

# Does Nordic walking improves the postural control and gait parameters of women between the age 65 and 74: a randomized trial

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**Abstract.** [Purpose] To assess the effect of 12-weeks Nordic walking training on gait parameters and some elements of postural control. [Subjects and Methods] Sixty-seven women aged 65 to 74 years were enrolled in this study. The subjects were divided into a Nordic Walking group (12 weeks of Nordic walking training, 3 times a week for 75 minutes) and a control group. In both study groups, a set of functional tests were conducted at the beginning and at the end of the study: the Forward Reach Test (FRT) and the Upward Reach Test (URT) on a stabilometric platform, and the analysis of gait parameters on a treadmill. [Results] The NW group showed improvements in: the range of reach in the FRT test and the URT test in compared to the control group. The length of the gait cycle and gait cycle frequency also showed changes in the NW group compared to the control group. [Conclusion] A 12-week NW training program had a positive impact on selected gait parameters and may improve the postural control of women aged over 65 according to the results selected functional tests.

**Key words:** Nordic walking, Postural control, Gait

*(This article was submitted Jul. 16, 2015, and was accepted Sep. 17, 2015)*

## INTRODUCTION

It is believed that physical activity for the prevention of falls should primarily aim to increase the strength of large groups of muscles, mainly in the lower limbs, as well as improve gait, balance, and coordination parameters<sup>1)</sup>. Among the organized exercise systems only Tai-Chi has been mentioned in this context, and the importance of physiotherapy is emphasized<sup>2)</sup>. However, it has not been determined which specific forms of rehabilitation activities should be undertaken in order to achieve satisfactory results in this field.

Nordic Walking (NW) is a relatively new type of walking training. It involves marching using poles, and is an adaptation of cross-country skiing. The main purpose of using the poles is to involve the muscles that are not used during normal walking. This enables high intensity exercises to be performed at a relatively low level of perceived exertion. NW is also a form of physical activity which is recommended for the elderly. There is evidence of its importance

in the prevention and physiotherapy of musculoskeletal disorders, vascular diseases, cardiovascular diseases and Parkinson's disease<sup>3)</sup>. Parkatti et al. reported that NW improved all health-related components of fitness of the elderly based on functional tests, however, no improvement of gait parameters was observed<sup>4)</sup>. Takeshima et al. have confirmed the efficacy of a 12-week NW training program and its positive impact on selected fitness parameters on the basis of a physical fitness test and a test on a force platform<sup>5)</sup>. However, gait parameters were not assessed. In another study it was demonstrated that NW training improved both the strength and walking speed of the elderly, compared to the traditional walking training<sup>6)</sup>. However, the impact of NW on postural control has not been examined. Exercise is recommended to improve abnormal posture control during walking, and the use of exercises focused on performing two independent tasks has a particular impact on the improvement of gait parameters and postural control<sup>7)</sup>.

In this study, a set of objective tests were used to evaluate the fitness elements related specifically to postural control, especially those used during daily routines, such as reaching in various directions or bending the body and gait parameters. This study used a force platform to evaluate performance in specific functional tests the Forward Reach Test (FRT) and the Upward Reach Test (URT) to evaluate the changes in postural control during reaching. Moreover, kinematic gait analysis was performed in order to assess the

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potential impact of NW training on selected gait parameters. Our hypothesis was that a long-term NW training would improve gait symmetry, lengthen the gait cycle, and decrease the frequency of the strides made eliciting greater economy of energy and improvement in incorrect gait patterns of the elderly. Gait analysis of this study mainly focused on assessment of coordination and symmetry of gait. The aim of the study was to evaluate the effects of 12 weeks Nordic walking training on selected gait parameters and elements of fitness related to postural control.

## SUBJECTS AND METHODS

This study followed a randomized controlled trial design. The subjects were randomly assigned to 2 groups: the experimental group (NWg) and the control group (Cg) (Fig. 1). Next, the patients performed the baseline tests. The tests were conducted by blinded assessors, in a single blind experiment; the person making the measurements did not know to which study group a given subject belonged. Simple random sampling was used, with unmarked envelopes and a 1:1 chance of drawing a group.

Sixty-seven volunteers who met the inclusion criteria, were enrolled in the study. The inclusion criteria were: age between 65 and 74 years, no regular physical activity in leisure time, and a willingness to participate in the study. The exclusion criteria were: age, regular forms of physical activity undertaken in leisure time, professional activity, musculoskeletal dysfunctions preventing exercise and walking, acute inflammations possibly associated with a disease, previous episodes of cardiac arrest, uncontrolled arrhythmias, chronic heart failure (NYHA 3 and 4), uncontrolled and untreated high blood pressure (over 140/90 mm/Hg at rest), uncontrolled asthma, diabetes with insulin treatment, liver or renal failure, neoplastic disease or medical advice against taking exercise.

The level of physical activity of all subjects was assessed using a physical activity questionnaire the 7-Day Physical Activity Recall (7PAR)<sup>8</sup>, in order to compare the initial level of physical activity between the groups at baseline.

All the patients were informed about the purpose and procedures of the study in detail and gave their consent to participation in the study. The study received the approval of the local Bioethical Committee of University of Medical Sciences No. 216/11.

The subjects of the experimental group and the control group performed the same set of tests at the beginning and at the end of the 12-week training period.

The functional equilibrium tests performed on the force platform aimed to evaluate postural control while reaching. The study used two reliable functional equilibrium tests: FRT and URT. The tests were performed with the subjects standing on a force platform (CQ – Stab Poland) placed against a wall. Measuring tapes were stuck to the wall, in accordance with the diagram presented in the study by Row et al<sup>9</sup>. The assessed parameters included the length of forward reach (measured tape affixed horizontally) and upward reach (centimetre tape affixed at a 45-degree angle), and the forward displacement of the centre of pressure (COP) in relation to the initial position of the patients, labeled point “0”.

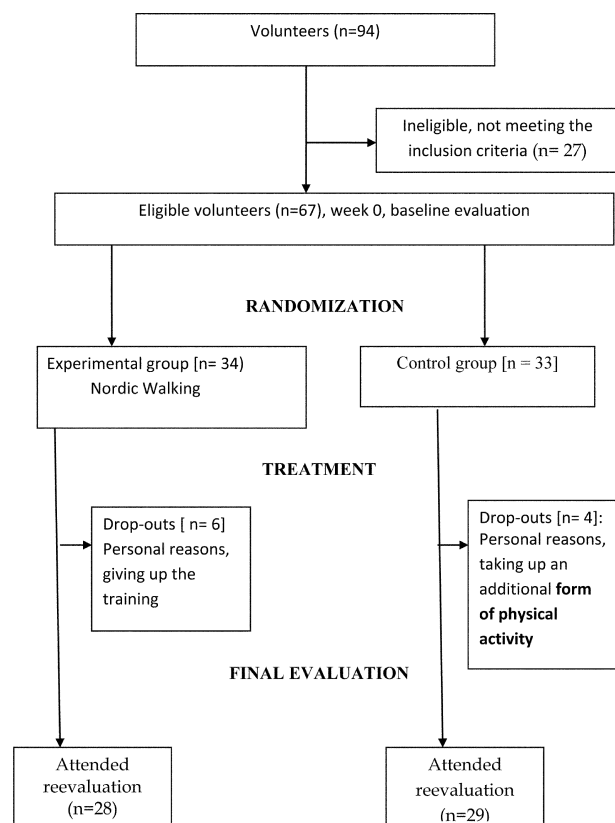


Fig. 1. The flow of participants through the trial

Point “0” was determined as the vertical projection from the centimetre tape stuck to the wall onto the furthest point of the foot on the force platform. These points were marked with a special tape, which the subjects were not allowed to cross, and were identical for all measurements and subjects. The position of the platform in the baseline and post-intervention tests was identical (marked with a tape stuck to the floor), the position of the feet and the upper limbs also remained unchanged (the tape stuck to the platform, the measuring tapes stuck to the wall). The evaluated parameters included the forward displacement of the COP (the furthest point in the computer diagram), and the forward and upward reach (forward or upward movement of the fingers on the centimetre tape). Both in the baseline and post-intervention tests, the patients performed the test 3 times and the best result, in which the patient reached the furthest, was chosen for use in the analysis.

Gait parameters were evaluated on a Zebris FDM-T Treadmill (Zebris® Medical GmbH, Germany). This treadmill has often been used as a research tool to examine the elderly, and patients with neurological deficits<sup>10, 11</sup>. The subjects performed two trials at baseline and post-intervention at a rate of 4 km/h, which reflected their average walking speed. The first trial lasted for 30 seconds and was supposed to prepare the patient for walking on the treadmill, the second lasted for 5 min and the results were used in the analysis.

The subjects from of NWg performed a 12-week training programme. Training sessions were held three times a week. A training session lasted for 75 minutes: 10 minutes

**Table 1.** The descriptive characteristics of the subjects (mean  $\pm$  SD)

Feature	Nordic Walking group (n=28)	Control group (n=29)
Age (years)	70.5 $\pm$ 3.7	71 $\pm$ 2.9
Gender	Female – 100%	Female – 100%
Weight (kg)	67 $\pm$ 9.9	66.4 $\pm$ 11.2
BMI (kg/m <sup>2</sup> )	27.13 $\pm$ 3.7	26.9 $\pm$ 4.5
Height (cm)	157.2 $\pm$ 5.9	159.5 $\pm$ 5.8
	Rest: 45:52	Rest: 46:00
The time spent in physical activity during leisure in the week preceding the study (7PAR – hours: min)	Light PA: 84:12 Average PA: 31:02 High PA: 05:51 Very high PA: 0:00	Light PA: 80:16 Average PA: 30:01 High PA: 06:45 Very high PA: 0:00

There were no significant differences in any of the parameters between the Nordic walking group and the Control group.

of warm-up activities with stretching, 60 minutes of walking and 5 minutes of “cool-down” activities with stretching. Each session was performed in a group and was supervised by two instructors. The walking distance and pace of the groups were gradually increased by the instructors who took into consideration both the period of the intervention and the level of perceived exertion of the participants (mean pace: 1st week: 4.2 $\pm$ 0.2 km/h; 12th week: 5.6 $\pm$ 0.2 km/h). The pace of walking was monitored by the instructors, using handheld equipment (Polar GPS Sensor G5, Polar Electro Oy, Kempele). In each session, when participants reached half the distance, they had short break during which they performed breathing exercises. The participants in both groups received the recommendation, that they should perform exercise, no less than 12 and no more than 14 points on the perceived exertion scale<sup>12</sup>). The subjects of Cg received detailed instructions regarding walking training, which they performed unsupervised over the next 12 weeks. Moreover, each CG subject was given a GPS sensor with instructions to turn it on before starting a walk, and to turn it off after finishing the walk. Once a month the data concerning the amount of training and the times of individual training were checked. The subjects of both groups (NWg and Cg) were told not to take up any additional forms of physical activity, and not to change their current eating and motor habits during the course of the study. Before the start of the training, the subjects in NWg were taught to the proper technique of walking with poles (a 2-hour instruction).

The distributions of continuous data were assessed using the Shapiro-Wilk's test. As data were not normally distributed, comparisons between the two study groups were performed using the Mann-Whitney test. For paired variables, the Wilcoxon test was used. P-values < 0.05 were considered significant. The statistical analyses were conducted using the STATISTICA 2009 software package.

## RESULTS

The subjects of both groups were similar in terms of the basic descriptive characteristics and the level of physical activity as assessed by 7PAR (Table 1).

The results obtained in the URT and FRT tests demonstrate

**Table 2.** The results of the Forward Reach Test and the Upward Reach Test performed on a stabilometric platform (mean $\pm$  SD)

Test	Nordic Walking group	Control group
Baseline Test FRT (cm)	114.8 $\pm$ 3.4	115.9 $\pm$ 3.8
End Test FRT (cm)	115.8 $\pm$ 4.6*	116.7 $\pm$ 4.1
Baseline Test FRT COP (mm)	89.05 $\pm$ 10.3	84.8 $\pm$ 13.2
End Test FRT COP (mm)	85.10 $\pm$ 9.4	80.5 $\pm$ 13.2
Baseline Test URT (cm)	105.5 $\pm$ 5.9	105.2 $\pm$ 3.7
End Test URT (cm)	107.8 $\pm$ 5.5* ,**	105.9 $\pm$ 4.4
Baseline Test URT COP (mm)	87.13 $\pm$ 10.3	84.6 $\pm$ 13.8
End Test URT COP (mm)	82.0 $\pm$ 12.2	81.9 $\pm$ 12.8

FRT: Forward Reach Test, URT: Upward Reach Test, COP: Centre Of Pressure

\*p<0.05 in the Wilcoxon test

\*\*p<0.05 for differences between the groups in the changes from baseline to post-intervention

that after NW training, the NWg subjects showed significant improvement in the range of reach in both tests, compared to the baseline. Also the difference between the URT results at the baseline and post-intervention tests proved to be significantly different from that of the control group. Neither group showed a statistically significant improvement in the maximum forward COP displacement (Table 2).

Gait analysis failed to identify any significant changes during the evaluation of a single stride and any of its phases. The only parameter which showed a noticeable change was the slightly reduced percentage difference from baseline in the swing phase of the control group at post-intervention. However, the analysis of the full gait cycle showed it was longer (cm) at post-intervention in NWg, and this was accompanied by prolongation of the time of strides and a reduction in their frequency compared to Cg (Table 3).

## DISCUSSION

The study attempted to evaluate the impact of Nordic walking training, on some parameters of functional fitness

**Table 3.** The treadmill walking parameters (mean± SD)

Gait parameters	Nordic Walking Group		Control Group	
	Baseline	End	Baseline	End
Width (cm)	6.2±1.6	5.9±1.6	5.9±1.8	5.8±1.8
The difference in stride length between the left and the right leg (cm)	2.4±2.3	2.9±1.8	2.4±1.6	3.1±1.3
The difference in stride-making time between the right and the left leg (sec)	0.01±0.01	0.01±0.01*	0.09±0.01	0.01±0.01
The percentage difference in the total time of the stance phase between the left and the right leg (%)	0.8±0.5	0.7±0.7	1.1±0.7	0.7±0.4
Load response (%)	0.9±0.7	0.8±0.9	1.0±0.5	0.7±0.6
Single support (%)	0.8±1.3	0.6±0.6	1.1±1.1	0.7±0.4*
Pre-swing (%)	0.9±0.7	0.84±0.9	1.0±0.6	0.7±0.5
The percentage difference in swing phase time between the left and the right leg (%)	0.8±1.3	0.7±0.6	1.1±1.1	0.7±0.4*
The percentage of double support time (%)	25.0±2.3	24.1±2.4	25.5±2.3	24.8±2.0
The length of the cycle (cm)	101.8±9.01	112.4±11.2*,**	106.2±12.4	108.9±10.5
The time of the cycle (sec)	1.00±0.1	1.1±0.1*	1.0±0.1	1.0±0.1
Cadence (strides/min)	60.6±6.9	55.6±7.1*,**	57.7±5.2	56.9±4.3

\*p&lt; 0.05 in the Wilcoxon test

\*\*p&lt;0.05 for differences between the groups in the changes from baseline to post-intervention

of women over 65 years of age. The evaluated parameters were associated with postural control, balance and gait, i.e. the elements of fitness which may play important roles in the prevention of falls. In most cases, the obtained results were consistent with the research hypothesis and showed that Nordic walking has potential as a form of exercise for the elderly.

Postural control disorders are an important factor contributing to the risk of fall<sup>6</sup>). Postural control is defined as the ability to control the body's position in space for the purposes of stability and orientation, and is critical during standing balance and walking tasks<sup>13</sup>). Postural control was analyzed using a stabilometric platform, which is often used in studies of the elderly and in neurology<sup>14, 15</sup>). However, in the present study it was used as an auxiliary tool to evaluate the displacement of the centre of pressure (COP) during two functional tests, URT and FRT. These tests are commonly used as a reliable method of measuring dynamic balance. Moreover, URT has been defined as the more demanding test, reflecting everyday-life activities better than FRT<sup>9</sup>). Drawing on the experience of the authors, the measurements were performed in a similar way, but facilitated by the placement of coloured sticky tapes on the floor and the stabilometric platform, and measuring tapes on the wall, which were not removed throughout the study in order to maintain a uniform standard of research. The results suggest that only NWg subjects improved their range of reach the both in the FRT and URT tests, however only significant found between NWg and Cg was in the post-intervention changes from baseline in the URT test. No significant changes in the forward displacement of the centre of pressure were observed, contrary to what had been expected. Moreover, the average results indicate that there was a decreasing trend in this result, which may suggest that during trials, the NWg subjects moved COP to their heels and at the same time tried to reach forward and upward more boldly. It is possible that NW training did not increase body

control while moving COP forward during the URT and FRT tests, but it could have improved muscle strength and trunk stability, thereby improving postural control.

The URT or FRT tests help to evaluate the ability to maintain balance during a functional task<sup>16, 17</sup>), and perhaps, in the future, these tests should be incorporated into a comprehensive assessment of dynamic balance and postural control. Parkatti et al.<sup>4</sup>), demonstrated a statistically significant improvement in all the components of the fitness test for the elderly, apart from the "backscratch test". Similar results were reported by Lee et al.<sup>18</sup>), and by Kukkonen-Harjula et al. in a study in which the tested women showed improvements in most tests evaluating physical fitness, but each time on the basis of a different set of tests<sup>19</sup>). In that study measurements of postural control were not taken into account, and balance was assessed using the standing on one-leg time and walking backwards. It seems that the strength of the trunk muscles plays a vital role in maintaining balance when crossing the circumference of the support base, and during each phase of walking the erector spinae and multifidus muscles are engaged<sup>20</sup>). These muscles probably work in a similar way regardless of whether we use poles or not, especially since opinions about the reduced burden on the legs and the trunk during walking with poles were premature<sup>21, 22</sup>). The evaluation of the involvement of individual trunk muscles during NW calls for further investigation.

Studies suggest that gait parameters should be evaluated at least once a year<sup>23</sup>), since selected gait parameters may become an important index for determining the risk of falling. Our study results are promising, because they demonstrate that in the Nordic walking group the length (cm) and time (sec) of the gait cycle were increased and the frequency of strides decreased. Earlier studies have demonstrated that walking training performed once a week, can improve gait speed and performance during the "Timed up & go test"<sup>24</sup>). Moreover, the results of our study are consistent with other findings that show that

the use of different forms of unconventional walking (e.g. with music or with exaggerated upper-body involvement) improves gait parameters<sup>25</sup>).

The assumptions of the present study seem similar to those made by Takeshima et al<sup>5</sup>. In their study, it was suggested that NW should be the recommended form of physical activity for improving fitness and reducing the risk of fall in the elderly. In our study the evaluation of postural control by selected functional tests gave promising results. However, it seems that the intervention had a greater efficacy among elderly persons with high risk of falls or a history of falls.

Limitations of the study. The subjects of this study were only women (no man volunteered), therefore, it is difficult to draw conclusions for the entire population of the elderly and, in order to draw definitive conclusions, the size of the experimental group needs to be increased. The functional tests performed on the stabilometric platform were experimental. For this reason, an objective and universally recognized functional test should be used at the later stage of the study for the comparison of results. At this stage of the study there was no supervised control group and it was difficult to determine whether walking would not affect the results in a way similar to the Nordic walking training. Therefore, at a further stage of the study, a group will be created which, instead of the Nordic walking training, will perform traditional walking in a supervised form.

Finally, it is in our opinion that 12-week NW training has a beneficial impact on selected gait parameters and may improve postural control, on the basis of results of selected functional tests performed by women between the ages of 65 and 74.

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