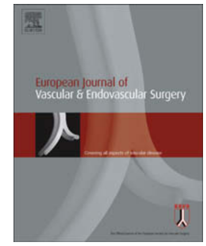
Eur J Vasc Endovasc Surg (2008) **36**, 689–694



Nordic Poles Immediately Improve Walking Distance in Patients with Intermittent Claudication

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Submitted 20 April 2008; accepted 26 June 2008
Available online 1 October 2008

KEYWORDS
Peripheral arterial disease;
Intermittent claudication;
Exercise therapy;
Nordic pole walking;
Cardiopulmonary workload

Abstract *Objectives:* To investigate the immediate effects of Nordic pole walking (NPW) on walking distance and cardiopulmonary workload in patients with intermittent claudication.
Methods: Using a standardised treadmill test (3.2 km h^{-1} at 4% gradient), walking distance, cardiopulmonary responses, leg pain and perceived exertion during NPW were compared to responses evoked by normal walking in 20 patients with intermittent claudication. The distance to onset of claudication pain (claudication distance: CD) and to maximum walking distance (MWD), heart rate (HR), expired gas parameters, leg pain (Borg's CR-10 Scale) and perceived exertion (Borg's Rating of Perceived Exertion: RPE Scale) were compared.
Results: CD increased significantly from a median (range) distance of 77 m (28–503) to 130 m (41–1080) and MWD increased significantly from 206 m (81–1078) to 285 m (107–1080) when patients used the Nordic poles ($P = 0.000$). The level of leg pain at MWD was also significantly reduced during NPW ($P = 0.002$). Perceived exertion at MWD did not increase despite an increase in cardiopulmonary work, as indicated by an increase in oxygen consumption (16.5%; $P = 0.000$).
Conclusion: These results show that NPW immediately enables patients with intermittent claudication to walk further with less pain, despite a higher workload. NPW might also be a useful exercise strategy for improving the cardiovascular fitness of patients with intermittent claudication.

Introduction

Narrowing of the arteries in the legs caused by atherosclerotic peripheral arterial disease (PAD) can limit lower-limb blood flow during walking. This leads to a cramp-like pain (intermittent claudication) in the calf muscles on walking. Intermittent claudication affects up to 20% of the elderly population and 50% of claudicants die within 10 years.[1] Risk factor modification reduces vascular events such as myocardial infarction and stroke by one-third, but there is little evidence that it improves walking distance.[2] Surgical or endovascular revascularisation is not appropriate for many of these patients because of the diffuse nature of their arterial disease.[3]

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1078-5884/$34
doi:10.1016/j.ejvs.2008.06.036

Exercise therapy is a relatively inexpensive, low risk treatment, compared to interventional procedures. Regular supervised exercise can improve walking distance.[4] The greatest benefits seem to be when patients exercise three times a week, for 30 min and walk to maximal pain levels.[5] A recent meta-analysis has shown that supervised exercise therapy increases walking distance more than unsupervised exercise, but the cost-effectiveness has been questioned.[6] This is because supervised exercise programmes are relatively expensive to run and long-term compliance can be a problem.

Despite an extensive body of evidence supporting the positive effects of lower-limb exercise rehabilitation, physical activity levels are lower in patients with symptomatic peripheral arterial disease than in age-matched controls.[7] Alternative exercise modalities that can reduce the level of ischaemic pain resulting from lower-limb exertion might help some patients to overcome the barriers to conventional forms of exercise rehabilitation (i.e., walking) and increase their enthusiasm for maintaining a physically active lifestyle. We have recently shown that upper-limb aerobic exercise training is well tolerated in patients with intermittent claudication[8] and can evoke symptomatic improvements in this patient group.[9,10] Although the mechanisms remain unclear, it is probably due to improved cardiovascular fitness.[11]

Nordic pole walking (NPW) is a form of exercise that involves a significant contribution from the upper-limbs and shoulders (used predominately during forward propulsion) and could lead to an improved exercise tolerance in this patient group. NPW has become an accepted form of exercise training for athletes and is a popular recreational sport in Scandinavia. In athletes NPW results in a significant increase in oxygen use (23%) and caloric expenditure (22%) compared to regular walking, without an increase in perceived exertion.[12] NPW has also been shown to improve cardiovascular fitness in patients with intermittent claudication.[13]

Although previous research has studied the physiological responses to NPW in healthy individuals,[14–16] and patients with coronary artery disease,[17] the immediate effects of NPW in patients with intermittent claudication have not been studied. The primary aim of this study was to investigate whether NPW improves the walking distance in patients with intermittent claudication and secondly, to compare the cardiopulmonary responses, level of leg pain and perceived exertion evoked by NPW with those evoked by normal walking in this patient group.

Materials and Methods

Patients

A total of 21 male patients (median age 70 yrs, range 57–79 yrs) with stable intermittent claudication (defined as having stable symptoms and no intervention for over 6 months) were recruited from the Sheffield Vascular Institute at the Northern General Hospital, Sheffield, UK.

Patients were recruited consecutively from the vascular clinic, without any selection bias. They had symptoms of variable severity (Table 1). The clinical diagnosis of PAD was established on the basis of the patient's history and physical examination, and was confirmed by Doppler assessment of resting ankle-brachial pressure index (ABPI) of <0.9. Patients were excluded if they had exercise limiting angina; shortness of breath on exercise; severe arthritis or any other condition which prevented them from undertaking exercise. All the patients in this study had infra-inguinal disease which was not amenable to straightforward open or endovascular intervention. One patient was excluded because, although on the flat he could walk well with poles, he was unable to walk at the required speed on the treadmill. Ethical approval was obtained from the North Sheffield Local Research Ethics Committee and all patients provided informed consent before entering the study. Demographic data for the patient cohort are provided in Table 1.

Treadmill and NPW familiarisation

All patients attended the Exercise Laboratory for a familiarisation session, which lasted about an hour. Patients received comprehensive instructions on the NPW technique and were allowed ample practice time until members of the research team and patients themselves were confident that they had mastered the technique. During this session, patients initially walked on a flat treadmill at a slow speed, but as they gained confidence a target speed of 3.2 km h^{-1} was reached and the incline was raised to 4%. After this they were instructed to walk on the treadmill (3.2 km h^{-1} at 4% gradient) both with and without poles to maximum walking distance (maximum exercise tolerance). A 15 min rest recovery period was allowed between the two practice

Table 1 Demographics of the patient cohort

Variable	
Median age (range)	70 (57–79)
Body weight (kg)	86.7 ± 3.3
Height (m)	1.76 ± 0.01
Body mass index (kg m^{-2})	27.8 ± 1.0
Resting ABPI	0.61 ± 0.04
Smoking status (%)	
Current	30
Previous	65
Never smoked	5
Anti hypertensive medication (%)	45
Beta-blockers (%)	45
Previous heart attack (%)	40
Controlled angina (%)	70
Previous stroke (%)	10
Diabetes (%)	40
Statins (%)	100
Anti-platelet agents (%)	100

ABPI data are presented for the most symptomatic limb. Unless otherwise stated, values are means ± SE.

walks. During this session, patients were also familiarised with the expired gas analysis system, heart rate monitors, Borg's perceived exertion and pain scales[18] and the use of the safety harness during treadmill walking.

Treadmill walking assessments

Patients attended the laboratory where they performed two treadmill walking tests at the same constant walking speed and gradient (3.2 km h^{-1} and 4%, respectively) with a suitable rest period between the tests to ensure that they were adequately rested. One of the treadmill tests involved normal walking, without Nordic poles, and the other test involved walking with Nordic poles. A treadmill with an extra wide belt width was used (Saturn, HP Cosmos, Germany) providing ample room to enable correct pole walking technique. The speed of the treadmill protocol complies with internationally accepted recommendations for the clinical assessment of patients with PAD.[19] A gradient of 4% was chosen for the treadmill protocol, as pilot work with claudicants showed that most patients could walk a distance >80 m before experiencing intolerable claudication pain at this setting. This study was a crossover design, with the order of the two tests (walking with and without Nordic poles) being randomised for each patient. The maximum duration (distance) of the treadmill test protocol was set at 20 min (1080 m). Randomisation was performed just before the first walking test using a modified fishbowl technique.

Outcome measures

The distance walked before the onset of claudication pain (claudication distance, CD) and the maximum walking distance (MWD) which was achieved before the test was terminated due to intolerable claudication pain were recorded. Patients' oxygen consumption, ($\dot{V}O_2$) and other indices of cardiopulmonary work, including the minute volume of expired air ($\dot{V}E$) and respiratory exchange ratio (RER: $\dot{V}CO_2/\dot{V}O_2$) were measured breath by breath throughout the test, using an online gas analysis system (Ultima, Medical Graphics Corporation, USA). Heart rate (HR) was also continuously monitored using a polar HR monitor (Beat, Polar Electro-OY, Finland) and peak oxygen pulse at MWD was derived from oxygen consumption divided by HR (ml $beat^{-1}$). Ratings of perceived exertion (Borg RPE Scale[18]) at MWD and leg pain (Borg Category Ratio-10 (CR-10) Scale[18]) at CD and MWD were recorded. Blood pressure (BP) and ABPI were measured before and immediately after the test, and BP at 5 min intervals until it had returned to pre-test levels. Immediately after each treadmill assessment, patients were asked to state their reason for terminating the test.

Data analysis

Descriptive statistics were obtained. All dependent variables were first tested for normal distribution using the Kolmogorov—Smirnov goodness of fit test. The walking data (CD and MWD) were positively skewed and violated the assumption of normality, which is a common finding in claudication studies. As the CD and MWD data could not be normalised using data transformation techniques, the Wilcoxon signed ranks test for paired data was used to test for differences between the walking distances. The significance level was set at $P < 0.05$. Differences in the other dependent variables between the two conditions were analysed using the paired *t*-test. As multiple comparisons were being made, the alpha level was set to $P < 0.005$ using the Bonferroni correction to reduce the likelihood of type I errors. Data were analysed using the SPSS (version 13.0) statistical package (SPSS UK Ltd., Woking, UK.).

Results

Each patient performed the two walking tests (with and without Nordic poles) in random order. Two patients were able to walk for 20 min with Nordic poles. For these patients the test was terminated, since this was the maximum time allocated for the test. Their CD and MWD were, therefore, taken to equal the maximum distance of 1080 m. It was not possible to compare the cardiopulmonary data at CD or MWD in these two patients. Hence the gas analysis comparisons are based on data from 18 patients only. These two patients were stopped by claudication pain when walking without poles.

There was no significant difference in results whichever test was performed first (8 patients performed the NPW test first, 12 patients performed the 'no poles' test first). Patients were allowed adequate recovery time between tests to ensure that they were rested before the second test.

Walking distances

CD increased significantly from a median (range) distance of 77 m (28—503) without poles to 130 m (41—1080) with poles ($P = 0.000$; Fig. 1A), representing a 69% increase. MWD increased significantly from 206 m (81—1078) without poles to 285 m (107—1080) with poles ($P = 0.000$; Fig. 1B), representing a 38% increase. A large range in patients' individual percentage improvement was observed. CD increased by 15—273% (median 64%) and MWD increased by 2.4—389% (median 64%).

ABPI

The decrease in ABPI (mean $\pm$ SE) for the most symptomatic leg was less after NPW (0.15 ± 0.03), than after walking without the poles (0.20 ± 0.03), but the difference was not significant ($P = 0.10$).

Pain (Borg's CR-10 Scale)

As expected, patients' perception of the onset of claudication pain was similar between the two walking tests. At MWD patients experienced less pain when using the Nordic poles (4.3 ± 0.5 versus 5.6 ± 0.5 on the Borg CR-10 Scale; $P = 0.002$), corresponding to a change in pain perception from "strong (heavy)" to "somewhat strong". The reduction in leg pain with NPW, expressed as mean difference (95% confidence interval), was 1.4 (0.6—2.2)

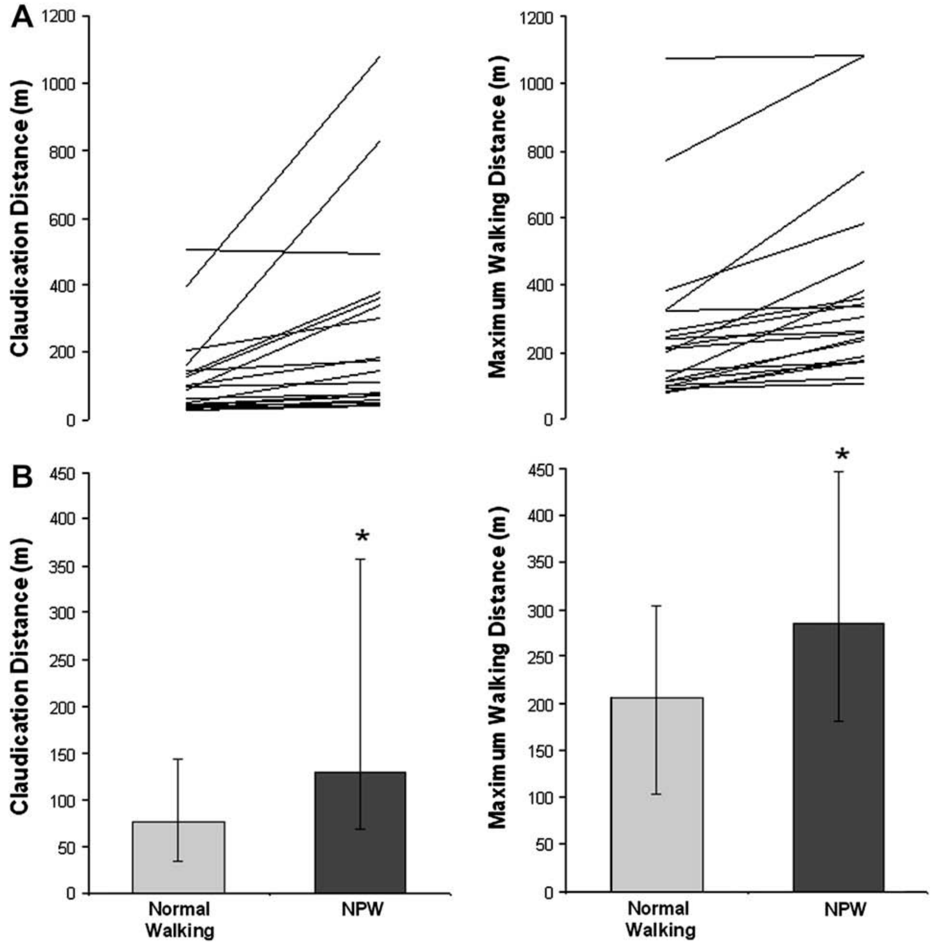

Figure 1 Effect of normal walking and NPW on pain-free (claudication) distance in individuals (*upper*) and the group as a whole (*lower*). *$P < 0.000$, *vs* normal walking, Wilcoxon signed ranks test (A). Effect of normal walking and NPW on maximum walking distance (MWD) in individuals (*upper*) and the group as a whole (*lower*). *$P < 0.000$, *vs* normal walking, Wilcoxon signed ranks test (B). Data are expressed as medians and the 25th and 75th quartiles.

Borg CR-10 units (Fig. 2). Importantly, eight of the 20 patients terminated the NPW test for reasons other than claudication pain (e.g., breathlessness, exhaustion, tiredness). All the 'no pole' tests were stopped because of claudication pain.

Cardiopulmonary variables

The results for all the cardiopulmonary variables and perceived exertion data are reported in Table 2. $\dot{V}O_2$ was increased by 18% at CD ($P = 0.002$) and by 16.5% at MWD ($P = 0.000$) with NPW. This increased level of oxygen consumption at CD and MWD were accompanied by a significant increase in $\dot{V}E$ at CD and MWD ($P = 0.001$) and there was a trend for an increase in RER at MWD ($P = 0.02$). HR was significantly elevated by 7% ($P = 0.000$) at CD and by 9% at MWD ($P = 0.46$) when patients walked with Nordic poles. The peak oxygen pulse (ml of oxygen consumption per heart beat) was also significantly increased at MWD during NPW ($P = 0.007$). Despite the increase in cardiopulmonary work at MWD, perceived exertion at maximum exercise tolerance (MWD) was not different between the two walking tests ($P = 0.65$).

Discussion

This is the first study to compare the immediate benefits of NPW in patients with intermittent claudication. The results demonstrate that NPW causes an immediate and significant increase in the distances patients can walk to CD and MWD at a walking speed of $3.2\ \text{km h}^{-1}$, and that NPW evokes a significantly higher level of cardiopulmonary work, as evidenced by a higher HR, $\dot{V}O_2$ and $\dot{V}E$ at CD and increased levels of $\dot{V}O_2$, $\dot{V}E$, RER and oxygen pulse at MWD. Despite increased work during NPW, perceived exertion at MWD was similar and patients experienced less leg pain when walking with Nordic poles. This suggests that NPW could be a useful method of improving cardiovascular fitness in claudicants who are usually unable to walk fast enough or for long enough for this response to occur. It might also be a more acceptable form of exercise for these patients because of the lower level of leg pain experienced.

As NPW enables patients with intermittent claudication to immediately walk further, it could have a huge impact on their lifestyle. Patients were able to walk between 15–273% further before experiencing the onset of

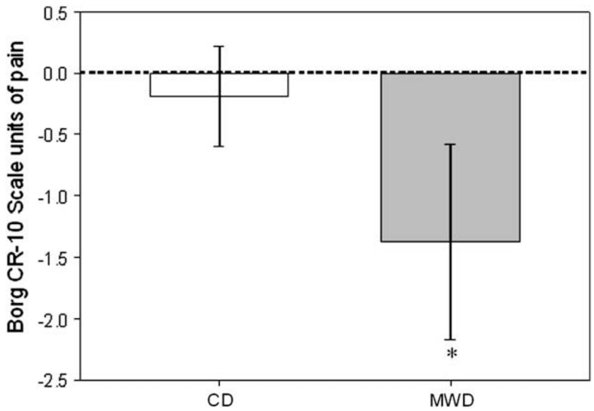

Figure 2 Reduction in perception of leg pain at claudication (CD) and maximum walking distance (MWD) with NPW, compared to normal walking. Data are expressed as the mean difference (95% confidence interval) in Borg CR-10 units. $^*P = 0.002$, paired t-test.

claudication pain and 2.4–389% further before having to stop due to intolerable leg pain or other factors, such as breathlessness and feelings of tiredness etc. The large range in walking distances with Nordic poles might be explained by differences in NPW technique, cardiovascular fitness and medication (e.g., beta-blockers).

The median increases in CD (69%) and MWD (38%) were lower than those typically observed following programmes of exercise training in patients with intermittent claudication,[4] but these improvements were immediate and represent clinically important changes for most of the patients. The eight patients who terminated the NPW test due to tiredness and exhaustion were excited by their first comparatively painless workout for a long time. The two patients who were able to walk for the maximum 20 min duration with poles immediately bought their own Nordic poles.

The decreased level of leg pain during NPW is attributable to a reduction in lower-limb loading stress. Willson *et al*. (2001) showed that the use of walking poles enables individuals to walk at faster speeds with lower ground reaction and vertical knee joint forces and with a reduced knee extensor angular impulse and support moment.[20] It has been suggested by Collins *et al*. (2003) that the longer stride may allow the calf muscles longer recovery time and, therefore, use the limited blood supply more efficiently.[21] That effect, coupled with change in weight distribution through the legs may explain why the patients can walk further immediately.

The involvement of the trunk, arm and shoulder muscles during NPW accounts for the increase in cardiopulmonary work at a given walking speed.[15] $\dot{V}O_2$ was increased by 16–18% and $\dot{V}E$ was increased by 18–23% between CD and MWD with NPW. These increases are similar to previous studies in healthy men and women, which have reported elevations in HR in the range of 9–16% and increases in oxygen consumption in the range of 8–23% during NPW in comparison to normal walking.[12–16] The relatively small increases in HR (7% at CD and 9% at MWD) are probably explained by the high percentage of patients (45%) on beta-blockers, which can limit HR. The increase in oxygen pulse at MWD suggests that stroke volume increased significantly despite beta-blockade.

Perceived exertion with or without Nordic poles at MWD was similar, suggesting that leg pain influences this variable in claudicants. The increase in cardiopulmonary work for a given level of perceived exertion suggests that the use of Nordic poles could be a useful strategy for increasing the cardiovascular fitness in this patient group. This could have important clinical implications for patients who cannot normally walk far enough or fast enough to provide a sufficient cardiopulmonary exercise stimulus.[17] In addition, the lower level of leg pain encountered during walking together with the increased distance could make this form of exercise rehabilitation more appealing to patients, and encourage better compliance to a physically active lifestyle. In this respect, previous research has reported both qualitative and quantitative improvements in walking performance following a 24-week programme of NPW training in patients with intermittent claudication.[13] A 51% improvement in treadmill walking time, reduced perception of claudication pain and improvements in perceived distance and walking speed scores on the Walking Impairment Questionnaire[22] were reported by Langbein *et al*.

Table 2 Indices of cardiopulmonary stress (work) and perceived exertion during NPW and normal walking

	NPW	Normal walking	Mean difference (95% confidence interval)	*P*-value
HR at CD (beats min^{-1})	107 ± 5	100 ± 5	7 (4–9)	0.000
HR at MWD (beats min^{-1})	115 ± 4	112 ± 6	3 (−5–11)	0.456
$\dot{V}O_2$ at CD (l min^{-1})	1.12 ± 0.08	0.95 ± 0.06	0.17 (0.07–0.26)	0.002
$\dot{V}O_2$ at MWD (l min^{-1})	1.20 ± 0.05	1.03 ± 0.06	0.18 (0.09–0.26)	0.000
$\dot{V}E$ at CD (l min^{-1})	35.17 ± 2.61	28.63 ± 1.84	6.55 (2.90–10.19)	0.001
$\dot{V}E$ at MWD (l min^{-1})	45.23 ± 2.59	38.20 ± 2.44	7.03 (3.11–10.96)	0.001
RER at CD (l min^{-1})	0.88 ± 0.01	0.84 ± 0.02	0.03 (0–0.07)	0.077
RER at MWD (l min^{-1})	0.98 ± 0.02	0.92 ± 0.03	0.05 (0.01–0.10)	0.016
RPE at MWD	14.6 ± 0.6	14.4 ± 0.03	0.3 (−0.9–1.4)	0.653
Oxygen pulse at MWD (ml $beat^{-1}$)	10.83 ± 0.69	9.63 ± 0.73	1.20 (0.38–2.02)	0.007

Unless otherwise stated, data in Table 2 are presented as means ± SE. *P*-values are shown for paired *t*-test comparisons between NPW and normal walking conditions of the study.

(2002)[13] after 24 weeks of polestriding training. In addition 'an enhanced mood' in pole walkers, compared to either of the other two groups (control and exercise classes) has been reported by Stoughton (1992).[23] This feel good factor was very evident in our study.

Conclusion

Our results demonstrate that NPW immediately enables patients with intermittent claudication to walk further with less leg pain, despite higher cardiopulmonary work at MWD. NPW could, therefore, be a useful exercise strategy for increasing the cardiovascular fitness of these patients. Further research is needed to explore the training effect, cost effectiveness and long-term benefits of NPW in these patients.

Funding

None.

Competing Interests

None.

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