Effects of 24-Week Land- and Water Walking Interventions on Body Composition in Older Adults

Authors:

Louise H. Naylor [1], Barbara A. Maslen [1], Kay L. Cox [1,9], Angela L. Spence [2], Elisa Robey [1], Howard H. Carter [3], Nicola T. Lautenschlager [4-6], Nicola D. Ridgers [7], Carmela Pestell [8], Daniel J. Green [1]

[1] School of Human Sciences (Exercise and Sport Science), The University of Western Australia, Perth, WA, Australia
[2] School of Physiotherapy and Exercise Science, Curtin University, Perth, WA, Australia
[3] Department of Nutrition, Exercise and Sports, University of Copenhagen, Copenhagen, Denmark
[4] Academic Unit for Psychiatry of Old Age, Department of Psychiatry, The University of Melbourne, Melbourne, VIC, Australia
[5] North Western Mental Health, Melbourne Health, Melbourne, VIC Australia.
[6] School of Psychiatry & Clinical Neurosciences and WA Centre for Health & Ageing, University of Western Australia, Perth, WA, Australia
[7] Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Deakin University, Geelong, Australia
[8] School of Psychological Science, University of Western Australia, Perth, WA, Australia
[9] School of Medicine, University of Western Australia, Perth, WA, Australia

Corresponding author: Daniel Green. The University of Western Australia M408, Nedlands WA 6009, Australia. Phone +61-8-6488 2361. E-mail: danny.green@uwa.edu.au

Trial registration: This study was a registered clinical trial (ACTRN12614000017628)

ABSTRACT

Introduction: Increasing physical activity is a priority worldwide, including for older adults who may have difficulty performing traditional forms of exercise. Water-based exercise may provide an alternative if the benefits are comparable. We compared the impact on body composition variables of 24-week water- versus land-walking interventions in healthy but inactive older adults. **Methods**: 72 participants (62.5 ± 6.8 yr) were randomised to a land-walking (LW), water-walking (WW) or control (C) group in a supervised centre-based program. The exercise groups trained 3 times/week at matched intensity, increasing from 40-45% to 55-65% HRR. Height, weight, body mass index (BMI), waist and hip girths were recorded, and dual X-ray absorptiometry (DXA) provided fat and lean tissue masses. Participants were re-assessed 24 weeks after completion of the intervention. **Results**: There were no significant changes in body mass or BMI following either exercise protocol, however central adiposity was reduced in both exercise groups, and the WW group increased lower limb lean mass. These benefits did not persist over the follow-up period; there was a general pattern for all participants to increase in fatness after cessation of the centre-based interventions. **Conclusion**: Exercise can confer beneficial effects on body composition which are not evident when examining weight or BMI. Both WW and LW improved body composition. Water walking can be recommended as an exercise strategy for this age group due to its beneficial effects on body composition which are similar to, or exceed, those associated with land-walking. For benefits to persist, it appears that exercise needs to be maintained.

Key Words: exercise, adiposity, older adults, aquatic exercise, lean tissue, physical activity

Exercise is recommended as an intervention that can have positive impacts on human health, including decreasing cardiovascular risk and amelioration of the detrimental physical effects of ageing and chronic diseases (1, 2). These effects may result, in part, from the influence of exercise on body weight and/or composition. However it has been suggested that exercise has relatively modest impacts on body weight and body mass index (BMI) in humans (3, 4). Whilst valid in the context of population studies and epidemiology, body weight and BMI may be relatively limited indices of the health benefits of exercise in individual subjects, since they provide no insight regarding changes in the composition and/or distribution of body mass. This is particularly relevant with regard to exercise training, since it can induce increases in lean tissue mass (e.g. skeletal muscle) that may mask decreases in body fatness. For this reason, contemporary studies of exercise training have focused on changes in body composition (fat vs lean tissue), alongside those in regional distribution (android, gynoid, visceral). The development of dual energy X-ray absorptiometry has greatly assisted in this regard (5, 6).

Current guidelines for physical activity recommend both aerobic and resistance components for optimal benefit (7-9). This recommendation recognises the distinct benefits of different exercise modalities on cardiovascular and musculoskeletal function. However, incorporation of both components into an exercise program involves substantial time commitment. Some previous studies have attempted to overcome this limitation, for example by incorporating both strength and aerobic exercises into a session of circuit training, with the aim of combining benefit (10). Nonetheless this approach assumes the availability of specialised equipment. In addition, such exercises may be challenging for specific population groups such as older, exercise-naïve adults. Furthermore, the World Health Organisation recommends that older adults who cannot participate in routine forms of physical activity should maintain participation to the extent that their abilities and conditions allow (9).

Upright water walking may provide a more appropriate approach to combining the benefits of aerobic and resistive exercise in older populations (11, 12) since the movement of the lower limbs against the water provides some degree of resistance, whilst also minimising the risk of falls and the possibility of joint and musculoskeletal injury.

To our knowledge, there are few randomised controlled trials comparing the impacts of water walking and land-based walking, performed at matched intensity, in humans (11, 12). The literature on non-swimming based aquatic exercise is dominated by "aquatic aerobic" type exercise and such studies have not typically adopted a randomised controlled trial (RCT) approach to compare the relative benefit of land versus water based exercise. Moreover, few have characterised the physiological effects on outcomes such as body composition. We therefore designed a 24-week, centre based and closely supervised RCT of exercise training interventions in which subjects were randomised to either an observational control group, versus land- or water-based walking program performed at matched intensity. In this paper we focus on the impacts of these interventions immediately following 24 weeks of training, and also after a further 24-week follow-up period, on outcomes including body composition and the distribution of lean and fat mass in older inactive adults. We examined a null hypothesis that interventions performed at the same relative intensity would induce similar changes in body composition and distribution.

METHODS

Participants

Seventy-two individuals (62.5±6.8 years) provided informed consent to participate in a 24-week exercise/control program. Participants were randomised to a land-walking (LW), water-walking (WW) or an education (control - C) group. The participants were healthy but inactive, with an initial exercise level of less than 60 minutes of moderate or higher intensity exercise per week. Baseline characteristics for each intervention group are recorded in Table 1. More detailed participant information including the consort diagram and methods are available in an earlier report (13); in brief, potential participants were community-dwelling, aged 50 years or older and female participants were postmenopausal. Potential participants were all subjective memory complainers as described in our methods paper (13) and were excluded if they had pre-existing medical conditions, including those that would contra-indicate exercise, or if they were taking medications that were likely to confound the outcome measurements for the study.

Ethical Approval

The study was approved by the UWA Human Research Ethics Committee, and conformed to the standards set by the Declaration of Helsinki. All participants provided written, informed consent before any assessments being performed. This study was a prospectively registered clinical trial (ACTRN12614000017628).

Intervention Protocols

The exercise was supervised and centre-based, with sessions three times per week. Water walking took place in a heated (28-30 °C), chest-deep swimming pool on the university grounds; land walking was within the university grounds as well as the adjacent river foreshore recreation area. The exercise intensity was based on individual heart rate reserve (HRR) values (13), following an initial graded maximal exercise test on a treadmill. Studies of the acute effects of walking in water have demonstrated that, at matched heart rates, there is a similar oxygen cost relative to walking in air (14, 15), suggesting that the use of heart rate as a tool for exercise prescription is valid and feasible. HRR takes into account differences between participants in resting heart rate, and has been recommended in preference to percentage of HR maximum by the American College of Sports Medicine (16). Water walking and land walking groups performed one interval and two continuous exercise sessions per week, at the same heart rate intensity. Heart rate was measured continuously during each session using a Polar RS300X HR monitor (Polar Electro Oy, Finland).

The exercise sessions initially comprised 15 minutes of exercise at an HRR of 40-45%, building to 50 minutes at 55-65% HRR over the course of the study. Heart rates were monitored and recorded by the trainers every five minutes during the session with the mean HR over 50 minutes used to determine the %HRR. Participants were given the opportunity to make up any missed sessions in order to maximise adherence. After the 24-week exercise intervention and subsequent assessments, the study continued for a further 24-week 'post' period. During this phase, the LW and WW groups were free to exercise or not, of their own volition. Apart from the addition of the exercise sessions the LW and WW groups were asked to maintain their usual lifestyle behaviours throughout the study.

The control group attended the university four times during the first 24 weeks to maintain involvement with the research team and to account for any potential Hawthorne effects. These visits involved participation in an informal educational seminar on a topic which was expected to be of interest, but unrelated to physical activity (e.g. Basic First Aid and CPR). This group was requested to maintain their baseline activity level and lifestyle throughout the course of the study, but no contact with the university was required during the second 24 weeks of the study.

Assessments

A graded exercise test was undertaken at baseline on a treadmill. The protocol comprised 3-minute continuous stages with continuous 12-lead ECG monitoring, with treadmill speed and grade increasing throughout the test. The test was complete when the participant reached volitional exhaustion and peak HR was assessed as the highest value recorded during the final stage of exercise.

All other baseline testing was repeated at the end of the intervention (24 weeks) and again at the end of the follow-up period (48 weeks). Height and weight were measured with the subject barefoot in lightweight clothing. The same highly accurate digital scales (CPWplus-200, Adam Equipment, Oxford CT, USA) were used throughout the study. Waist and hip circumferences were measured three times using a constant-tension tape (Lufkin W606PM, Cooper Industries, USA); the median measure was used for analyses. Dual X-ray absorptiometry (DXA, Lunar Prodigy Advance, GE Healthcare, Madison, WI, USA) was used to determine segment and whole-body fat and lean tissue masses. In addition, DXA assessment provides measures of fat distribution for android and gynoid regions. The android region reflects a more central abdominal adiposity, whereas the gynoid region includes more peripheral fat distribution encompassing the lower hip and upper thigh regions.

Representative weekly physical activity was measured at each assessment time point using an ActiGraph accelerometer (ActiGraph GT1M, Pensacola, FL, USA) for a continuous 8 day period, to control for changes in free-living physical activity. The accelerometer was attached to an elasticised strap, and placed over clothing, on the right hip bone. A diary was used to record hours of wear. ActiGraph data were analysed using a customised Excel macro by a member of the research team (NR) who was blinded to group allocation. Freedson adult cut points (17) were used to classify the data into periods reflecting sedentary, light, moderate, moderate-to-vigorous and vigorous physical activity.

Statistical Analysis

Analyses were conducted using SPSS v23 and STATA v15. Data were analysed on an intent-to-treat basis. Due to the correlated and repeated measure nature of the data, separate linear mixed models were used to investigate the relationship between the body composition variables, group (control, land-based walking, water-based walking) and time (baseline and 24 weeks), while accounting for time-invariant covariates (age and sex), and interactions between group and time. A random intercept was included in each model to account for the repeated nature of the data. The analyses were repeated to test the maintenance of the intervention effects (24 weeks to 48 weeks). Statistical significance was set at $p \leq 0.05$. For those who had complete data at baseline and 24 weeks, and 24 and 48 weeks, unadjusted means, standard deviations and confidence intervals were calculated for the body composition outcome variables (Tables 2 and 3).

RESULTS

One of the land-walking participants withdrew for personal reasons after randomisation, and requested their data be destroyed. Intention-to-treat analysis was therefore based on the remaining 71 participants. The groups were well balanced on baseline characteristics (Table 1). Retention of participants was very good, overall 12 participants withdrew at various stages of the study (13). From 71 participants at baseline, 63 (88.7%) completed the 24 week testing and 60 (84.5%) completed the 48 week testing. In accordance with accepted statistical practice, data in the figures is based on the mixed model analysis for the 71 subjects who attended the baseline assessment. The mean data presented in Table 2 summarise the 24-week intervention phase of the study and are based on those participants who had complete data for baseline and 24 weeks. Table 3 summarises the post-intervention follow-up and includes mean data for those who had complete data at both 24 and 48 weeks.

Adherence to the exercise program was similar across the land- and water-walking groups, with mean attendance rates of 83.2 ± 4.7% for the land-walking and 79.2 ± 4.8% for the water-walking group. Training intensity did not differ between groups over the course of the 24 weeks (supplementary Figure 1), and was in accordance with the heart rate intensities dictated by the protocol.

Exercise intervention effects

Body mass, BMI and Anthropometry. There were no significant differences between the land-walking, water-walking and control groups for changes in total body mass (Figure 1A, 2A) after the 24-week intervention period. Accordingly, changes in BMI did not differ between the groups as a result of the exercise intervention (Table 2). Mixed models analysis revealed a significant group x time interaction for waist circumference (Figure 1B, 2B) over the 24 week intervention period. Waist circumference decreased over the course of the intervention for the land-walking group in comparison to the control group (P=0.008); the difference between WW and C groups was not significant. Hip circumference did not change significantly as a result of the intervention (Table 2). In accordance with these results, the waist-to-hip ratio (Figure 1C, 2C), an index of body mass distribution, was also associated with a group x time interaction (P=0.014), with a reduction in the land-walking group compared to the control group over the 24-week intervention.

Body composition changes: DXA results. The DXA analysis provided estimates of lean and fat tissue masses for the whole body and separate body segments (trunk, lower limbs etc.). Whole body, android and gynoid absolute fat masses are presented for each group in Figure

1D-F, with the change over the 24-week intervention presented in Figure 2D-F, and percent fat values given in Table 2. A significant group x time effect was observed for android fat over the course of the exercise intervention, whether expressed as a percentage of total mass or an absolute mass in kilograms. The water-walking group showed a significant decline in mass of android fat (*P*=.028; Figure 1E) as well as android fat expressed as a percentage of total body fat (*P*=.031; Table 2) in comparison to the control group. There were no statistically significant differences between land-walking and control groups for these parameters, and no significant changes in whole body or gynoid region fat masses.

Whole body, trunk and lower limb lean masses are presented in Figure 1G-I with the change over the course of the intervention presented in Figure 2G-I. Mixed models statistical analysis revealed a significant increase in the lean tissue mass of the lower limbs for the water-walking group compared to the control group over the course of the intervention (*P*=.019; Figure 1I). There were no statistically significant differences between land-walking and control groups.

Post exercise follow-up

After completion of the 24 week exercise/control group intervention, a follow-up 'post' phase of a further 24 weeks was completed such that participants were re-assessed at 48 weeks (see Table 3 and Figure 3). This post phase enabled assessment of the maintenance of any body composition changes as a result of the initial 24-week interventions. Total body fat percent showed a statistically significant increase over the follow-up period (*P*=0.028; Figure 3C,D) along with percent fat of the lower limbs (*P*=0.035; Figure 3E,F). There was also a significant increase in total body fat in absolute terms (*P*=0.035; Table 3). Mixed models analysis of the 24-48 week data did not reveal any time x group interactions, therefore there was no evidence of maintenance of the intervention effect on body composition changes.

Analysis of the ActiGraph free-living physical activity data collected at baseline, 24 and 48 weeks revealed no significant change across the course of the study in sedentary time, light-, moderate-, moderate-to-vigorous or vigorous-intensity activity undertaken outside the formal exercise sessions in any group.

DISCUSSION

We designed a RCT to compare the impacts of a 24-week intervention involving either moderate intensity land or water based walking, performed at matched heart rates, in healthy but inactive older adults. Our findings suggest that, although there were no changes in gross measures of body weight or BMI in either group compared to the controls, both types of exercise had beneficial effects on body composition. Both LW and WW were associated with significant decreases in measures of central adiposity. LW decreased waist circumference and waist-to-hip ratio relative to controls, whilst WW decreased android fat. Lean tissue mass in the lower limbs increased in both groups, with significant differences in the WW group relative to controls. These findings indicate that exercise at matched HR intensity enhances body composition, an outcome which, in keeping with previous studies, is not apparent in body weight indices due to the countervailing impacts of exercise on lean and fat mass compartments.

Aging is associated with decreased muscle mass and increased fat mass in humans (18). Overweight and obesity are now highly prevalent in Western societies, with as many as 70% of older adults exhibiting higher than ideal BMI (19). Whilst height and weight are readily obtained measures, the age-related decrease in skeletal muscle mass is less easily assessed, but is nonetheless an important issue given the relevance of skeletal muscle to activities of daily living (20), falls prevention (21) and glucose homeostasis (22). Whilst relatively ineffective in terms of change in gross body weight (and BMI), exercise interventions can decrease body fat (2) and increase muscle mass (23), with associated benefit for metabolic health as people age. Regular large muscle group dynamic exercise, or aerobic exercise, is associated with enhanced fitness and cardiopulmonary function (24), whereas resistive exercises typically target skeletal muscle mass and function (25, 26). An ideal exercise is one that is time efficient, combines the benefits of aerobic and resistance exercise in terms of both cardiopulmonary and skeletal muscle function and is, above all, safe to administer in older and frail participants. Due to the resistance associated with walking through water, we speculated that our WW intervention might induce beneficial changes in body composition and distribution relative to a non-exercise control group, and land-based walking performed at similar intensity (%HRR). Whilst our findings provide evidence for the benefits of both LW and WW compared to doing no exercise, they can be interpreted as supporting the use of WW over LW since the former was associated with decreases in android fat *and* increased lower limb muscle mass. Water walking is also a safer alternative, given the decreased joint loading and likelihood of fall-related injuries associated with this modality.

There are few previous randomised controlled trials directly comparing water and land based walking in older adults, particularly of a substantial duration with centre-based and supervised activity and high compliance. There is an established literature focused on exercise in water (27, 28), but this has often been related to water activities (e.g. "aerobics") that are difficult to compare to equivalent land-based exercises. One strength of our study was the simplicity of the interventions (i.e. walking) which allowed for valid group comparisons. We chose to match intensity using %HRR, due to the availability of HR assessment, the validity of exercise prescription based on individualised HR_{max} data derived from graded exercise testing and because our previous studies of the impact of water immersion on hemodynamics suggest a similar relationship between HR and oxygen consumption in water and land based walking (15). Some previous studies of water walking effects on body composition have indicated that water-walking can be effective for improving body composition. In a recent study by Lee and colleagues (12), 24 weeks of aquatic exercise or land-or treadmill-based walking in cardiac rehabilitation patients elicited reductions in percent body fat compared to controls, without concomitant changes in body mass. Gappmaier and colleagues (11) also reported improvements in body composition following 13 weeks of water walking in obese women. Participants in that study showed significant reductions in body mass, however this intervention also incorporated dietary restriction. Both of these studies utilised bioimpedance scales, skinfolds or underwater weighing techniques to assess body composition. The use of DXA analysis for body composition enabled us to more accurately assess changes in fat and lean tissue for different body regions. DXA has been shown to be a more reliable method than bioimpedance for the measurement of body composition (29), and provides data at a body-segment level, whereas underwater weighing and bioimpedance provide whole-body estimates only.

Dual energy X-ray absorptiometry is currently considered to be an optimal approach for assessing body composition and change in regional lean and fat distribution in humans. Our DXA findings, along with assessment of waist girth, are indicative of beneficial visceral fat mass changes (waist girth, android adiposity) as a result of both of our exercise interventions. Visceral fat is associated with detrimental cardiometabolic sequelae, including insulin resistance, lipid profile abnormalities and the development of type 2 diabetes (30-33). Effective targeting of this compartment of fat mass is a clinically relevant finding of our study. A recent meta-analysis of the impacts of aerobic and resistance exercise training suggested beneficial impacts of the former, but not necessarily the latter, in terms of decrease in visceral fat (34). The authors concluded that interventions targeting visceral fat mass should emphasise aerobic training. Our findings suggest that walking exercise undertaken in the water benefits central adiposity, but also improves leg lean mass. Human skeletal muscle represents the body's largest reservoir for glucose disposal (22), with a specific glucose transporter (GLUT4) activated with muscular contraction (35). WW therefore appeals as an intervention that may combine the benefits of reduction in visceral fat alongside preservation or increase in skeletal muscle hypertrophy.

Our study design allows some inference to be drawn regarding the maintenance of exercise training effects. Across the 24-48 week time period subjects were no longer in contact with the study staff and desisted from attending supervised exercise sessions. No specific direction was given to the participants in relation to this follow-up stage; they were free to exercise or not. It was of interest to see whether these formerly inactive participants maintained the change in activity levels associated with the supervised training interventions, particularly as we observed excellent adherence during the interventional phase. Analysis of the Actigraph results suggested that there were no systematic changes in free-living physical activity over the intervention and post phases of the study, hence the changes we observed were likely due to the exercise intervention *per se,* with no systematic alteration or carry-over of volitional exercise. These data suggest that the maintenance of benefits associated with body composition requires the ongoing exposure to the stimulus of exercise (Figure 5).

This study has several strengths and also some limitations. Centre-based programs benefit from intensive supervision and optimisation of compliance with the prescriptive components of an exercise intervention. Our findings are therefore likely to be robust in terms of the differences we observed between experimental and control groups. However, our findings are not necessarily translatable to subjects in the community, who are not always supported or supervised in their pursuit of exercise. Indeed, this is reinforced by our post-intervention follow-up data, which suggests that exercise needs to be sustained for the body composition benefits to endure. Our study was formally and independently randomised (13), and we did not specifically discriminate during recruitment. More women than men were recruited and, although the proportion was similar between groups, a sub-group analysis of sex differences was not possible due to limited power. Finally, we did not design this study as a comprehensive lifestyle modification program, rather it deliberately focused on the relative effects of two exercise training modalities. As we did not include a robust assessment of diet or dietary change across the intervention or subsequent follow-up period we cannot be sure that the changes in body composition were not due to dietary modification. However, diet-induced changes in body mass result in reductions in lean mass and as we did not observe any significant decrease in whole body lean mass, a change in dietary habits is unlikely to be an explanation for the changes in body composition we observed. Further, our observation of an increase in lower limb lean mass in the WW group compared to the control group supports the view that the exercise was the major contributor to the body composition changes.

CONCLUSION

Twenty-four weeks of either land-walking or water-walking in healthy but inactive older adults produced beneficial effects on body composition, which were not apparent when examining body mass or BMI in isolation. Anthropometric measurements and DXA assessment of whole-body and regional fat and lean tissue masses showed that both exercise interventions reduced measures of central adiposity, with reductions in waist circumference and waist-to-hip ratio evident in the land-walking group, and reductions in android fat for the water-walking group. In addition, the water-walking exercise program increased lean tissue mass of the lower limbs, an important finding given the reduction in lean mass that occurs with aging and that typically accompanies dietary interventions. Water-walking can therefore be considered a safer and preferred exercise modality for older adults, with body composition benefits similar, or superior to, those achievable from land-walking when both interventions are performed at a matched heart rate intensity.

Acknowledgements

This work was supported the National Health and Medical Research Council of Australia (1045204). DG is supported by a NHMRC Principal Research Fellowship (APP1080914). NR is supported by a National Heart Foundation of Australia Future Leader Fellowship (ID 101895). The authors would like to thank our research participants, exercise supervision staff and the research staff who contributed to the study.

Conflict of Interest

The authors have no conflicts of interest to declare. The results of the study do not constitute endorsement by the American College of Sports Medicine and are presented clearly, honestly and without fabrication, falsification, or inappropriate data manipulation.

Table 1. Baseline characteristics of the Control, Land-based and Water-based walking groups

	Control		**Land-walking**		**Water-walking**	
	n=23 (6M, 17F)		n=23 (6M, 17F)		n=25 (7M, 18F)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	62.1	(7.0)	62.7	(7.0)	62.6	(6.7)
Height (cm)	167.8	(9.6)	165.1	(8.0)	166.9	(7.2)
Body mass (kg)	73.8	(13.6)	74.4	(11.1)	76.8	(19.8)
BMI (kg/m^2)	26.2	(4.1)	27.3	(3.4)	27.3	(5.6)

Table 2. Body composition changes during the 24-week intervention period for control, land-walking and water-walking groups, compared to baseline values. Data are mean ± SD. (For primary variables, see Figures 2-3).

		Control n = 20		**Land-walking** n = 22		**Water-walking** n = 21	
		Mean	(SD)	Mean	(SD)	Mean	(SD)
Hip circumference (cm)	Baseline	102.9	(6.7)	104.4	(7.5)	103.9	(11.8)
	24 weeks	103.4	(6.8)	104.5	(7.5)	104.0	(11.5)
Lower limb fat (%)	Baseline	40.7	(11.0)	42.0	(11.5)	37.8	(8.6)
	24 weeks	40.8	(10.9)	41.2	(11.2)	36.8	(9.2)
Trunk fat (%)	Baseline	39.5	(8.4)	43.0	(6.1)	39.8	(9.3)
	24 weeks	39.3	(8.0)	42.3	(8.0)	38.4	(9.9)
Android fat (%) **	Baseline	43.8	(8.8)	48.1	(6.3)	44.4	(11.2)
	24 weeks	44.3	(8.9)	47.3	(6.8)	43.0	(9.1)
Gynoid fat (%)	Baseline	44.9	(9.1)	46.3	(9.5)	42.8	(7.7)
	24 weeks	44.9	(9.2)	45.8	(9.4)	41.9	(8.0)
Whole body fat (%)	Baseline	38.6	(8.4)	41.2	(7.6)	37.7	(7.7)
	24 weeks	38.6	(8.3)	40.5	(7.4)	36.6	(8.2)
Lower limb fat (kg)	Baseline	9.36	(2.86)	9.64	(3.51)	8.71	(3.77)
	24 weeks	9.45	(2.78)	9.51	(3.31)	8.73	(4.00)
Trunk fat mass (kg)	Baseline	14.3	(5.4)	16.0	(4.1)	15.7	(7.3)
	24 weeks	14.3	(5.2)	15.6	(4.4)	15.0	(7.4)

** Mixed models analysis revealed a significant group x time interaction for percent fat for the android region, with the difference evident between control and water walking groups (P=.031). Other variables did not show significant differences.

Table 3. Body composition changes over the 24 week follow-up 'post' period, for those participants who had data for both 24 and 48 week time points. Data are mean ± S.D.

		Control		**Land-walking**		**Water-walking**	
		n=20		n=19		n=18	
		Mean	(SD)	Mean	(SD)	Mean	(SD)
Body mass (kg)	24 weeks	73.5	(13.8)	73.2	(10.7)	72.1	(19.3)
	48 weeks	74.1	(13.9)	73.1	(11.2)	72.5	(11.3)
BMI (kg/m^2)	24 weeks	26.3	(3.8)	26.5	(3.0)	26.3	(6.0)
	48 weeks	26.5	(3.9)	26.5	(3.3)	26.4	(6.2)
Waist circumference (cm)	24 weeks	86.8	(11.8)	84.7	(11.8)	86.8	(16.3)
	48 weeks	86.8	(12.0)	85.6	(9.9)	87.8	(18.1)
Hip circumference (cm)	24 weeks	102.9	(7.1)	103.5	(6.2)	103.1	(12.8)
	48 weeks	103.2	(6.8)	104.0	(8.8)	103.0	(11.8)
Waist-to-hip ratio	24 weeks	0.844	(.098)	0.818	(.078)	0.837	(.077)
	48 weeks	0.841	(.100)	0.823	(.073)	0.846	(.088)
Whole body fat (%)*	24 weeks	38.6	(8.3)	39.9	(7.6)	36.7	(8.6)
	48 weeks	39.5	(7.9)	40.4	(7.7)	37.2	(8.0)
Lower limb fat (%)*	24 weeks	40.8	(10.9)	41.5	(11.6)	37.6	(9.3)
	48 weeks	41.6	(10.8)	42.2	(11.6)	38.3	(9.0)
Trunk fat (%)	24 weeks	39.3	(8.0)	41.3	(6.2)	37.9	(10.3)
	48 weeks	40.4	(7.5)	41.7	(6.1)	38.6	(6.1)
Android fat (%)	24 weeks	44.3	(8.9)	46.0	(6.3)	42.6	(10.9)
	48 weeks	44.9	(8.1)	46.3	(6.4)	43.1	(11.0)
Gynoid fat (%)	24 weeks	44.9	(9.2)	46.0	(9.6)	42.4	(8.3)
	48 weeks	45.6	(9.3)	46.9	(9.6)	43.0	(8.1)
Whole body fat (kg)*	24 weeks	27.0	(7.4)	27.9	(6.8)	26.3	(12.2)

	48 weeks	27.9	(7.4)	28.2	(7.3)	26.6	(12.1)
Lower limb fat (kg)	24 weeks	9.5	(2.8)	9.6	(3.3)	8.8	(4.2)
	48 weeks	9.5	(2.7)	9.7	(3.5)	8.7	(4.3)
Trunk fat (kg)	24 weeks	14.3	(5.2)	14.8	(3.9)	14.2	(7.2)
	48 weeks	14.8	(4.9)	15.0	(3.9)	14.5	(6.8)
Android fat (kg)	24 weeks	2.5	(1.1)	2.6	(0.7)	2.6	(1.4)
	48 weeks	2.6	(1.2)	2.6	(0.8)	2.6	(1.5)
Gynoid fat (kg)	24 weeks	5.0	(1.2)	5.1	(1.3)	4.7	(1.9)
	48 weeks	5.1	(1.2)	5.2	(1.5)	4.7	(1.8)
Whole body lean mass (kg)	24 weeks	43.4	(10.6)	42.1	(8.9)	42.8	(9.1)
	48 weeks	43.0	(10.3)	41.6	(8.9)	42.6	(9.5)
Lower limb lean mass (kg)	24 weeks	13.7	(3.1)	13.6	(3.3)	13.9	(3.2)
	48 weeks	13.4	(3.2)	13.2	(3.2)	13.3	(3.4)
Trunk lean mass (kg)	24 weeks	21.6	(5.6)	20.8	(3.7)	21.2	(4.3)
	48 weeks	21.5	(5.2)	20.7	(3.9)	21.5	(4.4)

* Mixed models analysis revealed significant time effects for lower limbs percent fat (P=.035); whole body percent fat (P=.028) and whole body absolute fat mass (P=.035); no other differences were statistically significant for the post-intervention period.

Figure Legends:

Figure 1 - Absolute changes in selected anthropometric and body composition variables during the 24-week intervention for control, land walking and water walking exercise groups. Values are presented as mean ± SEM. Mixed models analysis revealed significant group x time interactions for waist circumference, waist-to-hip ratio, android fat mass and lower limb lean mass; * $P < 0.05$. C, control group; WW, water-walking group; LW, Land-walking group.

Figure 2 - Mean changes in anthropometric and body composition variables corresponding to those in Figure 1 from baseline to 24 weeks for control, land walking and water walking groups. Values are presented as mean ± SEM. C, control group; WW, water-walking group; LW, Land-walking group; circ., circumference.

Figure 3 - Post-intervention changes (24 to 48 weeks) in waist circumference and percent fat mass of the whole body and lower limbs. Mixed models analysis revealed a significant time effect for whole body percent fat (P=.028), whole body absolute fat mass (P=.035, data not shown) and for lower limb percent fat (P=.035), for the end of the 24-week follow-up phase (48 week time point) compared to the end of the exercise intervention period (24 weeks). C, control group; WW, water-walking group; LW, Land-walking group.

References

1. Cartee GD, Hepple RT, Bamman MM, Zierath JR. Exercise Promotes Healthy Aging of Skeletal Muscle. Cell metabolism. 2016;23(6):1034-47. Epub 2016/06/16. doi: 10.1016/j.cmet.2016.05.007.
2. Pedersen BK, Saltin B. Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases. Scand J Med Sci Sports. 2015;25 Suppl 3:1-72.
3. Johns DJ, Hartmann-Boyce J, Jebb SA, Aveyard P. Diet or exercise interventions vs combined behavioral weight management programs: a systematic review and meta-analysis of direct comparisons. J Acad Nutr Diet. 2014;114(10):1557-68.
4. Swift DL, Johannsen NM, Lavie CJ, Earnest CP, Church TS. The role of exercise and physical activity in weight loss and maintenance. Prog Cardiovasc Dis. 2014;56(4):441-7]
5. Goedecke JH, Micklesfield LK. The effect of exercise on obesity, body fat distribution and risk for type 2 diabetes. Medicine and sport science. 2014;60:82-93.
6. Thibault R, Genton L, Pichard C. Body composition: why, when and for who? Clinical nutrition (Edinburgh, Scotland). 2012;31(4):435-47.
7. Australian Government DoH. Make your Move – Sit less – Be active for life! In: Health Do, editor. 2014.
8. Tremblay MS, Warburton DE, Janssen I, Paterson DH, Latimer AE, Rhodes RE, et al. New Canadian physical activity guidelines. Appl Physiol Nutr Metab. 2011;36(1):36-46; 7-58.
9. World Health Organization. Global Recommendations on Physical Activity for Health. Geneva: 2010.
10. Maiorana A, O'Driscoll G, Cheetham C, Dembo L, Stanton K, Goodman C, et al. The effect of combined aerobic and resistance exercise training on vascular function in type 2 diabetes. Journal of the American College of Cardiology. 2001;38(3):860-6.
11. Gappmaier E, Lake W, Nelson AG, Fisher AG. Aerobic exercise in water versus walking on land: effects on indices of fat reduction and weight loss of obese women. J Sports Med Phys Fitness. 2006;46(4):564-9.
12. Lee JY, Joo KC, Brubaker PH. Aqua walking as an alternative exercise modality during cardiac rehabilitation for coronary artery disease in older patients with lower extremity osteoarthritis. BMC cardiovascular disorders. 2017;17(1):252.
13. Green DJ, Cox KL, Badcock JC, Ainslie PN, Pestell C, Maslen BA, et al. Does manipulation of arterial shear stress enhance cerebrovascular function and cognition in the aging brain? Design, rationale and recruitment for the PREVENTIA randomised clinical trial. Mental Health and Physical Activity. 2018;15:153-63.
14. Evans BW, Cureton KJ, Purvis JW. Metabolic and circulatory responses to walking and jogging in water. Res Q. 1978;49(4):442-9.
15. Pugh CJ, Sprung VS, Ono K, Spence AL, Thijssen DH, Carter HH, et al. The effect of water immersion during exercise on cerebral blood flow. Medicine and science in sports and exercise. 2015;47(2):299-306.
16. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Medicine and science in sports and exercise. 2011;43(7):1334-59.
17. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. Medicine and science in sports and exercise. 1998;30(5):777-81.
18. Delmonico MJ, Harris TB, Visser M, Park SW, Conroy MB, Velasquez-Mieyer P, et al. Longitudinal study of muscle strength, quality, and adipose tissue infiltration. Am J Clin Nutr. 2009;90(6):1579-85.
19. Australian Institute of Health and Welfare. Healthy Communities: Overweight and obesity rates across Australia, 2015-15 (In Focus). Canberra2016.
20. Baumgartner RN, Wayne SJ, Waters DL, Janssen I, Gallagher D, Morley JE. Sarcopenic obesity predicts instrumental activities of daily living disability in the elderly. Obesity research. 2004;12(12):1995-2004.

21. Balogun S, Winzenberg T, Wills K, Scott D, Jones G, Aitken D, et al. Prospective Associations of Low Muscle Mass and Function with 10-Year Falls Risk, Incident Fracture and Mortality in Community-Dwelling Older Adults. J Nutr Health Aging. 2017;21(7):843-8.
22. DeFronzo RA, Jacot E, Jequier E, Maeder E, Wahren J, Felber JP. The effect of insulin on the disposal of intravenous glucose. Results from indirect calorimetry and hepatic and femoral venous catheterization. Diabetes. 1981;30(12):1000-7.
23. Distefano G, Goodpaster BH. Effects of Exercise and Aging on Skeletal Muscle. Cold Spring Harbor perspectives in medicine. 2018;8(3).
24. Lavie CJ, Arena R, Swift DL, Johannsen NM, Sui X, Lee DC, et al. Exercise and the cardiovascular system: clinical science and cardiovascular outcomes. Circ Res. 2015;117(2):207-19.
25. Brook MS, Wilkinson DJ, Smith K, Atherton PJ. The metabolic and temporal basis of muscle hypertrophy in response to resistance exercise. European journal of sport science. 2016;16(6):633-44.
26. McGlory C, Devries MC, Phillips SM. Skeletal muscle and resistance exercise training; the role of protein synthesis in recovery and remodeling. Journal of applied physiology (Bethesda, Md : 1985). 2017;122(3):541-8.
27. Barker AL, Talevski J, Morello RT, Brand CA, Rahmann AE, Urquhart DM. Effectiveness of aquatic exercise for musculoskeletal conditions: a meta-analysis. Arch Phys Med Rehabil. 2014;95(9):1776-86.
28. Waller B, Ogonowska-Slodownik A, Vitor M, Rodionova K, Lambeck J, Heinonen A, et al. The effect of aquatic exercise on physical functioning in the older adult: a systematic review with meta-analysis. Age Ageing. 2016;45(5):593-601.
29. Sillanpaa E, Cheng S, Hakkinen K, Finni T, Walker S, Pesola A, et al. Body composition in 18- to 88-year-old adults--comparison of multifrequency bioimpedance and dual-energy X-ray absorptiometry. Obesity (Silver Spring, Md). 2014;22(1):101-9.
30. Boyko EJ, Fujimoto WY, Leonetti DL, Newell-Morris L. Visceral adiposity and risk of type 2 diabetes: a prospective study among Japanese Americans. Diabetes Care. 2000;23(4):465-71.
31. Despres JP, Lemieux S, Lamarche B, Prud'homme D, Moorjani S, Brun LD, et al. The insulin resistance-dyslipidemic syndrome: contribution of visceral obesity and therapeutic implications. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 1995;19 Suppl 1:S76-86.
32. Despres JP, Moorjani S, Lupien PJ, Tremblay A, Nadeau A, Bouchard C. Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. Arteriosclerosis (Dallas, Tex). 1990;10(4):497-511.
33. Nguyen-Duy TB, Nichaman MZ, Church TS, Blair SN, Ross R. Visceral fat and liver fat are independent predictors of metabolic risk factors in men. American journal of physiology Endocrinology and metabolism. 2003;284(6):E1065-71.
34. Ismail I, Keating SE, Baker MK, Johnson NA. A systematic review and meta-analysis of the effect of aerobic vs. resistance exercise training on visceral fat. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2012;13(1):68-91.
35. Rose AJ, Richter EA. Skeletal muscle glucose uptake during exercise: how is it regulated? Physiology (Bethesda). 2005;20:260-70.