図３　休憩時の血圧・乳酸測定の様子