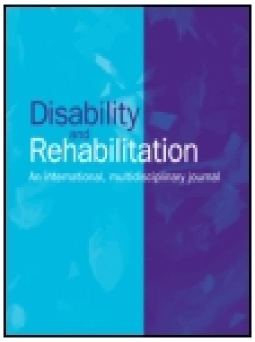

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REHABILITATION IN PRACTICE

Nordic pole walking improves walking capacity in patients with intermittent claudication: a randomized controlled trial

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ABSTRACT
Purpose: The aim of the study was to compare the efficacy of Nordic pole walking (NPW) training with traditional treadmill training (TT) on a claudication (CD) and maximum walking distance (MWD) in patients with peripheral arterial disease (PAD). *Method*: Patients with intermittent claudication (IC) ($n = 70$; age=68.27) in the Fontaine class II were randomized into a two three-month rehabilitation programs performed three times per week. TT were finished by 31 patients, NPW by 21. Walking capacity was measured by an exercise treadmill test (ETT) with the Gardner–Skinner protocol (before and after the program) and six minute walk test (6MWT) (before, during and after the program). *Results*: In an ETT both groups reached significant increase in CD and MWD ($p \leq 0.005$). In 6MWT NPW group reached significant increase in both CD ($p = 0.001$) and MWD ($p = 0.001$), whereas the TT group only in MWD ($p = 0.001$). *Conclusions*: NPW has been shown to be as effective as the standard TT and is much less expensive. It should be the preferred method of exercise for PAD patients with IC.

➤ IMPLICATIONS FOR REHABILITATION

- Nordic walking training is a valuable form of rehabilitation for peripheral arterial disease (PAD) patients with intermittent claudication (IC).
- Nordic walking has been shown to be as efficient as traditional treadmill training. It is however more cost-effective method of rehabilitation in PAD patients.

KEYWORDS:
Intermittent claudication (IC), Nordic pole walking (NPW), treadmill training (TT)

HISTORY
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Introduction

Peripheral arterial disease (PAD) is a common disorder in which insufficient blood flow to limb is caused by obstruction or narrowing of limb arteries. The main causes of PAD is atherosclerosis. Other but quite rare causes are: peripheral arterial embolism, thromboangiitis obliterans (Buerger's disease) or artery compression syndromes [1,2].

PAD affects 3–10% of the population and its prevalence increases with age. For people aged 50–59 years, the occurence is estimated to be about 2.5%, while for people aged over 70 years, it is 15–20% [3]. In Poland, every year there are about 40 000 new cases [4]. Patients with PAD often suffer from other cardiovascular diseases, including hypertension (40%), ischemic heart disease (25%) and cerebrovascular disease (10–15%). The intermittent claudication (IC) as a typical symptom of PAD occur in about 6% of patients with age 60 and over [3].

IC is caused by ischemia of the lower limb muscles. Lower blood flow and decreased oxygen uptake by working muscles causes pain in leg impaired patient's ability to walk. Claudication occurs while walking, and subsides when patient stops [1]. Limited walking due to pain, leads to disease progression.

Rehabilitation of patients with PAD is a complex, continuous and multi-stage undertaking, initiated immediately after diagnosis and individually matched to the capabilities of the patient. A basic method of exercise for patients with IC is supervised, individual walking program.

Evidence-based medicine refers to a supervised walking program on a treadmill. The Trans-Atlantic

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Inter-Society Consensus II (TASC II) [3] proposes the workload treadmill protocol in which the speed and an increase in grade provokes pain in 3–5 min. According to the five-point Likert scale of pain by the *American College of Sports Medicine* (ACSM), the greatest benefit is obtained with submaximal ischemic pain (level 4 – moderate pain intensity) when walking [3,5]. The training session should last from 30 (at the beginning) to 50 min [3]. In the literature, the most commonly used workloads are a constant speed of 3.2 km/h (2.0 mph) and gradation to 12% [6–8].

The main objective of the rehabilitation of patients with IC is an increase of the claudication distance (CD) and maximum walking distance (MWD). In accordance with the recommendations of the ACSM and *American Heart Association* (AHA), walking at moderate intensity repeated five times a week for a minimum of 30 min, using the intervals method (8–10 min of physical effort preceded by a short rest) significantly improves hemodynamic parameters, aerobic capacity, lipid profile, carbohydrate metabolism and body mass control [9]. Research shows that in patients with IC supervised walk training should be performed in sessions lasting at least 30–45 min, three times a week for a minimum of three to six months (class I of recommendations, level of evidence A) [3,7,8].

Rehabilitation carried out in accordance with the TASC II recommendations results in a significant increase in CD and MWD [10–14]. The studies report improved lipid metabolism, reduced oxygen consumption and increased walking capacity of the patient [13].

NPW was recently proposed as another walking exercise method for patients with IC [15–21]. This type of physical activity has documented usefulness in the rehabilitation of patients with multiple health problems, including neurological and circulatory disorders [22,23].

NPW has beneficial effects on cardiovascular system and biomechanical responses [24]. Compared with normal walking, NPW increases oxygen consumption (20–23%), heart rate (HR), caloric expenditure and lactic acid with no changes in effort perception [25–28].

Long term of regular NPW practice improves muscle endurance and strength of the upper limbs [28,29], which aid forward propulsion, and can further improve walking capacity in PAD patients. The use of Nordic poles has similar impact on the lower extremity as normal walking, but improves stability and is safer for the elderly with joints and postural balance problems [30,31].

Preliminary results of the effect of NPW training in PAD patients revealed improved walking capacity [15,16], increased claudication distance [15,17,18] and reduce perceived leg pain [15–17]. However, few studies compared NPW and treadmill exercise in PAD patients [19–21].

The aim of the study is to compare efficacy of a traditional supervised exercise program with treadmill, and supervised NPW programme on CD and MWD in patients with PAD.

Materials and methods

The study was approved by the Ethics Committee of the Medical University of Wroclaw, Poland (Ref. KB-130/2008). All individuals gave a written consent before entering the study, according to the Declaration of Helsinki.

Participants

The study included 70 patients aged 51–86 (mean 68.27) diagnosed with a PAD with IC. The subjects were assigned to two gropus: group I – training on a treadmill (TT) ($n = 35$), group II – NPW training ($n = 35$) using pseudo-randomization method.

Inclusion criteria for the study were: ABI below 0.9, claudication pain while walking (Fontaine's class IIa and IIb), written declaration from the physician about the absense of contraindications for participation in exercise program, patient's consent to participate in a three month walk training program.

Exclusion criteria were: critical limb ischemia, foot ulcers, inability to walk on a treadmill or with Nordic poles, inability to exercise three times weekly, current participation in other clinical trials, surgery or a myocardial infarction within the past three months, poorly controlled hypertension and/or diabetes, mental disorders.

Exercise treadmill test (ETT)

Before and after the three-month walk training program, Exercise treadmill test (ETT) was conducted on a treadmill with a 12-lead electrocardiogram. To determine walking capacity Gardner–Skinner protocol [32] was used, with a constant speed of 3.2 km/h (2.0 mph) and increase in grade of 2% every 2 min. During the ETT, standardized verbal encouragement was given. Patients were continuously monitored for hemodynamic response: HR and blood presure (BP). The rest values were analyzed.

CD was measured as the distance in meters just before the onset of claudication with the use of the five-point Likert scale of pain (1 – no pain, 2 – onset of claudication, 3 – mild, 4 – moderate, 5 – maximum pain), regardless of whether this was manifested as muscle pain, ache, cramps, numbness, or fatigue. MWD was determined by the maximum claudication pain or point of termination [3,32,33]. Both, CD and MWD were calculated using results from two consecutive ETT and averaged for the analysis.

Six-minute walk test (6MWT)

Before, during (after 16 training sessions) and after a three-month walk training program, Six minute walk test (6MWT) was conducted on a marked 30-m long corridor. Patients were instructed to walk with daily speed as many rounds as possible in 6 min. Individual stops were allowed during the test if claudication pain became intolerable, but the clock was not stopped during this time. Patients who stopped walking due to claudication pain were encouraged to return to walk as soon as possible.

CD was measured under the same conditions as in ETT. MWD was a total distance reached after six minutes of the test. Before and immediately after the test, BP, HR and rating of perceived exertion (RPE) were recorded. RPE was determined by 10-point Borg scale where 0 = no exertion and 10 = maximal exertion/exhaustion [33,34].

Exercise program – methods

The program of supervised walk training was carried out for three months (36 training sessions), three times a week from 30 (first week) up to 50 min. Each training began with a short warm-up (5–10 min) which consisted of flexibility exercises for upper and lower extremities and spine. Training was ended with stretching and breathing exercises (3–5 min). Before and after each training session, BP and HR were recorded. The rehabilitation program was conducted at the University of Physical Education in Wroclaw under medical supervision.

Treadmill training (TT)

Treadmill training (TT) was conducted on a treadmill HX-100 with the constant workload protocol based on TASC II guidelines [3]. Speed and slope were constant, amounted to 3.2 km/h (2.0 mph) and 12% grade. Patients walked up to the reach of submaximal level of pain (ACSM – level 4) and next rested in standing position when the level of pain decresed to 1 (no pain) but no longer than 2 min. If the pain after this time was not withdrawn, the distance on treadmill was usually shorter. Time of the training was gradually lengthened. At the beginning it was 30 min in which patients took more interval repeates and if the physioterapist noted less breakes for rest for about 2–3 training sessions the time of TT was successively extended (but no longer than 50 min). During the rest periods HR was monitored by the treadmill grips. In our physical center, patients trained parallely on two treadmills.

NPW training

NPW was performed by a qualified physiotherapist using the NW technique according to the guidelines of the International Nordic Walking Federation (INWA) with the KV+ poles (http://inwa-nordicwalking.com/). The pole length was adopted for each subject based on body height (0.7 × height). Patients trained under the same conditions as in TT. During the rest period, patients monitored HR individually. NPW was conducted in a group (max 12 participants) generally in outdoor. When the weather was bad patients trained in a sports hall.

Statistical analysis

Descriptive statistics were used to obtain: sample size, mean, standard deviation or counts and percentage share. Before performing the analysis, normality (D'Agostino–Pearson test) and homogenity of variance (Leneve's test) was assessed. In the absence of an assumption of normality of data, a logarithmic transformation was applied in order to satisfy the normality assumptions of the data. In order to evaluate the differences between the TT and NPW (between group comparison), a Student's *t*-test (or Welch's test) was performed. For the comparison of research before and after (within group) rehabilitation, Student's *t*-test for paired data was used, or when comparing before, during and after repeated measures ANOVA analysis was performed. Differences between TT and NPW in baseline clinical charasteristic were assessed using Student's *t*-test (in case of quantitative data) or Chi squared test (in case of qualitative data). The level of statistical significance $p \leq 0.05$ was adopted.

Results

Fifty-two patients completed full rehabilitation program: $n = 31$ in TT group and $n = 21$ in NPW group. Eighteen patients did not finish the program. The main reasons for dropouts from the training programs were personal problems and health disturbances. The characteristics of the TT and NPW groups are presented in Table 1.

Exercise treadmill test (ETT)

The results of CD and MWD obtained in a ETT for both groups are shown in Table 2. There was a significant

Table 1. Baseline clinical characteristics of treadmill training group (TT) and Nordic pole walking group (NPW).

Characteristics	TT ($n = 31$)	NPW ($n = 21$)	Total ($n = 52$)	p Value
Age [years]	67 (±7.4)	67 (±9.3)	67 (±8.15)	1.00
Women [n]	6 (19.35%)	9 (42.86%)	15 (28.85%)	0.13
Men [n]	25 (80.65%)	12 (57.14%)	37 (71.15%)	
BMI [kg/m^2]	27.85 (±3.72)	26.77 (±4.34)	27.42 (±3.97)	0.34
ABPI				
– Right	0.675 (±0.19)	0.758 (±0.17)	0.709 (±0.19)	0.11
– Left	0.680 (±0.16)	0.710 (±0.22)	0.692 (±0.18)	0.57
Comorbidities [n]				
Hypertension	27 (87.10%)	12 (57.14%)	39 (75.00%)	0.02*
Dyslipidemia	19 (61.29%)	9 (42.86%)	27 (53.85%)	0.26
Diabetes type 2	12 (38.71%)	8 (38.09%)	20 (38.46%)	1.00
Coronary heart disease	10 (32.26%)	10 (47.62%)	20 (38.46%)	0.38
Degenerative changes of the spine and peripheral joints	15 (48.39%)	4 (19.05%)	19 (36.54%)	0.04*
Kidney diseases	3 (9.68%)	4 (19.05%)	7 (13.46%)	0.42
Chronic venous insufficiency	1 (3.23%)	3 (14.29%)	4 (7.69%)	0.29
Hemodynamic parameters[a]				
– HR [beats/min]	72.3 (±13.34)	71.9 (±15.14)	72.15 (±13.95)	0.92
– SBP [mmHg]	134.2 (±16.13)	134.8 (±11.23)	134.4 (±14.23)	0.89
– DBP [mmHg]	77.4 (±8.15)	77.6 (±7.52)	77.5 (±7.83)	0.93
CD [m]				
– Treadmill test[b]	88.52 (±34.65)	114.86 (±92.35)	99.15 (±64.97)	0.64
– Six-minute walk test	219.97 (±96.27)	177.76 (±87.00)	202.92 (±94.43)	0.08
MWD [m]				
– Treadmill test 2	164.24 (±74.91)	224.38 (±143.69)	188.83 (±110.84)	0.21
– Six-minute walk test	343.50 (±66.46)	354.00 (±56.07)	347.74 (±62.12)	0.96

ABI: Ankle-Brachial Index; BMI: Body Mass Index; HR: Heart Ratio; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; CD: Claudication Distance; MWD: Maximum Walking Distance.
[a]Measured at rest.
[b]The average of two treadmill tests repeated in one week.
*$p \leq 0.05$.

Table 2. Results of exercise treadmill test (ETT) for TT ($n = 31$) and NPW ($n = 21$) group.

			TT			NPW			Total		
Parameters		Student t	Mean	SD	p Value	Mean	SD	p Value	Mean	SD	p Value
MWD (ETT)	B	0.09	164.24	74.91	0.001	224.38	143.69	0.002	188.53	110.84	0.001
	A	0.14	290.23	222.28		363.67	225.19		320.47	224.22	
CD (ETT)	B	0.64	88.52	34.65	0.001	114.6	92.35	0.005	99.15	64.97	0.001
	A	0.59	151.38	95.30		166.05	97.53		157.54	95.52	

B: Before; A: After; SD: Standard Deviation.

increase in both CD and MWD in TT and NPW groups ($p = 0.001$). For NPW group CD increased by 51.19 m (114.86 versus 166.05, $p = 0.005$), and MWD by 139.29 m (224.38 versus 363.67, $p = 0.002$) on average. The TT group increased CD by 62.86 m (88.52 versus 151.38, $p = 0.001$), and MWD by 125.99 m (164.24 versus 290.23, $p = 0.001$) on average. There were, however, no significant differences between the the two groups (MWD $p = 0.14$; CD $p = 0.59$).

Six minute walk test (6MWT)

The results of CD and MWD obtained in a 6MWT for both groups are shown in Table 3. In NPW group there were significant changes in both distances. MWD increased in relation to the baseline by 38.52 m (354 versus 392.52, $p = 0.002$), and CD increased by 73.14 m (163.48 versus 236.62, $p = 0.001$) on average. The TT group resulted in an increase of MWD by 31.61 m (343.5 versus 375.11, $p = 0.001$), and the CD increased by 35.96 m (219.67 versus 255.63, $p = 0.12$) on average. Interestingly after six weeks, there was a significant increase in CD only in the NPW group ($p = 0.001$).

Hemodynamic parameters and RPE

HR and BP did not change significantly in either group (Table 4). RPE significantly changed after the 6MWT in the NPW group only ($p = 0.046$) (Figure 1). The largest increase in the level of fatigue was observed in the middle of the rehabilitation program, which was reflected in the increase of CD and MWD after six weeks (66.82 versus 12 m).

Discussion

We have compared the effects of NPW and TT in patients with IC and improved efficacy of both methods.

Table 3. Results of six-minute walk test (6MWT) for TT ($n = 31$) and NPW ($n = 21$) group.

Parameters		TT				NPW			Total		
		Student *t*-test	Mean	SD	*p* Value	Mean	SD	*p* Value	Mean	SD	*p* Value
MWD (6MWT)	B	0.55	343.50	66.46		354.00	56.07		347.74	62.12	
	D	0.42	349.98	73.74	0.001	366.00	60.23	0.002	356.27	68.58	0.001
	A	0.37	375.11	69.79		392.52	63.88		382.14	67.38	
CD (6MWT)	B	0.11	219.67	96.27		163.48	91.32		202.92	94.43	
	D	0.51	250.23	112.07	0.12	230.30	90.28	0.001	242.26	103.39	0.001
	A	0.50	255.63	103.22		236.62	93.76		247.95	99.01	

B: Before; D: During; A: After; SD – Standard Deviation.

Table 4. Hemodynamic parameters (resting values) for TT ($n = 31$) and NPW ($n = 21$) group.

Parameters		TT				NPW			Total		
		Student *t*-test	Mean	SD	*p* Value	Mean	SD	*p* Value	Mean	SD	*p* Value
HR	B	0.84	72.32	13.34	0.50	71.90	15.14	0.45	72.15	13.95	0.99
	A	0.36	72.82	11.79		69.76	11.13		71.51	11.50	
SBP	B	0.88	134.19	16.13	0.25	134.76	11.23	0.23	134.42	14.23	0.09
	A	0.82	129.29	13.72		130.48	16.19		129.80	14.68	
DBP	B	0.93	77.42	8.15	0.74	77.62	7.52	0.69	77.50	7.83	0.97
	A	0.96	76.96	9.16		76.90	9.55		76.94	9.23	

B: Before; A: After; SD: Standard Deviation.

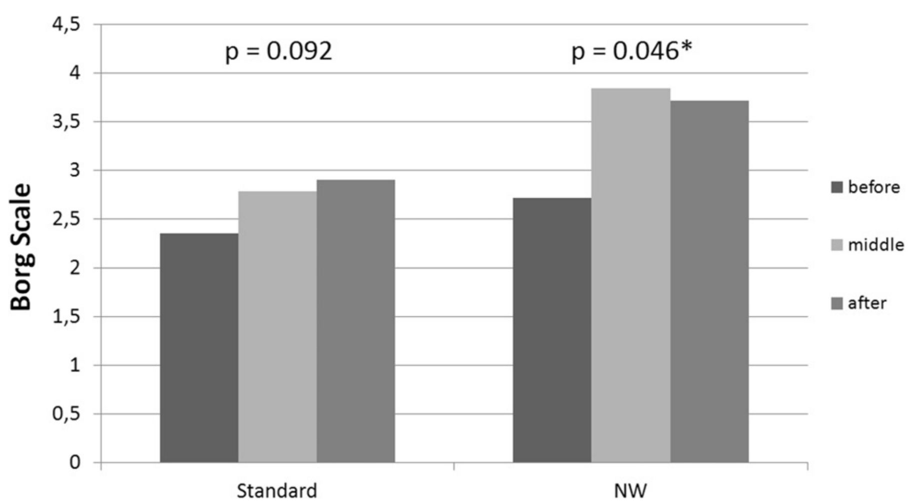

Figure 1. Analysis of the rating of perceived exertion (RPE) according to the 10-point Borg scale; *p* value refers to the comparison between groups (*$p < 0.05$).

Published studies suggest that NPW may be superior to standard TT in patients with IC [19,20].

Our findings clearly show that a three-month supervised walk training program leads to a significant increase in CD and MWD. No significant differences between NPW and TT were detected. Similar results were obtained in studies by Collins et al. [19]. The less costly NPW might be a more cost-effective way of rehabilitation for PAD patients.

The minimal rehabilitation period in which noticeable changes occur in CD is also discussed. Sanderson et al. [35] showed that only six weeks of rehabilitation on a treadmill significantly increases CD. Our results do not confirm it in the case of TT. However, NPW after six weeks resulted in a significant increase in CD, which validates faster effects of rehabilitation than TT.

NPW technique characterised diagonal movements with contralateral hand-foot coordination so that the swing phase is always double, with one leg and with the pole of the opposite hand. It gives greater stability with more muscle-engagement than ordinary walking [31]. Walking with poles evokes increased cardiovascular and respiratory response [23,24]. Interestingly, the NPW exercise lacks perceived fatigue despite the considerable energy expenditure which may be caused by the psychological benefit of outdoor training [27]. It leads to lengthening the excerise time undertaken by the PAD patients and immediately increases their CD and MWD.

Study by Oakley et al. [18] confirms the superiority of NPW over the ordinary walking in significant increase of CD and MWD ($p = 0.000$) as well as a reduction in pain of the lower limbs ($p = 0.002$) in PAD patients [18]. However, studies comparing TT and NPW found no significant differences between both the methods [19], similar to our findings.

TT is the recommended form of physical activity for rehabilitation of patients with IC [3]; however, in our opinion NPW better replicates movement pattern for regular walking. Treadmill walking forces gait speed which is often difficult to maintain for elderly patients and generates fear of falling. Walking with poles gives patients feeling of better stability. In addition, NPW is an inexpensive form of rehabilitation, it can be done anywhere and has improved patients' mood [36]. Training with poles does not need to be supervised over the time, but we suggest systematic visits with experienced instructor which will monitor rehabilitation process and improve technique skills.

In conclusion, NPW has been shown to be as effective as the standard TT. Lower costs and greater availability are additional benefits which should be considered by vascular societies for recommending the NPW method to the rehabilitation programs for PAD patients with IC.

Limitations

Major limitation of this study is disparity in the size of the two groups. This was due to patients being lost to the study for personal and medical reasons.

Declaration of interest

This publication is part of a project called "WROVASC – an Integrated Cardiovascular Centre", which was co-financed by the European Regional Development Fund, within the Operational Program Innovative Economy, from 2007–2013. The study was carried out at the Research and Development Centre of the Regional Specialist Hospital, in Wroclaw [POIG.01.01.02-02-001/08-03].

All contributors report no conflict of interest.

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