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Self-guided brisk walking training with or without poles: a randomized-controlled trial in middle-aged women

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Walking with poles (Nordic walking, NW) has become popular. We compared training responses of brisk walking (W) or NW on cardiorespiratory and neuromuscular fitness. We randomized 121 non-obese sedentary women (aged 50–60) to an NW or W group (NWG, WG), to train 40 min four times weekly for 13 weeks. Intensity was based on subjective perception of exertion. Cardiorespiratory performance was assessed in four levels corresponding to 50%, 65%, 80% and 100% of peak VO_2. Fifty-four NWG and 53 WG subjects completed the study. The mean intensity was about 50% of heart rate (HR) reserve. The baseline peak VO_2 was 25.8 (SD 3.9) mL/min/kg. Both groups improved peak VO_2 similarly (NWG 2.5 mL/min/kg, 95% confidence interval (CI) 1.9–3.3; WG 2.6, CI 1.9–3.3). In the submaximal stages while walking with or without poles, HR and lactate decreased after training in both groups, but the changes were not statistically significantly different between the groups. Of the neuromuscular tests after training, the only significant difference between the groups was in the leg strength in the one-leg squat, favoring WG. In conclusion, both training modes improved similarly health-enhancing physical fitness, and they were feasible and safe.

Walking (W) is a widely practised form of moderate-intensity health-enhancing physical activity (Morris & Hardman, 1997). In Nordic walking (NW), the exerciser uses poles or sticks, which resemble those for cross country skiing. The essential physiological difference of NW vs W is the use of upper body musculature, introducing a larger central training stimulus for the circulation. NW may acutely increase energy consumption by about 20% more in comparison with W performed at the subjectively estimated same speed (Church et al., 2002). While heart rate (HR) is somewhat greater in NW than in W for the same speed, the same relative training intensity is achieved by a slower speed in NW.

Despite the increasing popularity of NW especially among the middle-aged and elderly, there are scarce training data on its effects on fitness and health. In a randomized-controlled study, NW or W training increased maximal oxygen consumption (VO_{2max}) equally in middle-aged women (Larkin, 1992). Muscle strength of the upper body did not change but muscle endurance improved (Karawan, 1992).

In the present work, we wanted to study training effects of walking with or without poles on health-related fitness (HRF) in 50–60-year-old sedentary women. Our interests were cardiorespiratory fitness in both submaximal and maximal exercise, and neuromuscular fitness. The hypotheses were that both training modes improve submaximal cardiorespiratory performance more than performance in maximal exercise, and that NW improves submaximal performance more than W training does. The main outcome was submaximal cardiorespiratory performance and the secondary outcomes were peak VO_2 and neuromuscular fitness. In addition, we monitored training injuries.

Materials and methods

Recruitment of participants and study design

Volunteers were recruited through newspaper advertisements. Women were eligible if they were 50–60 years of age, their body mass index (BMI, weight divided by the square of height in meters) was 20–30, they exercised no more often than twice weekly, had no health problems preventing from training and used no drugs affecting HR.

Of 392 contacts, 212 fulfilled the above-mentioned initial criteria, and 140 women were randomly chosen for screening assessments, including a physician's check-up and a maximal exercise test. The study plan was explained and a written informed consent was obtained. The study was approved by the ethical research committee of the local hospital district. In the screening examinations, 19 persons were excluded, mostly due to medical reasons. Thus, 121 women were accepted into

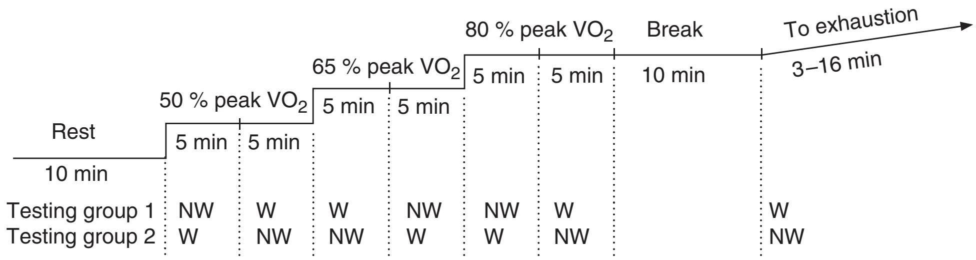

Fig. 1. Testing protocol for submaximal and maximal exercise performance.

the study and they were randomized to the NW training group (NWG, $N = 60$) and to the walking training group (WG, $N = 61$). The randomization was performed by our statistician not involved in screening assessments. Group allocation was told to the subjects after baseline exercise testing, which followed 1–2 months after screening.

There were no previous NW training studies giving information about submaximal cardiorespiratory fitness. Therefore, our power calculations were based on peak VO_2, with the assumption of a difference of at least 2 mL/min/kg for the change (SD of the change 3 mL/min/kg) (Asikainen et al., 2002) between the groups after training. Such a difference will be detected at 5% statistical significance with an 80% level of power having 37 persons in both study groups. Assuming a 20% drop-out, we aimed at 100 persons (50 persons in both groups) starting training.

Training prescription and monitoring

Training took place outdoors individually in August–November. Exercise instructors held two instruction sessions in small groups on NW (for NWG) and W (for WG) technique, on exercises for warm-up and cool-down and on the use of HR monitor (M61, Polar Electro, Kempele, Finland). The length of NW poles (Exel Nordic Walker Trainer, Exel Oyj, Mäntyharju, Finland) was determined by multiplying the subject's height by 0.7.

Training intensity was based on subjective perception of exertion. The oral prescription given was "walk briskly so that breathing is enhanced." Even though HR monitors were worn in all training sessions, the subjects were advised not to follow the monitor's display during exercise. Each training session lasted for 40 min, in addition to warm-up for 1–5 min and cool-down and stretching for 5 min. After a familiarization period for 2 weeks, the training frequency was four times weekly.

After each exercise session, the subjects recorded mean HR and session duration from their HR monitor to training logs. In addition, they recorded a rating of perceived exertion (RPE, scale 6–20) (Borg, 1970), and other physical activities. Training logs were checked weekly by exercise instructors, and eventual training problems were discussed.

For calculation of HR reserve (HRR, maximal HR minus resting HR) of exercise sessions, the subjects measured resting HR using an HR monitor on three successive mornings on the fourth, eighth and 13th week of training.

Training-related injury was defined as an acute or overuse injury preventing from NW or W training for at least 1 day (Ekstrand et al., 1983). All time-loss injuries were verified and treated by a physician. Musculo-skeletal pain in five regions during the previous 3 months on 1 or more days was assessed before and after training, using a validated self-administered questionnaire (Kuorinka et al., 1987).

The subjects were advised not to change other lifestyle habits, especially not to lose weight by dieting. Body weight and height were measured in light clothing without shoes, and BMI was calculated. Waist circumference was measured halfway between the lowest rib and the iliac crest.

Fitness assessments

A screening maximal exercise test was performed walking on a treadmill (Telineyhtymä Oy, Kotka, Finland). The test also served as subject familiarization with respiratory breath-by-breath gas analysis (V_{max} 229, SensorMedics, Yorba Linda, California, USA). ECG (Case 12, Marquette Electronics Inc., Milwaukee, Wisconsin, USA), and VO_2, CO_2 and volume of ventilation were monitored continuously for 12 min or until respiratory exchange ratio (RER) increased to about 1.0 and VO_2 over 20 mL/min/kg. After a short pause, the test was continued without the mask until subjective exhaustion, increasing the slope every minute with unchanged speed.

The assessments before (baseline) and after the 13-week training included a graded exercise test (GXT) and neuromuscular fitness tests. In GXT, three submaximal exercise levels were used, calculated (according to American College of Sports Medicine, 1998) from the screening exercise test to correspond to 50%, 65% and 80% of estimated peak VO_2 (using linear regresssion between HR and VO_2). In each level and for both study groups, the testing modes were NW and W, each for 5 min (Fig. 1). The order of starting mode (NW or W) was randomized. Respiratory gases and ECG were monitored. After every 5 min, a fingertip blood sample was taken, and RPE was recorded. After the 30-min submaximal exercise, there was a pause for 10 min, followed by 1-min exercise stages, starting from the last submaximal level, to exhaustion. This part was performed by W or NW, similar to the mode during the last level of the submaximal exercise (Fig. 1). At exhaustion, the last blood sample was taken. Capillary blood samples were deproteinized with trichloroacetic acid, and lactate (LA) concentration was analyzed using an enzymatic method.

The same individual speed and inclination were used in GXT before and after training. The order of starting exercise (NW, W) was randomized, yielding testing groups 1 and 2 (Fig. 1). The three submaximal intensities (as percentages of estimated peak VO_2) were calculated individually based on the screening exercise test. The number of tested subjects in the randomized study groups (NWG, and WG) before and after training was 26 and 24, and 22 and 20 in the testing group 1, and 25 and 27, and 23 and 24 in the testing group 2.

Steady-state respiratory variables during submaximal exercise in three levels were calculated as an average during the last 2 min of each 5-min stages. Peak VO_2 was determined as the highest 1-min sliding average during GXT.

To assess neuromuscular fitness, we used selected HRF tests (one-leg standing balance, dynamic balance in backwards walking, neck–shoulder mobility, leg strength in the one-leg squat) developed at the UKK Institute (UKK HRF Test Battery) (Suni et al., 1996, 1998; Rinne et al., 2001), and dynamic upper arm extension (to simulate NW; the test was terminated at 50 repetitions). The testing personnel were trained and used a test manual developed for UKK HRF Test Battery to ensure quality and safety.

Statistical analyses

Our main outcome submaximal cardiorespiratory performance was operationalized as HR, LA, oxygen pulse (ratio of VO_2 to HR) and ratio of LA to VO_2 (per kg body weight), and the secondary outcomes were peak VO_2 and the abovementioned five neuromuscular fitness tests.

Descriptive results are given as means and SD. Analysis of covariance (ANCOVA) with baseline measures as covariates was used to analyze training effects on primary and secondary outcomes of cardiorespiratory responses. Effects were determined as net differences (differences between the changes in NWG and WG) with 95% confidence intervals (CIs). In submaximal exercise tests, the starting mode of exercise was used as a covariate in addition to baseline measurements. The possible interaction between the training group and the starting exercise was also tested in ANOVA. The mode of testing (NW or W) in GXT was used as a factor in ANCOVA, in addition to the factor "group assignment" (NWG or WG) to study their possible interactions in training responses of peak VO_2.

For analysis of training effects on neuromuscular fitness, subjects below the 40th percentile of the test values were categorized as low fit. The criterion of low fitness was based on data of women of similar age in a previous population study (Suni et al., 1999). For dynamic upper arm extension, there were no population data and the cut-off point for low fitness was set at 30 repetitions (of maximum 50). Training effects were analyzed using logistic regression analysis, adjusted for differences in baseline distributions. Odds ratios (ORs, with 95% CIs) between the study groups for subjects with low fitness in different tests were calculated.

Training effects on the occurrence of musculo-skeletal pain in different regions during the previous 3 months were analyzed using logistic regression analysis. OR between the study groups for subjects having pain were calculated.

All statistical analyses were performed using the SPSS statistical software package, version 12.0 (SPSS Inc., Chicago, Illinois, USA).

Results

Of the 121 women randomized, four did not start training. In addition, one developed severe dysrhythmia in the baseline GXT, and another had an ankle fracture not related to training. Thus, 115 women (57 in NWG, 58 in WG) started training. Their mean age was 54 (SD 3) years. Their mean BMI was 25.1 (SD 2.7) in NWG and 26.1 (2.7) in WG. Fifty-one had estrogen treatment, 11 had medication for hypertension and four for dyslipidemia. Four were smokers. There were no marked differences in the proportions of medication users or of smokers between the study groups.

There were nine drop-outs (three in NWG, six in WG; four training-related non-severe injuries in the lower extremities, two illnesses not related to training, three lack of time) during training, and hence 106 women (54 in NWG, 52 in WG) participated in post-training exercise testing. There were no substantial differences in the baseline characteristics of the subjects who completed the training program compared with those who discontinued (data not shown).

The mean duration of training was 13.6 weeks (range 12.4–15.4). The mean number of participated exercise sessions was 46 (range 33–51) of 49 prescribed. During training sessions, the average HR was 122.8 (SD 9.9) beats/min (b.p.m.) in NWG and 120.3 (8.7) b.p.m. in WG, corresponding to 53.9 (6.2) % and 52.0 (6.8) % of HRR. The average RPE was 13.6 (1.4) in NWG and 13.7 (1.4) in WG. The levels of HR and its proportion from HRR (%HRR), and of RPE did not change within the groups during training, and neither did the changes differ statistically significantly between the groups. The average difference (NWG vs WG) was 2.5 b.p.m. for HRR, 1.9% for %HRR and −0.1 for RPE (ANOVA of repeated measurements). Resting HR decreased similarly in both groups during training (from about 63 to 60 b.p.m.). The mean weight decreased 0.5 kg in both groups, and the waist circumference decreased 2.8 cm in NWG and 2.2 cm in WG. None of these changes differed statistically significantly between the groups.

Cardiorespiratory responses to maximal exertion in GXT before and after training are shown in Table 1. Within the training groups, maximal HR and RER did not change during training, while maximal LA increased by about 0.4 mmol/L. None of these changes differed statistically significantly between the groups. The mean increase in peak VO_2 during training was 2.5 mL/min/kg (CI 1.9–3.3) in NWG and 2.6 mL/min/kg (CI 1.9–3.3) in WG. The net difference of peak VO_2 between the training groups was −0.1 mL/min/kg (CI −1.1–0.9).

Submaximal cardiorespiratory performance was assessed in three levels to correspond to 50%, 65% and 80% of predicted screening peak VO_2. In the baseline laboratory test while walking with poles, these levels represented on average 52%, 67% and 79% of measured baseline peak VO_2, and while walking without poles, 50%, 64% and 77%. The inclination and speed were kept the same in the post-training measurements when these levels corresponded on average to 51%, 63% and 74% of measured post-training peak VO_2 in NW and to 48%, 61% and 73% in W. The mean RPEs were similar in both study groups at baseline; during the first submaximal stage, it was about 10–11, during the second stage about 13–14 and during the third about 16 in both exercise modes. RPEs did not change after training except for the third stage (decreased to about 15).

Parameters of submaximal performance (HR, LA) in the three levels while walking with poles on the treadmill are shown in Table 2. The mean HR and

Table 1. Heart rate, respiratory exchange ratio, ventilation and VO_2 at maximal treadmill exertion, and post-exercise capillary lactate concentration

	Before, means (SD)	After, means (SD)	Net difference* (95% CI)
HR_{max} (beats/min)			
NWG	175.2 (10.6)	175.6 (10.4)	− 0.3 (− 2.3 – 1.7)
WG	174.3 (12.0)	175.2 (11.1)	
RER_{max}			
NWG	1.16 (0.05)	1.18 (0.06)	0.01 (− 0.1 – 0.03)
WG	1.15 (0.05)	1.16 (0.06)	
V_{Emax} (L/min; BTPS)			
NWG	68.8 (11.2)	71.7 (12.1)	− 0.2 (− 2.9 – 2.6)
WG	69.7 (12.2)	72.6 (10.7)	
Peak VO_2 (mL/min/kg)			
NWG	26.0 (4.0)	28.4 (4.3)	− 0.1 (− 1.1 – 0.9)
WG	25.8 (3.8)	28.4 (3.9)	
LA_{max} (mmol/L)			
NWG	6.3 (1.4)	6.7 (1.7)	0.0 (− 0.5 – 0.5)
WG	6.6 (1.5)	6.9 (1.5)	

Means (SD) before and after training in the NWG and in the WG, and net differences* between the groups.

*The net difference is the between-group difference at the end of training, adjusted for the baseline value and the order of starting exercise as covariates (analysis of covariance), given as means and 95% confidence intervals (CIs).

NWG, Nordic walking group ($N = 52$); WG, walking group ($N = 49$); HR_{max}, maximal heart rate; RER_{max}, maximal respiratory exchange ratio; LA_{max}, maximal lactate; VO_2, oxygen consumption.

Table 2. Heart rate and capillary lactate in three submaximal intensities (50%, 65% and 80% of predicted initial peak VO_2) while walking with poles on the treadmill

Testing intensity/group	HR			LA		
	Before, means (SD)	After, means (SD)	Net difference* (95% CI)	Before, means (SD)	After, means (SD)	Net difference* (95% CI)
50% VO_2						
NWG	119.5 (12.8)	117.0 (12.1)	0.3 (− 2.9 to 3.4)	1.1 (0.4)	1.0 (0.4)	0.1 (0.0 – 0.2)
WG	114.4 (11.4)	113.1 (11.0)		1.1 (0.4)	0.8 (0.2)	
65% VO_2						
NWG	135.7 (14.4)	130.8 (13.0)	− 0.1 (− 3.2 to 2.9)	1.4 (0.7)	1.0 (0.5)	0.0 (− 0.1 – 0.2)
WG	132.4 (12.8)	128.5 (12.0)		1.3 (0.7)	1.0 (0.5)	
80% VO_2						
NWG	150.1 (14.6)	144.6 (14.6)	0.1 (− 2.9 to 3.0)	2.2 (1.2)	1.6 (0.9)	0.1 (− 0.1 – 0.3)
WG	149.0 (15.3)	143.7 (13.7)		2.7 (1.9)	1.7 (1.0)	

Means (SD) before and after training in the NWG and in the WG, and net differences* between the groups.

*The net difference is the between-group difference at the end of training, adjusted for the baseline value and the order of starting exercise as covariates (analysis of covariance), given as means and 95% confidence intervals (CIs).

HR, heart rate (beats/min); LA, capillary lactate concentration (mmol/L); NWG, Nordic walking group ($N = 51$–54); WG, walking group ($N = 50$–52); N, the number of subjects in different analyses varies due to some missing values.

LA decreased in both study groups after training, by about 4–5 b.p.m. and 0.4–0.8 mmol/L in the two highest levels. When walking without poles on the treadmill, the mean HRs of the three levels were 2.5–4.2 b.p.m. lower than when walking with poles, while no differences in LA concentrations between the testing modes were observed (data not shown). After training, the changes of the submaximal parameters while walking with poles were similar in both study groups when compared with walking without poles. There were no statistically significant differences between the study groups in the net differences of parameters of submaximal performance either while walking with or without poles. Neither was any interaction found between the mode of starting exercise and the group assignment (NWG, WG). The other submaximal parameters, the ratio of LA to VO_2 and the oxygen pulse behaved similarly to HR and LA during training and in comparison between the study groups and the exercise modes on the treadmill (data not shown).

The results of neuromuscular fitness tests are presented in Table 3. The only statistically significant difference for changes after training between NWG and WG was in the leg strength in the one-leg squat test. After training, the decrease in the proportion of women with low fitness was 4% units in NWG and 15% units in WG. The OR for decrease in low fitness in NWG was 3.72 ($P = 0.045$) vs WG, implying more improvement in WG.

Table 3. Neuromuscular fitness and its differences in subjects having low fitness, before and after training in the NWG and in the WG, and ORs between the groups

Test	Before (%)	After (%)	Difference (% units)	OR (95% CI)*
One-leg standing balance (<60 s†)				
NWG	34	24	−10.9	0.70 (0.25–1.92)
WG	17	22	5.5	1.00
Dynamic balance in backwards walking (>25 s†)				
NWG	29	14	−14.6	0.80 (0.26–2.41)
WG	33	18	−14.8	1.00
Neck–shoulder mobility (severe limitations†)				
NWG	27	35	8.3	1.58 (0.57–4.38)
WG	10	18	8.2	1.00
Dynamic upper arm extension (≤ 30 repetitions†)				
NWG	73	55	−18.2	1.05 (0.49–2.26)
WG	63	52	−11.1	1.00
Leg strength in one-leg squat (≥ 1 leg $<20\%$ added weight†‡)				
NWG	24	19	−3.7	3.72 (1.03–13.4)
WG	25	10	−15.4	1.00

*Logistic regression analysis, adjusted for baseline differences, given as odds ratios (ORs) with 95% confidence intervals (CIs).
†The cut-off levels for low fitness in the tests are given in parentheses.
‡Added weight in successive steps, using a weight belt.
NWG, Nordic walking group ($N = 54$–60); WG, walking group ($N = 52$–61); N, the number of subjects in different analyses varies due to some missing values.

Table 4. Musculo-skeletal pain and its differences in subjects having pain (during the previous 3 months), before and after training in the NWG and in the WG, and ORs between the groups

Pain region	Before (%)	After (%)	Difference (% units)	OR (95% CI)*
Neck				
NWG	76	60	−16.0	0.67 (0.25–1.80)
WG	67	61	−5.9	1.00
Elbow or forearm				
NWG	37	22	−15.7	0.46 (0.16–1.31)
WG	30	30	0.0	1.00
Back (sciatic type pain)				
NWG	20	20	0.0	0.36 (0.13–0.99)
WG	18	35	17.7	1.00
Hip				
NWG	16	20	4.1	0.53 (0.20–1.45)
WG	17	31	13.5	1.00
Knee				
NWG	16	34	18.0	0.79 (0.33–1.89)
WG	22	41	19.6	1.00

*Logistic regression analysis, adjusted for baseline differences, given as odds ratios (ORs) with 95% confidence intervals (CIs).
NWG, Nordic walking group; WG, walking group ($N = 50$–52); N, the number of subjects in different analyses varies due to some missing values.

Musculo-skeletal pain on 1 or more days during the previous 3 months before and after training is presented in Table 4. The only statistically significant difference for changes after training between NWG and WG was in the occurrence of sciatic type of pain. After training, it increased in WG vs no change in NWG, and the OR for the difference in pain was 0.36 ($P = 0.047$).

Over the 13-week study period, in NWG there were three time-loss injuries (ankle sprain and overuse injuries of the shoulder and heel). The total injury rate was 1.4/1000 NW training hours. In WG, there were four time-loss injuries (ankle sprain and overuse injuries of the lower limb). The total injury rate of WG was 1.9 injuries/1000 training hours. The incidences of injuries were not statistically significantly different between the study groups.

Discussion

In the present study, self-guided walking with or without poles for 13 weeks improved cardiorespiratory and neuromuscular components of health-related physical fitness similarly in sedentary middle-aged women. Our study had several strengths that add to its reliability. The number of subjects was sufficient for adequate statistical comparisons and the randomized groups were comparable. We randomized 121 women even though according to the power calculations, 74 persons should be enough for peak VO_2 assessments after training. This difference was due to our assumption of more women not being accepted in screening and more dropping out than occurred. Other strengths of our study were instruction of training techniques, good adherence and weekly follow-up of participants and exercise testing on the treadmill comprising both submaximal and maximal cardiovascular performance using both walking with and without poles. Unfortunately, we could not assess the speed or distance of outdoor training sessions.

When comparing training effects of walking with and without poles, one has to take into consideration on what kind of exercise testing training intensity was based and how intensity was assessed in the field. Also, the subjects' training status and acquaintance with NW technique are important. Anecdotally, Nordic walkers often state that they experience exercise as less strenuous when compared with walking. In another study (Oja et al., 1991), we compared cross country skiing and running training at the same intensity (as a proportion of maximum HR on bicycle) in sedentary men. Based on RPE, skiing was perceived as less strenuous, even though the training effect on maximal aerobic power was similar in both types of training. However, in the present training prescription, we aimed at similar perceived exertion in both training modes. Therefore, we did not use HR as a guiding principle because HR is higher in NW compared with W at the same speed.

Training intensity was given by oral instruction and based on the participant's perception of enhanced breathing and breathlessness. The prescription was aimed at moderate intensity (50–85% of HRR) according to recommendation to improve cardiovascular fitness (American College of Sports Medicine, 1998). The target was not told to the participants, but based on their weekly training logs on training HRs the desired training intensity was achieved. The average RPE values were similar in both study groups throughout training, which is in alignment with previous studies on acute responses of walking with and without poles (Porcari et al., 1997; Church et al., 2002). Further, average training RPEs of our subjects were similar to RPEs during the second submaximal stage of the laboratory exercise, representing about 65% of peak VO_2.

The increase in peak VO_2 (about 10% in both groups) after 13 weeks of training was modest and similar in both study groups, in agreement with Larkin (1992). The improvement in our walking group was similar to previous walking studies in middle-aged sedentary women (Kukkonen-Harjula et al., 1998; Asikainen et al., 2004). Our study also showed that the peak VO_2 and its change during training were not dependent on the mode of maximal exercise testing, i.e., with or without poles ($P = 0.72$ for the interaction between the test mode and the training mode).

In our previous walking study on a golf course (Parkkari et al., 2000), HR, VO_2 and LA levels decreased in submaximal exercise when walking on a treadmill after training. This trend was also observed in the present study but there were no statistically significant differences of the changes between the study groups. This discrepancy between the studies and also against studies on acute responses (Porcari et al., 1997) could partly be due to the fact that walking with poles uphill on a treadmill does not perfectly simulate NW outdoors. Even though the average training HRs were 2.5 b.p.m. higher in the NW group than in the walkers, this was not reflected in better submaximal laboratory performance of the Nordic walkers. This finding on our middle-aged women might be different from that on trained younger cross country skiers. Another possibility is that such a difference is small after all and has no training effect. The same might also apply to exercise with hand-held weights, which has been studied acutely (Evans et al., 1994) but not after training. In addition, maintaining good technique during testing might be difficult for untrained persons.

The effects of NW training on balance as well as on musculo-skeletal pain have not been studied before. In the present study, dynamic upper arm extension, which simulated the NW technique, did not improve more in the NW group in comparison with the walkers. This is similar to Karawan's (1992) study, where NW training resulted in increases in upper body muscle endurance in triceps lateral pulldown, but did not provide sufficient stimulus to increase muscle strength. It seems that to improve upper body muscle strength, more uphill NW training is required.

Anecdotally, it has been claimed that NW relieves neck–shoulder pain but there are no published training studies. Our study can be called a preventive intervention as we excluded persons with severe chronic neck or back pain. In another such intervention trial, anti-hypertensive lifestyle counselling, which included various modes of physical activity, decreased perceived disability due to neck pain (Mattila et al., 2004).

In our previous walking training study in a similar age group of post-menopausal women (Asikainen et al., 2006), walking in one or two exercise daily bouts combined with resistance training at home improved lower extremity muscular strength and 2-km walking time but not balance, using the same tests of neuromuscular fitness as in the present study. This finding is in accordance with our present results on neuromuscular fitness in that walking training increased leg strength more than NW. The poles in

NW are supportive and may thus diminish the training effect on lower extremities, while on the other hand NW might diminish sciatic type of back pain, as was seen in our study.

From training studies, there are no previous data on the safety of NW. We found injury rates (1.4 in NWG and 1.9 in WG per 1000 training hours), that were similar to those in a large cross-sectional cohort (Parkkari et al., 2004). Compared with many other activities, walking with and without poles is among the safest (Parkkari et al., 2004).

Perspectives

Our study showed that self-guided NW and W training had equal efficacy on cardiorespiratory and neuromuscular components of HRF, when the training intensity was prescribed using perceived exertion and when walking techniques were taught for both training modes. Both training types were feasible and safe modes of health-enhancing physical activity for sedentary non-obese middle-aged women. The results of our randomized and carefully monitored study add to the meager evidence on NW training. Thus, NW can be used along with walking to increase health-enhancing physical activity and to improve HRF, which includes multiple components. Further training studies on NW are needed to examine its efficacy in men, and in other age groups as well as in certain diseases or disorders (nonspecific neck and shoulder pain, prevention of osteoporosis and the metabolic syndrome). For field measurements of NW, the applicability of various walking tests should be studied.

Key words: Nordic walking, female, submaximal performance, cardiorespiratory fitness, neuromuscular fitness, injury, musculo-skeletal pain.

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