Scand J Med Sci Sports 2002: 12: 99–105
Printed in Denmark . All rights reserved

COPYRIGHT © MUNKSGAARD 2002 · ISSN 0905-7188
SCANDINAVIAN JOURNAL OF
MEDICINE & SCIENCE
IN SPORTS

Walking trials in postmenopausal women: effect of one vs two daily bouts on aerobic fitness

T-M. Asikainen, S. Miilunpalo, P. Oja, M. Rinne, M. Pasanen, I. Vuori

Urho Kaleva Kekkonen Institute for Health Promotion Research, Tampere, Finland

Accepted for publication 30 August 2001

We compared the effects of one vs two daily bouts of walking on aerobic fitness and body composition in postmenopausal women. One hundred and thirty-four subjects were randomized into exercise groups or a control group and 130 completed the study. The subjects walked 5 d/week for 15 weeks at 65% of their maximal aerobic power expending 300 kcal (1255 kJ) in exercise in one (Group S1) or two daily sessions (Group S2). VO_{2max} was measured in a direct maximal treadmill test. Body mass index (BMI) was calculated and the percentage of body fat (fat%) estimated using skinfold measurements. The net change in the VO_{2max} was 2.5 mL min/kg (95% CI 1.5, 3.5) (8.7%) in Group S1 and 2.5 mL min/kg (95% CI 1.5, 3.5) (8.8%) in Group S2. The net change in body mass was −1.2 kg (95% CI−1.9, −0.5) in Group S1 and −1.1 kg (95% CI −1.8, −0.4) in Group S2. The net fat% change was −2.1% (95% CI−2.7, −1.4) in Group S1 and −1.7% (95% CI−2.3, −1.0) in Group S2. Exercise improved the maximal aerobic power and body composition equally when walking was performed in one or two daily bouts.

The latest exercise recommendation of the American College of Sports Medicine (ACSM) (1998) states that adults should exercise 3–5 d/week at 40/50–80% of their maximum oxygen uptake reserve continuously for 20–60 min or accumulate the same amount of exercise in several daily bouts, for a minimum of 10 min, and expend 700–2000 kcal (2929–8368 kJ) weekly to gain positive effects on aerobic fitness and body composition (ACSM, 1998). The trend of exercise guidelines has been towards more frequent and more moderate exercise and also towards daily accumulation of exercise.

The theory of exercise accumulation is based mainly on epidemiological evidence. Only four randomized, controlled intervention studies (Ebisu, 1985; Jakicic et al., 1995; Murphy & Hardman, 1998; Woolf-May et al., 1999) with a total of 212 subjects support it. Some researchers regard the accumulation aspect of the latest ACSM exercise recommendations to be still speculative, because of sparse data (Barinaga, 1997; Hardman, 1999). More randomized, controlled dose–response studies with a sufficient amount of subjects in all age groups are clearly needed. There are no published studies on the accumulation hypothesis in postmenopausal women.

We conducted a randomized, controlled trial to compare the effects of equivolume brisk walking, once or twice a day, on aerobic fitness and body composition on 134 post-menopausal women. According to our hypothesis, both exercise groups should show similar and significant improvements in relation to a control group.

Material and methods

Design

The study was a randomized, controlled trial with three parallel groups: one (S1), two (S2) and no (C) daily walking sessions. The outcome measures were changes in maximal aerobic power, submaximal cardiorespiratory fitness and body composition. The study plan was approved by the Research Ethics Committee of the UKK Institute for Health Promotion Research. All the subjects gave their written informed consent.

Participants

The participants were recruited through an announcement in the local newspaper. A total of 700 subjects responded and 134 subjects fulfilled all the eligibility criteria and were accepted (Fig. 1).

The eligibility criteria were that the subjects were (1) female, and that at the time of the onset of the study should be (2) 2–10 years past the onset of menopause, (3) 48–63 years of age (4), no chronic diseases, (5) no regular medication, (6) non-smokers, (7) body mass index (BMI) < 32 kg/m, (8) resting blood pressure < 160/100 mmHg measured after 5 min bedrest, (9) not engaged in physically strenuous work or regular brisk leisure-time exercise more than once a week and (10) willing to continue previous diet and physical activity habits in addition to the exercise requirements of the study group. An equal number of women on hormone replacement therapy (HRT) and women without HRT were accepted.

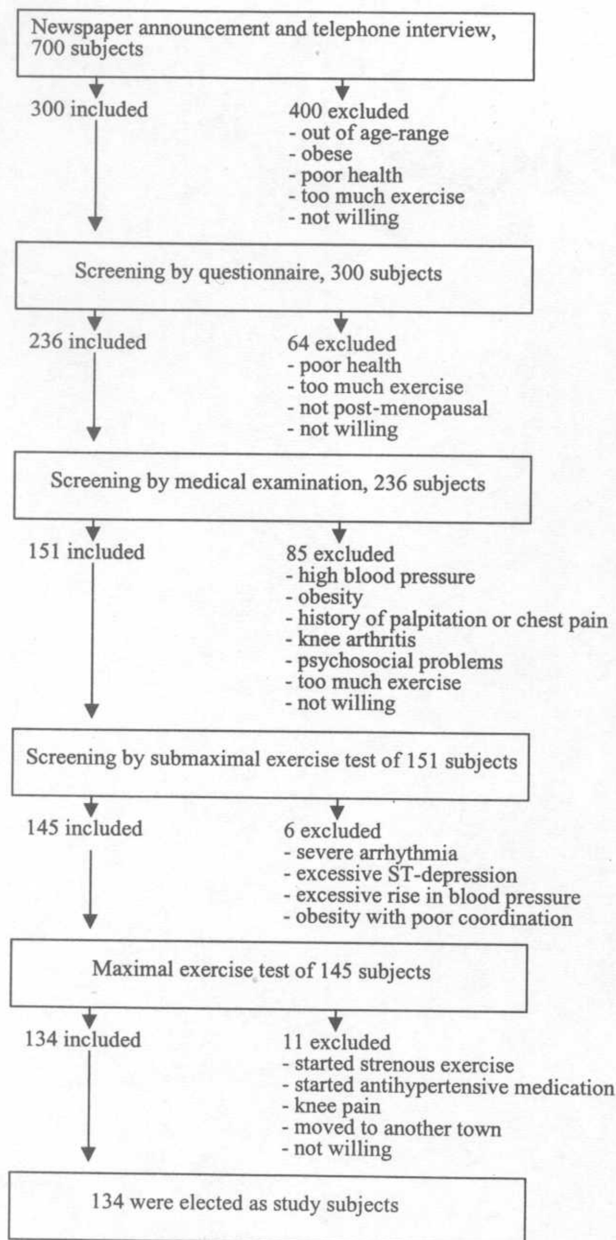

Fig. 1. Recruitment process.

Randomization

The HRT users and non-users were randomized separately in blocks of 15 subjects into the three groups, each including an approximately equal number of HRT users and non-users. The procedure yielded 46, 43 and 45 subjects in Groups S1, S2 and C, respectively (Fig. 2). The baseline characteristics of the subjects are shown in Table 1. The age range was 47–64 years, weight range 50–93 kg and BMI range 19–32.

Exercise intervention

The exercise program was planned according to the principles of the ACSM (1998) recommendation. The frequency of exercise was 5 d/week, the intensity 65% of the VO_{2max} and the weekly exercise volume 1500 kcal (6276 kJ). Daily training was continuous in Group S1 and divided into two equally long sessions with at least a 5-h interval in Group S2. Brisk walking was considered the most common and feasible form of sustainable dynamic aerobic exercise for sedentary subjects (Morris & Hardman, 1997) and was chosen as the mode of exercise. The minimum (15 weeks) recommended length for an intervention was chosen.

Table 1. Baseline characteristics of the subjects, means and standard deviations (SD)

	C	S1	S2
N	45	46	43
Age, years	56.5 (4.2)	57.8 (4.4)	57.6 (4.2)
Years from menopause	5.8 (2.0)	6.0 (2.2)	6.0 (1.8)
Weight, kg	67.0 (8.5)	67.6 (8.2)	67.9 (8.5)
BMI, kg/m	25.7 (2.8)	25.8 (2.7)	25.9 (2.8)
F percentage	37.2 (4.5)	36.9 (4.4)	37.1 (4.9)
$V0_2$ max, ml/kg	27.7 (3.5)	29.0 (3.8)	28.4 (3.6)
PA score (1)	2.5 (0.7)	2.6 (0.5)	2.6 (0.5)

(1) PA score = physical activity score (1–5).
1 = no regular PA weekly; 2 = some light PA every week; 3 = once a week brisk PA; 4 = twice a week brisk PA; 5 = three times a week or more brisk PA.

The individual target heart rate, corresponding to 65% of the VO_{2max}, was determined for each subject in the first maximal exercise test. The mean target heart rate was 132 (SD 10.7) beat/min in Group S1 and 130 (SD 11.2) beat/min in Group S2. The duration of daily exercise corresponding to 300 kcal (1256 kJ) was also calculated individually in the first maximal exercise test using the Weir formula, which estimates energy expenditure (kcal/min) from measured oxygen consumption (L/min) (Weir, 1949). The mean target duration was 46.6 (SD 5.4) min for Group S1 and 2×24.0 (SD 3.2) min for Group S2.

Two weekly walking sessions were supervised by an exercise leader on a 100-m indoor track. The other sessions, three for Group S1 and eight for Group S2, were unsupervised and took place according to the participants' preferences, on sidewalks, streets or forest trails or in parks. A heart rate monitor (Polar Edge, Polar Electro, Kempele, Finland) was used to control the walking pace in the 2-weekly supervised sessions and every third week in all weekly sessions. The participants, including those without the heart rate monitor, were also advised to record periodically the length of their walking route, in order to maintain the same relative pace in all weekly sessions.

The subjects in the exercise groups recorded their programmed exercise and also other habitual exercise in exercise diaries. They also wore step counters (Fitty 3, Kasper & Richter, Uttreuth, Germany) for 3 d, from Friday through Sunday, in the middle of the intervention period.

The supervised exercise sessions of both exercise groups included a light dynamic muscle workout for the main muscle groups (10 exercises in one set with 10 repetitions using 5-kg dumbbells or body mass as resistance) and flexibility exercises according to the ACSM (1998) guidelines as a warm-up and also for injury prevention. The flexibility exercises were repeated as a cool-down after walking. A few minutes of similar exercises were also recommended for use before and after the unsupervised exercise sessions.

Once a month the control group attended a meeting with lectures on health topics and a few minutes of light flexibility exercises. All the participants were asked to keep their previous diet, daily exercise habits and use of HRT constant. This was checked with a questionnaire followed by an interview at the beginning and at the end of the intervention.

Measurements

All the measurements were conducted before and after the training. A progressive, maximal exercise test on a treadmill

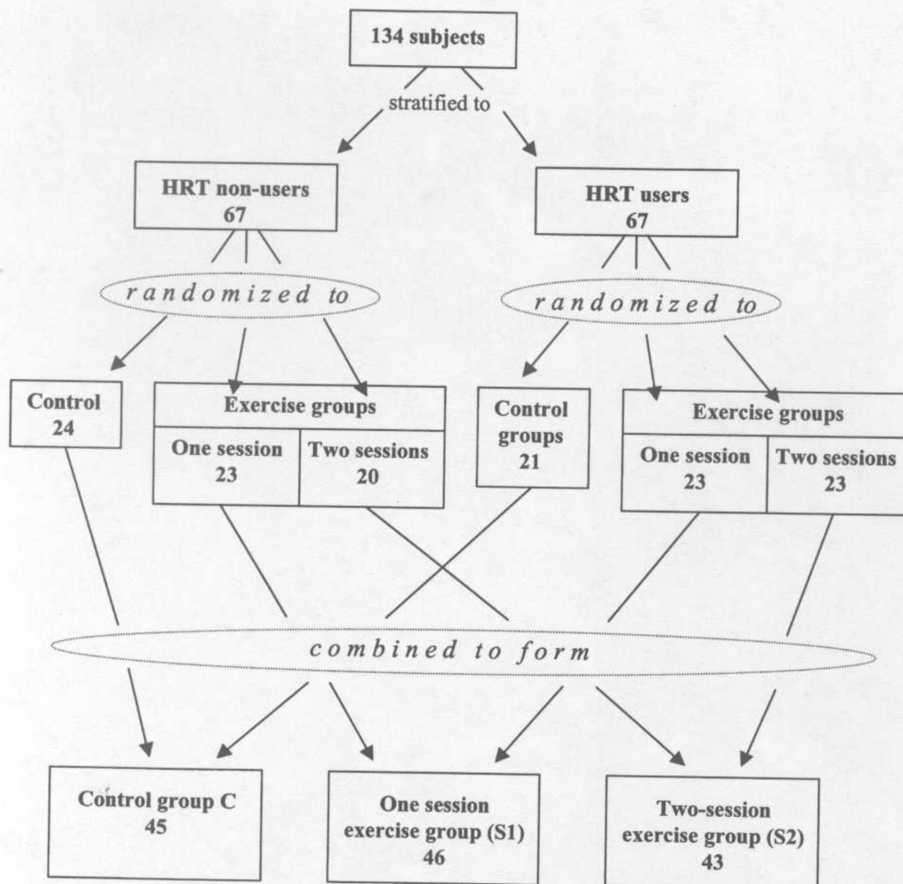

Fig. 2. Randomization process.

(Telineyhtymä Oy, Kotka, Finland) was used to measure the VO_{2max}. The submaximal response to exercise was monitored by heart rate measurements at absolute exercise levels corresponding individually to 65% and 75% of the VO_{2max} in the baseline exercise test. The treadmill test protocol (Oja, 1973) consisted of a warm-up for 5 min at 5 km/h on a 5% incline. The workload was increased in 3-min intervals, from very light to maximal load. The speed was increased by 0.5 km/h during the third, sixth and ninth stages, and the elevation of the treadmill was increased by 2.5% at each stage except the third. The electrocardiogram (ECG) was monitored (Case 12, Marquette Electronics Inc., Milwaukee, WI, USA) continuously. The participants reported their perceived exertion on the Borg scale (Borg, 1970) during each exercise stage. For habituation a separate submaximal test was performed few days before the first maximal exercise test.

VO_2 was measured breath-to-breath using a metabolic cart (Metabolic Measurement Cart 2900Z, Sensor Medics Corp., Anaheim, CA, USA). The analyzer was calibrated before each test. The maximum VO_2 was obtained from 1-min collected values (Howley et al., 1995). The criteria for maximum were the following: (1) best possible effort as judged by the test supervisor, (2) perceived exertion 19–20, (3) heart rate over 85% of the age-predicted maximum, (4) no significant rise (<2 mL min/kg) in VO_{2max} between the consecutive minute-to-minute gas analyses and (5) respiratory quotient over 1.05. All the participants had to fulfill the first criterion. The test was repeated within a week if the subject failed to give her best possible effort or if less than three of the other four criteria were not fulfilled.

Body mass (kg) and height (m) were measured in light clothing without shoes. Height was obtained to an accuracy of 0.005 m, and body mass was measured to the nearest 0.1 kg. The BMI was calculated as body mass (kg) divided by the square of the height (m). Skinfold thicknesses were measured at four sites: the mid-triceps, biceps, subscapularis and suprailiac muscles, using a Harpenden skinfold caliper (British Indicators Ltd, Luton, UK). Body density was estimated from the sum of the skinfolds according to a linear regression equation with age- and sex-specific coefficients according to Durnin (1974) and converted to the percentage of body fat using an adaptation of Siri's formula (Siri, 1961) for elderly women (Deurenberg, 1989).

Previous diet, daily exercise habits and use of HRT constant were checked with a questionnaire followed by an interview at the beginning and at the end of the intervention.

Physical activity was enquired using a PA score (1–5), described as follows: 1 = no regular PA weekly, 2 = some light PA every week, 3 = once a week brisk PA, 4 = twice a week brisk PA, 5 = three times a week or more brisk PA. Questions concerning exercise-related pain and injuries were asked at the end of intervention.

Sample size and statistical analyses

The calculations for adequate sample size were based on the assumption of about a 10% (3 mL min/kg (SD 4)) increase from the baseline VO_{2max} in the exercise group when compared with the change in the control group (type 1 error alpha 0.05). The power of the test was selected as 0.90. The calculations yielded a minimum of 39 participants for each study group. The actual number of subjects in each group was 43–46 at the onset of the study. The intention-to-treat principle was used, and all the subjects were asked to participate in the 15-week measurements, in spite of possible dropout from the exercise program or change in HRT use.

Results are given as means and standard deviations (SD). An analysis of covariance (ANCOVA) with baseline measurements as the covariates was used to analyze the training effects. *P*-values were calculated in testing for any differences between the groups. Training effects were determined as the net differences (i.e. the differences between the changes in each walking group and the control group). We calculated the 95% confidence intervals (CI) for the net change. A two-way analysis of covariance with the exercise groups and the HRT groups as factors was also used to analyze the interaction of these factors with the outcome measures.

Results

Compliance

Four subjects out of 134 did not participate in the 15-week measurements because of health problems: one subject was recovering from a gallbladder operation, one had an acute lumbar problem and one had newly detected diabetes. One exercise test was interrupted because of cardiac problems. In addition, because of technical difficulties, there was one missing value from the submaximal heart rate measurement at 75% of VO_{2max} and four at 65% of VO_{2max}.

Three of the 88 exercising subjects interrupted the exercise program: two because of lower limb problems, plantar fascitis and newly detected knee arthritis and one because of family reasons. All of them participated, however, in both exercise tests and were included in the results according to the intention-to-treat principle.

The mean values calculated from the exercise diaries showed that Group S1 attended 89% of the prescribed 75 sessions and Group S2 95% of the 150 prescribed sessions. Group S1 attended 88% and Group S2 92% of the 30 supervised exercise sessions. Absence from exercise was due to health problems, family reasons, work duties or travel. Less than 1% of the absence was due to musculoskeletal problems and the difference between the exercise groups was not statistically significant. The mean total duration of walking at the target heart rate per session was 47.9 (SD 14.2) min for Group S1 and 25.0 (SD 3.2) min for Group S2. The mean total daily duration of habitual physical activity, other than prescribed exercise, was 23.9 (SD 18.3) min for Group S1 and 27.8 (SD 18.8) min for Group S2. The mean total daily amount of walking, including both the prescribed exercise and habitual physical activity, estimated from the pedometer recordings, was 9.2 (SD 3.1) km for Group S1 and 10.4 (SD 3.0) km for Group S2.

All participants were given the possibility to work up gradually to their full exercise program during the first 2 weeks. An additional 2 weeks was allowed for six subjects in Group S1 and seven subjects in Group S2. During the last weeks of intervention five subjects in Group S1 and six subjects in Group 2 were allowed to use extra 1-kg weights, stair-walking or occasional jogging steps to reach their target

Table 2. Mean values and standard deviation (SD) before and after the intervention, and the net change (95% CI) between exercise and control groups* †

	N‡	Before	After	Net change (95% CI)	*P*-value†
VO_{2max}, ml/kg min					
S1	44	28.8 (3.7)	32.4 (4.1)	2.5 (1.5, 3.5)	
S2	43	28.4 (3.7)	32.0 (3.8)	2.5 (1.5, 3.5)	
C	43	27.7 (3.5)	28.9 (3.7		<0.001
HR at 75%VO_{2max}, bpm					
S1	44	141 (11)	140 (12)	−1.9 (−5.0, 1.1)	
S2	43	141 (11)	137 (12)	−3.7 (−6.8, −0.7)	
C	42	139 (13)	138 (15)		0.059
HR at 65%VO_{2max}, bpm					
S1	42	130 (12)	128 (13)	−1.4 (−4.7, 1.8)	
S2	42	129 (12)	126 (13)	−2.5 (−5.7, 0.7)	
C	41	128 (14)	128 (15)		0.310
Weight, kg					
S1	44	67.6 (8.4)	66.4 (7.8)	−1.2 (−1.8, −0.5)	
S2	44	67.8 (8.4)	66.6 (8.2)	−1.1 (−1.8, −0.4)	
C	43	66.7 (8.3)	66.7 (8.2)		0.001
BMI, kg/m^2					
S1	44	25.8 (2.7)	25.3 (2.5)	−0.5 (−0.7, −0.2)	
S2	44	25.9 (2.8)	25.5 (2.7)	−0.4 (−0.7, −0.2)	
C	43	25.6 (2.8)	25.6 (2.8		0.001
Fat%					
S1	45	36.8 (4.4)	34.3 (3.8)	−2.1 (−2.7, −1.4)	
S2	44	37.2 (4.9)	35.1 (4.6)	−1.7 (−2.3, −1.0)	
C	42	36.9 (4.2)	36.5 (3.7)		<0.001

VO_{2max} indicates maximal aerobic power; S1, one-session exercise group; S2, two-session exercise group: C, control group; HR, heart rate; BMI, body mass index; fat%, percentage of body fat.
†Analysis of covariance.
‡Dropouts are excluded.

heart rate. The mean length of the intervention was 14.4 (SD 2.9) weeks for Group S1 and 14.8 (SD 2.5) weeks for Group S2. The walking program was stopped 1 d before the exercise test.

There were no changes in diet reported in the questionnaire. Changes in exercise, corresponding to the intervention program, were reported in Groups S1 and S2. No changes in exercise were reported in the participants of the control group. Six participants changed their HRT status. In Group S1 two subjects started and one subject stopped the HRT. In Group S2 one subject started and two subjects stopped the HRT. All six subjects were included in their original group in the analyses to meet the intention-to-treat principle.

Changes in aerobic fitness and body composition

Aerobic fitness and body composition improved equally in both exercise groups compared to controls. The net increase in VO_{2max} was approximately 8%. The changes in submaximal heart rate were not statistically significant. Body mass decreased approximately 1 kg in both exercise groups and the corresponding BMI change was approximately 0.5 units. The fat% decrease was approximately 2% units in both groups (Table 2).

Discussion

The purpose of our study was to test the accumulation hypothesis among post-menopausal women, a group not investigated previously in accumulation studies.

The VO_{2max} improvement in our study was similar in both exercise groups, and agreed with the findings of other randomized, controlled accumulation studies. Ebisu (1985) studied the effects of jogging the same distance in one, two or three daily sessions at the 80% of the maximal heart rate (HR_{max}) for 10 weeks on 53 male students and found VO_{2max} responses of 6.9%, 9.8% and 8.3%, respectively. Jakicic et al. (1995) compared the effects of 20–40-min brisk walking performed in one continuous session or multiple 10-min bouts in a 20-week trial on 56 obese 35–46-year-old-women. The multiple-bout group had better adherence and exercised more than the continuous exercise group. The VO_{2max} increases were 5.6% in the multiple-bout group and 5.0% in the continuous exercise group. Murphy and Hardman (1998) studied 47 women, aged 38–51 years, performing 10 weeks of brisk walking at an intensity of 70–80% of the HR_{max}, 5 d/week, in one 30-min session vs three 10-min sessions, and found approximately 8% improvement in the VO_{2max} in both groups. Woolf-May et al. (1999) conducted a study of 56 adults walking 20–40 min in one, two or three bouts and reported similar responses in all exercise groups in a standardized step test and lactate measurements indicating aerobic fitness.

Table 3. Some randomized, controlled dose–response studies on VO_{2max} in women

Study	Intensity of exercise, % of the VO_{2max}*	Net change of VO_{2max} approximately
Santiago et al. (1987)		
20–40-year-old women		
jogging	78	31%
walking	62	21%
20 weeks		
Duncan et al. (1991)		
20–40-year-old women		
walking	83	16%
	60	9%
	46	4%
24 weeks		
Ready et al. (1996)		
56–67-year-old women		
walking	60	14%
5 or 3 times/ week		12%
24 weeks		
Kukkonen-Harjula et al. 1997		
30–55-year-old women		
walking	65–75	6.8%
15 weeks		
Murphy et al. 1998		
38–50-year-old women		
walking	63–76	8%
10 weeks		
Asikainen et al. (this study)		
43–63-year-old women		
walking	65	8%
15 weeks		
Jacicic et al. 1995		
35–46-year-old obese women		
walking and diet	60	5.6%
20 weeks		
Oja et al. (1991)		
20–65-year-old women		
walking	50	4.5%
10 weeks		

*The formula percentage VO_{2max} = 1.28% HR-29.12 was used.

There are also six other studies on exercise accumulation showing mainly similar results, but these studies lack randomization, or are uncontrolled, or do not compare effects of short bouts to long bouts of equivolume exercise (DeBusk et al., 1990; Snyder et al., 1997, Woolf-May et al., 1998; Jakicic et al., 1999; Boreham et al., 2000; Donnelly et al., 2000).

Regular brisk walking also had beneficial effects on the body composition of our participants. Body mass reduction was similar (1.7%) in both groups. The reduction in the percentage of body fat was also similar in both groups (about 2%-units). All these changes were small but consistent and statistically significant. Since our participants were not markedly obese and they reported no dietary changes, only slight reductions in body weight could be expected during our 15-week intervention

period, for which the total exercise energy expenditure was about 22 500 kcal (94 125 kJ). The findings of other randomized, controlled walking studies on normal-weight women have shown similar results: for example Kukkonen-Harjula et al. (1998) found a 1.5% reduction and Murphy and Hardman (1998) a slight reduction in four skinfold thicknesses in both exercise groups, but a significant 2.6% reduction of body mass only in short bout walkers. Ready et al. (1996) reported no significant changes in body mass, but the percentage of body fat decreased 1.1–1.3%-units.

The participants were recommended to contact the consulting physician (T-MA) in the event of any health problems. Of the total 73 consultations, 49 concerned exercise-related problems. In the questionnaire at the end of intervention 35% of the participants reported some exercise-related pain in the lower limbs, and for 17% the walking program was disturbed temporarily by pain, mainly at the beginning of the intervention. Exercise absence was very low, however, because most of the problems were minor. Four participants of 88 (5%) met major exercise-related health problems: one persistent plantaris fascitis, one deterioration of low back symptoms, one radius fracture on the icy walking trial and one mild, recurrent arrhythmia. Thus, our findings indicate that walking is a feasible form of exercise for sedentary post-menopausal women but there is a small risk of health problems. In exercise counseling these adverse effects should be prevented by guiding the participant to avoid overstrain. This means a gradual increase in the weekly training program and proper rest between exercise sessions. If exercise-related symptoms appear, early contact with the exercise counselor or a doctor is recommended.

Our study had several strengths. We had more subjects that any other accumulation study and the number of subjects was sufficient for adequate statistical comparisons. The randomized groups were comparable. The exercise dose was controlled carefully with supervision, heart rate monitors, exercise diaries and pedometers. The program was followed closely by participants and the dropout rate was small. Aerobic capacity was measured in a direct, maximal exercise test. To improve the design further, all the exercise sessions could be controlled and the intervention could be longer to ensure the detection of all potential effect.

Perspectives

Our study supports the current physical activity recommendation (ACSM, 1998). Regular brisk walking can produce training effects in post-menopausal women if the total amount of exercise is sufficient. Exercise can be divided into two daily bouts without compromising the training effects. This finding is useful for physicians as well as other professionals in exercise counseling for sedentary, post-menopausal women. The barriers to starting and maintaining a regular, time-consuming exercise program are great for elderly women who have not been accustomed to exercise training (Shephard, 1993). Physical activity that is integrated into everyday life, for example daily commuting or shopping, may be easier to begin and will be more likely to be continued regularly (Andersen et al., 1999; Dunn et al., 1999). Our results encourage the use of everyday possibilities for multiple walking bouts.

Key words: body fatness; dose–response; exercise; randomized controlled trial.

Acknowledgements

We thank Minna Aittasalo MSc, Ms Kati Rantamo, Ulla Hakala, Medical Laboratory Technologist and Kirsi Mansikkamäki, Medical Laboratory Technologist for their assistance in data collection, Mr Ismo Lapinleimu for his assistance with the statistical analyses and Ms Päivi Viitanen for her preparation of the manuscript, all from UKK Institute; Georgianna Oja ELS, for her editing of the language; and Steven N. Blair PED, from the Institute for Aerobics Research, Dallas, Texas, USA, for his valuable discussions during the study and his comments on an earlier draft. This study was supported in part by the Finnish Ministry of Education, the Juho Vainio Foundation and the Finnish Foundation for Cardiovascular Research. There are no conflicts of interest.

References

American College of Sports Medicine. Position stand. The recommended quantity and quality if exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998: 30: 975–991.

Andersen RE, Wadden TA, Bartlett SJ, Zemel B, Verde TJ, Franckowiak SF. Effects of lifestyle activity vs structured aerobic exercise in obese women. JAMA 1999: 281: 335–340.

Barinaga M How much pain for cardiac gain? News, comment. Science 1997: 276: 1324–1327.

Blair SN, Kohl HW, Paffenbarger DG, Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality; a prospective study of healthy men and women. JAMA 1989: 262: 2395–2401.

Boreham CAG, Wallace WF, Nevill A. Training effects of accumulated daily stair climbing exercise in previously sedentary young women. Prev Med 2000: 30: 277–281.

Borg G. Perceived exertion as an indicator of somatic stress. Scand J Rehab Med 1970: 2–3: 92–98.

DeBusk RF, Stenestrand U,Sheehan M, Haskell WL. Training effects of long versus short bouts of exercise in healthy subjects. Am J Cardiol 1990: 65: 1010–1013.

Deurenberg P, Westsrate, JA, van der Kooy K. Is an adaptation of Siri's formula for the calculation of body fat percentage from body density in the elderly necessary? Eur J Clin Nutr 1989: 443: 559–568.

Donnelly JE, Jacobsen DJ, Snyder Heelan K, Seip R, Smith S. The effects of 18 months of intermittent vs continuous exercise on aerobic capacity, body weight and composition, and metabolic fitness in previously sedentary, moderately obese female Int J Obes 2000: 24: 566–572.

Duncan JJ, Gordon NF, Scott CB. Women walking for health and fitness. How much is enough? JAMA 1991: 266: 3295–3299.

Dunn AL, Marcus BH,Kampert JB, Garcia ME, Kohl HW, Blair SN. Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness. A randomized trial. JAMA 1999: 281: 327–334.

Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr1974: 32: 77–97.

Ebisu T. Splitting the distance of endurance running: on cardiovascular endurance and blood lipids. Jpn J Phys Educ 1985: 30: 37–43.

Hardman AE. Accumulation of physical activity for health gains: what is evidence? Br J Sports Med 1999: 33: 87–92.

Howley ET, Bassett R Jr,Welch HG. Criteria for maximal oxygen uptake. review and commentary (brief review). Med Sci Sports Exerc 1995: 27: 1292–1301.

Jakicic JM, Winters C, Lang W, Wing RR. Effects of intermittent exercise and use of home exercise equipment on adherence, weight loss, and fitness in overweight women. A randomized trial. JAMA 282: 16: 1554–1650.

Jakicic JM, RR.Wing BA, Butler RJ, Robertson. Prescribing exercise in multiple short bouts versus one continuous bout: effects on adherence, cardiorespiratory fitness and weight loss in overweight women. Int J Obes 1995: 19: 893–901.

Kukkonen-Harjula K, Laukkanen R, Vuori I, Oja P, Pasanen A, Nenonen A, Uusi-Rasi K. Effects of walking training on health-related fitness in healthy middle-aged adults – a randomized controlled study. Scan J Med Sci Sports 1998: 8: 236–242.

Morris JN, Hardman AE. Walking to health (review article). Sports Med 1997: 23: 306–332.

Murphy MH, Hardman AE. Training effects of short and long bouts of brisk walking in sedentary women. Med Sci Sports Exerc 1998: 30: 152–157.

Oja P. Intensity and frequency of physical conditioning as determinants of the cardiovascular response of middle-aged men at rest and during exercise. Thesis. State College (PA): The Pennsylvanian State University, 1973.

Oja P, Mänttäri A, Heinonen A, Kukkonen-Harjula K, Laukkanen R, Pasanen M, Vuori I. Physiological effects of walking and cycling to work. Scand J Med Sci Sports 1991: 1: 151–157.

Ready AE, Naimark B, Ducas J, Sawatzky J-AV, Boreski SB, Drinkwater DT, Oosterveen S. Influence of walking volume on health benefits on women postmenopause. Med Sci Sports Exerc 1996: 28: 1097–1105.

Santiago MC, Alexander JF,Stull GA, Serfass RC, Hayday AM, Leon AS. Physiological responses of sedentary women to a 20-week conditioning program of walking or jogging. Scand J Sports Sci 1987: 2: 33–39.

Shephard RJ. Exercise compliance. The challenge of aging population. Can J Cardiol 1993: 9 (Suppl. d): 72d–74d.

Siri WE. Body composition from fluid spaces and density: analysis of methods. In: Brozek J, Henschel A, eds. Techniques for measuring body composition. Washington DC: National Academy of Sciences, 1961.

Synder KA, Donelly JE, Jakobsen DJ, Hertner G, Jakicic JM. The effects of long-term, moderate intensity, intermittent exercise on aerobic capacity, body composition, blood lipids, insulin and glucose in overweight females. Int J Obes 1997: 21: 1180–1189.

de Weir JBV. New method for calculating metabolic rate with special reference to protein metabolism. J Physiol 1949: 109: 1–9.

Woolf-May K, Kearney EM, Jones DW, Davidson RCR, Coleman D, Bird SR. The effect of two different 18-week walking programmes on aerobic fitness, selected blood lipids and factor XIIa. J Sports Sci 1998: 16: 701–710.

Woolf-May K, Kearney EM, Owen A, Jones DW, Davidson RCR, Bird SR. The efficacy of accumulated short bouts versus single daily bout of brisk walking in improving aerobic fitness and blood lipid profiles. Health Educ Res 1999: 14: 6: 803–815.