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REVIEW

Nordic walking in the second half of life

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Abstract
Objectives The objective of this article is to review the literature regarding the effectiveness and safety of Nordic walking (NW) in therapeutic rehabilitation in patients of an advanced age.
Methods Randomized studies comparing NW with different patterns of long-lasting physical rehabilitation in older adults (average age 65 years) were selected for the review. Studies were identified through a Medline database search covering the last 21 years.
Results Seventy-four studies on this subject were identified, 37 of them fulfilled the required criteria and 27 of these were analyzed in this review.
Discussion Nordic walking provides a safe and effective way to enhance physical activity in the elderly. It could also serve as a method of rehabilitation that improves fitness, the performance and the exercise capacity of aged persons with diseases associated with an advanced age: cardiovascular diseases due to atherosclerosis; metabolic syndrome without diabetes; early stage Parkinson's disease; chronic obstructive pulmonary disease and lowering depression in women with Sjögren's Syndrome.

Keywords Physical rehabilitation · Elderly · Diseases of advanced age · Atherosclerosis · Metabolic syndrome · Parkinson's disease

Introduction

Increased aging population is causing major worldwide health problems due to the rise in diseases associated with advanced age [1]. According to the World Health Organization (WHO) guidelines, one of the most important challenges with the aging population is providing proper physical rehabilitation for older patients [2]. Physical activity, even with low intensity, can improve the quality of life (QoL) and reduce the disability rate in the elderly population. It is challenging to find a form of physical activity suitable for older people.

Nordic walking (NW), defined as "Scandinavian walking with poles" in its current form, was invented in the 1920s by a Finn as a summer workout for skiers. NW is fitness walking using specially designed poles for the purpose of activating the upper body during walking. NW combines skiing, sport walking, and trekking [3]. It has been recognized as an exercise since the late 80s, but has gained worldwide attention as a popular form of recreation, sport, tourism, and rehabilitation only a few years ago [4–13]. NW is one of the fastest-developing forms of physical activity among older people in Europe, especially among those above 65 [14–16].

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By using the poles, the muscles in the upper body can be activated and the length of each step taken is supposedly increased resulting in a faster gait. NW appears to increase gait speed and cardiovascular metabolism—persons performing NW had a higher heart rate and higher oxygen consumption than walking without poles with low perceptible exertion [13]. NW does not overload the joints. [13].

The aim of this article is to review the evidence related to the safety and effectiveness of NW as therapeutic rehabilitation for patients of advanced age. Therapeutic rehabilitation means providing improvement of exercise capacity and overall health for disabled persons and the restoration of seniors to a useful place in society.

Methodology

Literature for review was selected from a PubMed database search covering the last 21 years (1994–2015) using the following criteria:

1. Randomized, prospective studies comparing supervised, chronic NW rehabilitation (lasting for 3 months or more) with different, classical patterns of long-lasting physical rehabilitation.
2. Study population with an average age of 65 years or more and diseased.
3. Studies including more than 40 participants.

The work's methodology consisted of entering passwords in PubMed database: Nordic walking, physical rehabilitation, chronic physical rehabilitation in connection with elderly patients, old age, seniors. Then it expanded to more articles by entering terms of all the diseases associated with old age, for instance: ischemic heart disease, heart failure, hypertension, peripheral occlusive disease, metabolic syndrome, diabetes type 2, pulmonary obstructive disease, orthopedic disorders, stroke, cancer, etc. The search at this level revealed 74 publications. After excluding publications which did not meet the criteria for inclusion in the study (mainly due to the younger age of the study population with mostly healthy volunteers, other than Nordic walking rehabilitation forms described, unsupervised NW trainings, retrospective and nonrandomized original papers, reviews) 37 articles remained in the evaluation. Out of these articles, ten have been removed because they described the evaluation of Nordic walking workouts in a short period of time in a group of healthy seniors or the study population was less than 40 patients, leaving 27 articles in the evaluation.

The criteria were sometimes mitigated due to lack of data. The safety and effectiveness of NW as a rehabilitation tool in diseases connected with old age was considered a more important criteria to take into account than the inclusion of 40 participants or their age over 65 years.

Nordic walking in geriatric cardiology and angiology

Cardiovascular diseases including ischemic heart disease, arterial hypertension, heart failure, stroke, and peripheral arterial disease are common among the elderly.

Coronary artery disease

Kocur et al. [3] presented the effects of NW training and walking without poles in a study of 80 men with good exercise tolerance in an early cardiac rehabilitation program (2–3 weeks after an acute coronary syndrome treated with primary percutaneous coronary intervention). A 3-week inpatient cardiac rehabilitation program (control group, mean age 54.5 ± 9.4 years old) supplemented with NW (NW group, mean age 51.4 ± 6.2 years old; five sessions per week) or with traditional walking training (walking training group, mean age 51.3 ± 7.1 year old) was conducted. Exercise capacity (in metabolic equivalents, METs) in symptom-limited treadmill exercise tests and physical fitness with the Fullerton Functional Fitness Test were measured before and after the training program. The mean exercise capacity after the rehabilitation program was significantly higher in the NW group than in the control group (10.8 ± 1.8 vs. 9.2 ± 2.2 METs). Moreover, improvement in mean exercise capacity in the NW group was significantly higher than in the control group (1.8 ± 1.5 vs. 0.7 ± 1.4 METs). In contrast to the control group, the results of all components of the Fullerton Test improved in the NW and traditional walking training groups. After the program, lower-body endurance and dynamic balance were the best in the NW group. Upper-body endurance was significantly better in the NW and walking training groups in comparison with the control group. In conclusion, NW may produce better exercise capacity, lower-body endurance, and coordination of movements in patients with good exercise tolerance participating in early, short-term rehabilitation after an acute coronary syndrome than traditional walking training and cardiac rehabilitation programs.

Similar methodology (NW training vs. walking without poles) was used in a late rehabilitation program by Wilk et al. [17]. The authors examined the influence NW had on exercise tolerance (measured on admission and after completing the rehabilitation program, in a six-minute walking test (6MWT), an exercise test following the modified Bruce protocol) and physical performance (Fullerton Test) in 30 patients (aged 40–66) 14–28 days

after a myocardial infarction treated with percutaneous coronary intervention. Ten patients were assigned to a control group with standard rehabilitation program, and 20 subjects were qualified to group additionally to standard rehabilitation performed NW training (five times a week for 3 weeks, each session lasting for 40 min and consisting of 3 km walks). Exercise tolerance was analyzed by measuring the rate-pressure product. The rate-pressure product is used in cardiology and exercise physiology to determine the heart workload and is obtained by multiplying heart rate (beats per minute) with systolic blood pressure (mmHg). The rate-pressure product is a measure of the energy consumption of the heart allowing the internal workload or hemodynamic response to be calculated. The authors found a significant improvement in exercise tolerance in both exercising groups; however, it was greater in the NW group (30 vs. 14 %). The measured rate-pressure product showed a significant improvement in the NW group only, with a mean of 7.9 ± 1.8 MET before the training sessions started and reaching a mean of 10.3 ± 2.3 MET after an intensive program. The improvement in the 6MWT was also greater in the NW group (22 %) in comparison with the control group (17 %). Both groups showed significant improvements in all variables measured in the Fullerton Functional Fitness Test except for upper-body strength and coordination, which were better in the NW group. No adverse cardiovascular effects were reported during the experiments that would require a reduction in training intensity or its termination.

Conclusion NW alone or as a supplement to a traditional cardiac early and late rehabilitation after acute coronary syndrome is a safe and effective method of enhancing patient physical activity.

Heart failure

A study of a 12-week NW training regime (45–60 min for one training, three times per week) for heart failure patients was presented at the 2012 Heart Failure Congress [18]. The study group consisted of 23 subjects, nine of whom were patients diagnosed with heart failure [New York Heart Association (NYHA) classification II/III, left ventricular ejection fraction (LVEF) <45 %; mean age 65.2 ± 6 years]; the remaining 14 were healthy subjects (mean age 63.3 ± 6 years) who served as a control group (without physical activity). Physical fitness was measured by the ability to complete a double sub-maximal 6MWT at a constant speed of 5 km/h, the participants did one test walking with NW poles, and one walking without the poles.

The cardiorespiratory response during both tests was also measured. In patients with heart failure, a mean increase in oxygen uptake of 14.7 % (2.9 mL/kg/min), and a mean increase in respiratory quotient of 18 % were observed after completion of the training regime in the NW group. On average, peak heart rate was 15 beats/min higher, maximal systolic blood pressure was 10 mmHg higher, and fatigue level was increased by two points on the Borg Scale for individuals training with poles compared with those without. All of these differences were statistically significant. Following the NW training regime, healthy subjects exhibited an average increase in oxygen uptake of 37 % (4.9 mL/kg/min) and their respiratory quotient was also higher (median increase of 5 %) compared with the group without poles. Peak heart rate, maximal systolic blood pressure, and fatigue level were also higher in the NW group (mean values of 20 beats/min, 15 mmHg, and two points on the Borg Scale, respectively). All of these differences were similarly statistically significant. No signs of cardiac ischemia or significant arrhythmias during the tests were observed in either group. The researchers concluded that NW allows healthy people and patients with heart failure to safely increase the intensity of exercise and gain additional cardiorespiratory benefits.

Previous pilot research in this field conducted by the same authors demonstrated similar results: aerobic exercise (especially NW) is a safe, easy, well-tolerated form of physical activity for patients (aged 40–75 years) with advanced heart failure (NYHA classification II/III, LVEF 30 ± 10 %) that improves their QoL and reduces the number of times they are admitted to hospital for heart failure exacerbation [19].

A trial conducted by a different group assessing NW compared to standard cardiac rehabilitation care within 54 patients (aged 62.4 ± 11.4 years) with heart failure (mean ejection fraction 26.9 ± 5.0 %) showed similar results as the studies above. Both groups performed 200–400 min of exercise per week for 12 weeks. The primary outcome measured after 12 weeks was functional capacity, assessed by a 6MWT. Compared with standard care, NW led to a higher functional capacity (mean Δ 125.6 ± 59.4 m vs. mean Δ 57.0 ± 71.3 m traveled during 6MWT; $P = 0.001$), greater self-reported physical activity (mean Δ 158.5 ± 118.5 min vs. mean Δ 155.5 ± 125.6 min; $P = 0.049$), increased right grip strength (mean Δ 2.3 ± 3.5 kg vs. mean Δ 0.3 ± 3.1 kg; $P = 0.026$), and fewer depressive symptoms (Hospital Anxiety and Depression Scale score mean Δ −1.7 ± 2.4 vs. mean Δ −0.8 ± 3.1; $P = 0.014$). No significant differences were found for peak aerobic capacity, left-hand grip strength, body weight, waist circumference, or symptoms of anxiety [20].

Conclusion NW is a well-tolerated, safe and effective form of physical rehabilitation for patients suffering from advanced heart failure and reduces the number of admissions to hospital for heart failure exacerbation.

Arterial hypertension

A recent study investigated regular NW training (60 min sessions, three times per week) performed over 3 months by women with and without arterial hypertension with mean age of 67 ± 6 years (age range 60–78). In the experimental group, 48 women (31 without arterial hypertension; 17 with arterial hypertension) participated in NW training, while 32 women (17 without and 15 with arterial hypertension) were enrolled in the control group (no extra exercise). ABP (arterial blood pressure) and heart rate (HR) were measured before and after the NW training: ABP was checked three times during two separate visits while home ABP was self measured by women four times a day for two consecutive days. After the end of the training, all the women had ABP and HR measured in the same way as before the training. In the experimental group, reduction of systolic blood pressure (SBP) and diastolic (DBP) in ambulatory (DSBP 9 mm Hg, DDBP 6.8 mm Hg) and home measurements (DSBP 4.9 mm Hg, DDBP 2.9 mm Hg) was observed. In the control group after 3-month observation no significant changes in ABP were found. The study revealed that both systolic and diastolic blood pressure was decreased in participants following the NW training program. This result confirms that NW could serve as an important element of non-pharmacological therapy for menopausal female patients with arterial hypertension [21].

Another study on patients with arterial hypertension, using similar methodology and subject profiles, reported the effects of a 3-month NW program on high blood pressure, pulse rate, maximal oxygen consumption, and fitness index. The authors invited 60 obese (mean body mass 70.9 ± 15.32 kg and mean body height 164.8 ± 7.24 cm), elderly women with mean age of 58.5 ± 6.9 years to participate. The study population was divided into two groups of 30 subjects, a NW group and a control group (informed that they should exercise). Three variables were recorded: pulse rate at rest, systolic blood pressure, and diastolic blood pressure. Three-month pole-walking led to the reduction in the pulse rate at rest, diastolic and systolic blood pressure at the level of significance of 0.01 ($P = 0.000$). Polewalking improved the values of fitness index (FITIND) and maximal oxygen consumption (VO_{2max}) at the level of significance of 0.01 ($P = 0.000$). In the final measurement, three variables, i.e. pulse rate at rest—HRR (NW group = 73.42 vs. control group = 79.68), systolic blood pressure—BPS (NW group = 118.42 mmHg vs. control group = 123.65 mmHg) and diastolic blood pressure—BPD (NW group = 79.04 mmHg vs. control group = 83.54 mmHg) showed lower results in the experimental group compared with the control group. In the final measurement, the experimental group showed higher values of the FITIND (NW group = 81.79 vs. control group = 62.66) and VO_{2max} (NW group = 21.83 vs. control group = 16.81) variables as compared to the control group. The authors highlighted that NW is a moderate physical activity which appears to be recommendable for elderly women, as long as it is not too vigorous, but intensive enough to induce favorable changes [22].

Conclusion NW significantly decreases both systolic and diastolic arterial blood pressure, and pulse rate at rest. The above studies showed that NW should be recommended as a non-pharmacological treatment of mild to moderate arterial hypertension.

Hyperlipidemia

Hagner et al. [23] analyzed the effects of a 12-week NW training program (three sessions each lasting 90 min per week) on the basic physiological and biochemical parameters accompanying menopausal transition. They examined 171 females divided into three groups: premenopausal (G1 group, $n = 65$, final menstrual period less than 60 days, age 36.5 ± 5.7 years), perimenopausal (G2 group, $n = 53$, defined by the final menstrual period of 60–365 days, age 49.3 ± 2.87 years), and postmenopausal (G3 group, $n = 53$, defined by the final menstrual period more than 365 days, age 62.5 ± 5.43 years) defined by self-reported menstrual characteristics. The results presented as medians and mean ± SD revealed a significant increase in maximal oxygen uptake (G1 group: 32.5 mL/kg/min before NW program comparing to 35.5 mL/kg/min after training, $P < 0.05$; G2 group: 29 mL/kg/min before NW program comparing to 31.5 mL/kg/min after training, $P < 0.05$; G3 group: 24 mL/kg/min before NW program comparing to 25 mL/kg/min after training, $P < 0.05$) and high-density lipoprotein (HDL; G1 group: 54.05 ± 10.14 mg/dL before NW program comparing to 59.72 ± 10.0 mg/dL after training, $P < 0.05$; G2 group: 55.40 ± 9.45 mg/dL before NW program comparing to 60.96 ± 12.55 mg/dL after training, $P < 0.05$; G3 group: 53.71 ± 8.44 mg/dL before NW program comparing to 57.36 ± 10.76 mg/dL after training, $P > 0.05$), as well as a significant reduction in total cholesterol level G1 group: 198 mg/dL before NW program comparing to 181 mg/dL after training, $P < 0.05$; G2 group: 202 mg/dL before NW program comparing to 194.3 mg/dL after training, $P < 0.05$; G3 group: 219 mg/dL before NW program comparing to 206 mg/dL after training, $P > 0.05$, low-density lipoprotein (LDL; G1 group: 135.80 ± 35.99 mg/dL before NW program comparing to 120.68 ± 28.84 mg/dL after training, $P < 0.05$; G2 group: 136.61 ± 37.15 mg/dL before NW program comparing to 124.46 ± 36.38 mg/dL after training, $P < 0.05$; G3 group: 140.17 ± 31.65 mg/dL before NW

program comparing to 130.18 ± 32.249 mg/dL after training, $P > 0.05$, triglycerides G1 group: 114 mg/dL before NW program comparing to 104 mg/dL after training, $P < 0.05$; G2 group: 119.25 mg/dL before NW program comparing to 105 mg/dL after training, $P < 0.05$; G3 group: 128 mg/dL before NW program comparing to 124 mg/dL after training, $P > 0.05$, body mass index (G1 group: 31.49 ± 5.39 kg/m^2 before NW program comparing to 29.73 ± 4.90 kg/m^2 after training, $P < 0.05$; G2 group: 31.72 ± 5.07 kg/m^2 before NW program comparing to 30.24 ± 4.45 kg/m^2 after training, $P < 0.05$; G3 group: 31.07 ± 4.64 kg/m^2 before NW program comparing to 29.62 ± 4.54 kg/m^2 after training, $P < 0,05$), and waist circumference (G1 group: 100 cm before NW program comparing to 92 cm after training, $P < 0.05$; G2 group: 104.5 cm before NW program comparing to 96 cm after training, $P < 0.05$; G3 group: 105 cm before NW program comparing to 98 cm after training, $P > 0.05$).

Nonrandomized study conducted by the same researches as above compared the effects of NW and Pilates on 196 overweight (BMI 25–29.9 kg/m^2) or obese (BMI > 30 kg/m^2) postmenopausal women (50–75 years old). [24] The study group was divided into three: 20 patients as a control group were advised to maintain their previous level of physical activity, 88 were qualified to NW program, and 88 to Pilates program. Both programs were performed under supervision three times per week for 10 weeks (30 sessions, 1 h each) and later without the trainer's supervision of the same amount at home. Twice—at the beginning and after the program anthropometric parameters (BMI) and biochemical parameters were obtained. After 10 weeks of training NW group showed a significant reduction in body weight (6.4 vs. 1.7 % in Pilates group), BMI (6.4 vs. 1.7 % in Pilates group), blood glucose level (3.8 vs. 1.6 % in Pilates group), total cholesterol (10.4 vs. 5.3 % in Pilates group), non-high-density lipoprotein (16.7 vs. 8.3 % in Pilates group), LDL cholesterol (12.8 vs. 7.5 % in Pilates group), triglycerides (10.6 vs. 6 % in Pilates group), and increase of HDL cholesterol (9.6 vs. 3.1 % in Pilates group). The adherence to training program was greater in NW group than in Pilates (47 % of women completed NW trainings vs. 39 % of women completed Pilates program). In conclusion, the type of exercise training was an independent predictor of changes in biochemical parameters: blood glucose and basic blood lipids concentrations.

Sarcopenia (muscle strength and mass decrease with age) may be triggered by oxidative stress. NW has well-known positive effects on several muscle groups. Authors in the next work investigated whether changes in the oxidative stress marker, malondialdehyde-modified low-density lipoprotein (MDA-LDL)/LDL cholesterol (LDL-C) ratio are associated with the change in handgrip strength (HGS), which is a useful indicator of sarcopenia, by a 12-week NW exercise among Japanese community-dwelling persons. The study included 65 women aged 67 ± 7 years and nine men aged 71 ± 8 years. NW exercise training program of 120 min per week was performed for 12 weeks. Before and at the end of the 12-week intervention, various confounding factors and HGS were measured. Changes in HGS and follow-up HGS increased progressively with decreased changes in the MDA-LDL/LDL-C ratio after the 12-week walking exercise ($r = -0.32$, $P = 0.006$ and $r = -0.35$, $P = 0.002$, respectively). Multiple linear regression analysis showed that changes in HDL-C ($\beta = 0.26$, $P = 0.019$) and MDA-LDL/LDL-C ratio ($\beta = -0.32$, $P = 0.004$) were significantly and independently associated with changes in HGS. When the data were further stratified by gender, the change in the MDA-LDL/LDL-C ratio was significantly and similarly associated with the change in HGS in women only. These results suggest that the change in MDA-LDL/LDL-C ratio may be a predictor for HGS after a 12-week NW exercise in community-dwelling persons [25].

Conclusion In addition to pharmacotherapy, NW could serve as a non-pharmacological treatment of atherogenic dyslipidemia in the elderly. NW training could decrease age-related sarcopenia in women.

Peripheral arterial disease

A study published in 2002 examined the efficacy of a polestriding exercise during a 24-week lasting randomized clinical trial. Fifty-two individuals with intermittent claudication were randomly placed into either a NW group (age 65.5 ± 7.0 years) or a non-exercise control group (age 68.6 ± 8.9 years). The polestriding exercise program was complex, consisting of supervised training three times per week for 4 weeks; then two times per week for 8 weeks; then one time per week for 4 weeks; then biweekly for 4 weeks; and finally, unsupervised training for 4 weeks. Starting in week five, the subjects took their poles home with instructions to repeat the most recent supervised training walk at an appropriate and convenient location near their residences. This was referred to as "unsupervised but directed" exercise. With both supervised and unsupervised exercise, the subjects were expected to complete a total of four 30- to 45-min polestriding exercise sessions per week. The main outcome measurements were: exercise duration on a symptom-limited incremental treadmill test; and the completion of a Walking Impairment Questionnaire which reported the rating of perceived leg pain, and results of constant work-rate treadmill exercise tests. The results showed that polestriding significantly improved exercise tolerance on the constant work-rate and incremental treadmill tests. The ratings of perceived claudication pain were significantly lower after the polestriding

training program. The subject-perceived distance and walking speed scores on the Walking Impairment Questionnaire significantly improved in the polestriding trained group only. The authors concluded that 6 months of polestriding training significantly improves the quantitative and qualitative measures of the exercise tolerance of patients limited by intermittent claudication pain [26].

Subsequent to this study, Oakley et al. [27] published work that investigated the effects of NW on walking distance and cardiopulmonary fitness in men with intermittent claudication. The study group consisted of 20 claudicants aged 57–79 years (median age 70 years). The results of several tests including the Standardized Treadmill Test (3.2 km/h at 4 % gradient), walking distance, leg pain (Borg's CR-10 Scale), perceived exertion (Borg's Rating of Perceived Exertion Scale), and expired gas parameters were considered. The results demonstrated that the walking distance without pain increased significantly from a median distance of 77 m (range 28–503) to 130 m (range 41–1080) and the maximum walking distance (distance with pain) increased significantly from 206 m (range 81–1078) to 285 m (range 107–1080) when patients used Nordic poles. Moreover, at the maximal walking distance, patients experienced significantly less pain when using poles, assessed subjectively on a ten point Borg scale, than when walking without poles (4.3 ± 0.5 vs. 5.6 ± 0.5). Significantly higher maximal oxygen uptake when walking with poles was observed both without feeling pain (1.12 ± 0.08 L/min) and with pain (1.20 ± 0.05 L/min) compared to walking without poles (0.95 ± 0.06, 1.03 ± 0.06 L/min, respectively). While walking, those patients feeling pain evaluated their perceived exertion similarly on a Borg 20-point scale. These research findings implied that NW allows patients with intermittent claudication to increase the distance they can walk due to reduced pain in their legs, despite higher cardiopulmonary work at the maximal walking distance. It means that NW is a useful exercise for improving cardiopulmonary fitness in this group of patients.

In a more recent study assessing the impact of NW on exercise endurance, cardiovascular training for increased QoL was given to 49 claudicants after a 24-week polestriding regimen. The subjects were divided into two groups: a NW group ($n = 25$, 65.8 ± 7.1 years of age) training three times weekly and a non-exercise control group ($n = 24$, 68.0 ± 8.6 years of age). A symptom-limited ramp treadmill test, ratings of perceived leg pain, and QoL data were obtained at baseline and upon the completion of training. After 24 weeks of polestriding training, the subjects increased their exercise endurance from 10.3 ± 4.1 to 15.1 ± 4.5 min in contrast with the control group subjects whose exercise endurance declined from 11.2 ± 4.7–10.3 ± 4.7 min. The relationships between systolic blood pressure, heart rate, rate-pressure product, oxygen uptake, perceived leg pain, and exercise time improved from the baseline symptom-limited treadmill test to the 6-month symptom-limited treadmill test in the polestriding group when compared with the control group. The improvement in QoL was also greater in the polestriding group. As in the other cited works, the authors noted that polestriding training significantly improved the clinical indicators of cardiovascular fitness and QoL, in addition to decreasing the symptoms of claudication pain during exertion [28].

Conclusion NW should be strongly considered as the main rehabilitation program for peripheral arterial disease patients in the intermittent claudication stage to increase the claudication distance and improve the cardiovascular condition.

Nordic walking in geriatric endocrinology

Impaired glucose tolerance, diabetes mellitus type 2, obesity

Fritz et al. [29] assessed the effects of increased physical activity lasting 4 months on the health-related quality of life (QoL) in 212 overweight (27.5–32 kg/m^2) individuals (mean age 61; 57–64 years) with type 2 diabetes mellitus ($n = 50$), with impaired glucose tolerance ($n = 34$) and normal glucose tolerance ($n = 128$), and without any severe physical or cardiovascular impairments. The subjects were randomized into either a control group who maintained an unaltered habitual lifestyle ($n = 125$), or a NW group who maintained a regimen of 5 h of NW per week over a 4-month period ($n = 87$). The self-reported physical activity, changes of body mass index, health-related QoL, and quality of sleep were assessed at the time of inclusion, and then again after 4 months. The NW group with normal glucose tolerance showed the improved quality of sleep, decreased body mass index (-1 kg/m^2 in group with impaired glucose tolerance and type 2 diabetes vs. 0 kg/m^2 in control group, $P = 0.0019$) with little or no musculoskeletal pain when compared with the control group. No correlation was evident between the improved quality of sleep and decreased body mass index. The authors concluded that NW could be introduced in a primary health care setting as a preventive, low-cost mode of exercise that promotes weight loss and improves health among overweight individuals.

Another study invited patients with type 2 diabetes mellitus only to evaluate the influence of a 4-month period of physical activity followed by an 8-month follow-up [30]. This was a single-blind, randomized, controlled intervention study. Sixty-eight patients (37 men and 31 women)

were randomized into three groups: NW ($n = 22$), exercise on prescription (EP, $n = 24$), and control (the control group received standard information on physical activity, $n = 22$). The authors found no difference in glycated hemoglobin (HbA1c) level, when comparing the intervention groups in relation to the control group after 4 months (DeltaNW = −0.4 %, DeltaEP = −0.2 %), after 12 months (DeltaNW = 0.0 %, DeltaEP = 0.3 %). However, fat mass assessed by dual energy X-ray absorptiometry decreased significantly in the NW group after 4 months (−1.0 kg) and after 12 months in both the NW (−1.8 kg) and exercise on prescription (−1.5 kg) groups.

Figard-Fabre et al. [31] investigated the effects of a NW program ($n = 12$) compared to a walking program ($n = 11$) on physiological and perceptual variables in 23 obese women. Patients trained over 12 weeks, three times per week. Body mass, body mass index, body fat, heart rate, resting blood pressure, and peak oxygen consumption were measured before and after the training period. In addition, the heart rate, rating of perceived exertion, and adherence were recorded during all training sessions. The body mass, body fat, and diastolic blood pressure significantly decreased in both groups ($P < 0.05$) after the training period, while peak oxygen consumption increased significantly in the NW group (+3.7 ml/kg/min, $P = 0.005$). During each training session, the mean heart rate ($P = 0.021$), heart rate at preferred walking speed ($P = 0.020$), and percentage of time at high intensity ($P = 0.031$) were higher in the NW group than in the walking group. Finally, the rating of perceived exertion was not influenced by the modality of exercise and the NW group showed a higher rate of adherence (91 ± 19 vs. 81 ± 29 %; $P = 0.011$). The authors concluded that NW activity in obese women allows an increase in exercise intensity and adherence to a training program without increasing the perception of effort leading to an enhanced aerobic capacity.

Conclusion NW is an effective activity for rehabilitation, prevention and treatment of mild stages of metabolic syndrome, although it has no positive impact on Hba1c levels in patients with diabetes type 2.

Nordic walking in geriatric neurology

Parkinson's disease (PD)

Van Eijkeren et al. [32] examined whether NW may improve mobility in patients with PD and whether any effect persists after the end of the training period. Nineteen PD patients (mean age 67.0 years, range 58–76; 14 men) who received a 6-week NW exercise program were included in the study. The exercise capacity and QoL were assessed prior to training, immediately after the training period, and 5 months after the training. Immediately after the training period, the authors observed a significant improvement in timed 10-m walking, the timed get-up-and-go test, the 6MWT, and QoL. All positive effects persisted for 5 months after the training. The compliance was excellent, and no adverse effects were observed. The authors concluded that NW provides a safe, effective, and enjoyable way to enhance physical activity and to improve QoL for PD patients.

A pilot study analyzed the effects of a 12-week program of NW training at different stages of PD compared to a healthy control group (CO). Selected functional outcomes were measured. 3D kinematics of 22 PD and 18 CO subjects matched according to age, gender, height, and weight, before and after the training were recorded using a motion analysis system (Vicon, Oxford). The effects of NW training were not statistically significant, but different patterns of effect were observed which were dependent on the severity of the disease. A reduction in the time required for sit-to-stand performance was observed in patients with a mild form of PD and the control group, while horizontal and vertical velocity of cognition increased. Patients with a more severe disease reacted in the opposite way, which could be due to the progression of PD during the training period. The authors concluded that NW training is an easy, economical and low-risk intervention that can help PD patients; however, the effects depend on the severity of the disease [33].

A nonrandomized clinical trial was conducted to determine if six male volunteers (72.7 ± 3.7 years of age) with PD who completed an 8-week, supervised NW exercise program, three times per week for 37 ± 3 min showed significant improvements in cognitive skills, activities of daily living, motor functions, and QoL. The results of this study were optimistic and indicate that an 8-week individualized exercise program increases perceived functional independence and QoL [34].

An innovative, clinically proven method for improving physical therapy in individuals with PD named "LSVT®-BIG" was derived from the Lee Silverman Voice Treatment program. It focuses on intensive exercising using high-amplitude movements. A study of 60 patients split into three randomly assigned groups with mild to moderate PD was performed. One group received one-on-one LSVT®BIG training, the second group received training in NW, while the third did non-supervised exercises at home. Patients from the first two groups received 16 h of supervised training within 4 or 8 weeks, respectively. The primary efficacy measurement between groups was the difference in change on the Unified Parkinson's Disease Rating Scale (UPDRS) motor score from baseline to follow-up at 16 weeks. UPDRS scores were obtained by

blinded video rating. Significant differences in UPDRS motor score between the groups were identified at the final assessment: a mean increase was noted in the LSVT®BIG group, whereas there was a mild decrease in the NW and home group. The LSVT®BIG group was also superior to the resting group in the timed-up-and-go and timed 10-m walking tests that were analyzed. No significant difference in QoL was noted between the groups. These results provide evidence that LSVT®BIG is an effective technique to improve motor performance in patients with PD and seems to be superior to NW [35]. In another work that compares NW training with LSVT®BIG on 60 patients with mild to moderate Parkinson's disease, who were randomly allocated to three treatment groups: patients received 16 h of individual Lee Silverman Voice Treatment-BIG training (BIG; duration of treatment: 4 weeks), 16 h of group training with NW (WALK; duration of treatment: 8 weeks), or nonsupervised domestic exercise (HOME; duration of instruction: 1 h). Cued reaction time (cRT) and noncued reaction time (nRT) were measured at the baseline and the termination of training and at follow-up 16 weeks after baseline in 58 patients. Differences between treatment groups in improvement in reaction times from baseline to intermediate and baseline to follow-up assessments were observed for cRT but not for nRT. Pairwise t test comparisons revealed differences in change in cRT at both measurements between BIG and HOME groups [intermediate: −52 ms; 95 % confidence interval (CI), −84/−20; $P = 0.002$; follow-up: 55 ms; CI, −105/−6; $P = 0.030$) and between WALK and HOME groups (intermediate: −61 ms; CI, −120/−2; $P = 0.042$; follow-up: −78 ms; CI, −136/−20; $P = 0.010$). There was no difference between BIG and WALK groups (intermediate: 9 ms; CI, −49/67; $P = 0.742$; follow-up: 23 ms; CI, −27/72; $P = 0.361$). [36].

Conclusion NW is a safe rehabilitation tool for PD patients although it should be refined to the early stage of the disease and if there are more effective programs available or not—it needs further studies.

Nordic walking in geriatric orthopedy/ rheumatology

Little is known about sports activity in patients after total hip resurfacing. A study published in 2010 evaluated the level of sports activities using a standardized questionnaire in 138 consecutive patients (152 hips) 2 years after total hip resurfacing. Range of motion, Harris hip score, Oxford score and radiological analysis were taken into consideration. Preoperatively, 98 % of all patients participated in one or more sports activities. Two years postoperatively, 98 % of the patients participated in at least one sports activity. The level of sports activity decreased after surgery. The number of sports activities per patient decreased from 3.6 preoperatively to 3.2 postoperatively. A significant decrease in participation of intermediate- and high-impact sports, especially tennis, soccer, jogging, squash, and volleyball, was observed, while a significant increase in the participation of low-impact sport (stationary cycling, NW, and fitness/weight training) was observed. Physical activity level measured by the Grimby scale was significantly higher than in the year before surgery. The duration of sport participation per week increased significantly after surgery. Men had a significantly higher sport level than women before and after surgery. Eighty-two percent of patients felt no restriction while performing sports. The results of this short-term follow-up study showed that sports activity after total hip resurfacing surgery is still possible; in fact, the level of physical activity increased with a shift toward low-impact sports. These findings are likely to be important in the decision-making process for hip surgery and should be communicated to prospective patients [37].

A study performed on 153 healthy, home-dwelling, postmenopausal women (mean age 72 years) emphasized the concept that in elderly women, good muscle strength in lower limbs is crucial for proper body balance, and that dynamic balance is an independent predictor of a standardized QoL estimation. During the study, several parameters were taken into consideration: general health, physical activity and QoL (assessed by questionnaire), dynamic balance (tested by a figure-of-eight running test), static balance (tested on an unstable platform), maximal isometric strength of the leg extensors (measured with a leg press dynamometer), and dynamic muscle strength of lower limbs (tested by measuring ground reaction forces with a force platform during common daily activities (sit-to-stand and step-on-a-stair tests). Thirty-three percent of the subjects reported that they participate in brisk exercise (NW, walking, cross-country skiing, swimming and aquatic exercises) at least twice a week, 22 % in some kind of brisk activity once a week in addition to lighter physical exercise. The remaining 45 % did not exercise regularly and were classified as sedentary. In the regression analysis with backward elimination, step-on-a-stair and sit-to-stand ground reaction forces, and leg extensor strength, age, brisk physical activity, the number of diseases, and dynamic postural stability explained 42 % of the variance in the dynamic balance. Similarly, dynamic balance (figure-of-eight running time), the number of diseases, and walking more than 3 km per day explained 14 % of the variance in the QoL score. Of these, figure-of-eight running time was the strongest predictor of the QoL score, explaining 9 % of its variance [38].

Conclusion Total hip resurfacing is a frequent orthopedic problem in older patients; the first study reviewed encourages the use of NW in a general physical rehabilitation program after hip surgery. Maintaining good condition of the musculoskeletal system is important in enhancing the QoL in older patients and NW was depicted as one of the most frequently chosen patterns of physical rehabilitation in this population by the second study reviewed.

Sjögren's syndrome (SS)

Strömbeck et al. [39] investigated the effect of a moderate- to high-intensity exercise program (NW training) on aerobic capacity, fatigue, anxiety, depression, the ratings of perceived exertion and health-related QoL in women with primary SS. Twenty-one women aged 41–65 years with primary SS were ranked according to the degree of fatigue and allocated to an exercise group (medium to high-intensity aerobic home exercise, partially supervised by trained walker, NW group) or a control group (low-intensity home exercises). The aerobic exercise method was NW for 45 min three times a week for 12 consecutive weeks. Ten patients in the control group were given written instructions for a range of motion exercises to be performed at home three times a week over 12 weeks. Otherwise, the patients were told to maintain their current level of activity during the 12-week program. The patients kept exercise logs. Outcome measures were assessed at baseline and after 12 weeks. The analysis of all investigation parameters showed significant differences between the groups, with better values for the NW group concerning aerobic capacity (significant improvement was seen in VO_{2max} L/min ($P = 0.03$) and the improvement in VO_{2max} mL/kg/min almost reached statistical significance ($P = 0.06$), fatigue was significantly reduced (fatigue was also assessed by a 100-mm visual analog scale (VAS) where 0 was defined as 'not fatigued at all' and 100 as 'extremely fatigued', fatigue was significantly reduced in the NW group, as measured with VAS ($P = 0.03$), ratings of perceived exertion (Borg RPE-Ratings of Perceived Exertion scale), there was a significant improvement in the NW group in the RPE scale ($P = 0.03$) and depression (the depression score was significantly lower in the NW group ($P = 0.02$). The Hospital Anxiety and Depression scale (HADS) has been constructed to assess anxiety and depression in patients with somatic diseases. It contains 14 items for self-assessment on a scale from 0 to 3. Seven items are intended to measure anxiety and seven depression, independent of each other, and the entire scale ranges from 0 to 21 each for anxiety and depression. A score of 8–10 on a subscale represents possible psychiatric morbidity and a score of more than ten represents clinical anxiety or depression. There were no differences in anxiety and health-related QoL (no differences were seen in any of the eight dimensions of SF-36) between the groups.

Conclusion These findings support the necessity of an appropriate aerobic exercise, like NW training, in the treatment of primary SS.

Chronic back pain

An active approach, including both specific and unspecific exercise, is the most widely recommended treatment for patients with chronic low back pain. One hundred and thirty-six patients with lower back and/or leg pain greater than three on the 11-point numeric rating scale and lasting longer than 8 weeks after a multidisciplinary intervention at a back center were included in a study of exercise as a rehabilitation tool for chronic back pain. The invited patients were randomly divided into three groups: NW supervised by a specially trained instructor twice a week for 8 weeks; unsupervised NW for 8 weeks after one training session with an instructor followed by advice to perform NW at home as much as they liked; 1-h individual motivational talk including advice to remain active and to maintain the daily function level that they had achieved during their stay at the back center. Outcome measures were pain, function, overall health, cardiovascular ability, and activity level. No mean differences were found between the three groups in relation to any of the outcomes at baseline or after the 8-week follow-up. All groups experienced some mean improvement in pain and disability during the intervention period. Despite no statistically significant difference between the groups for pain, disability, and patient-specific function the supervised NW group generally fared best. Moreover, patients from this group tended to use less pain medication and tended to seek less concurrent care for their back pain at the 8-week follow-up. No negative side effects were reported [40]. In the next study in this subject, the authors enrolled 16 elderly women (the age 71.80 ± 3.64 years) with chronic low back pain. The purpose of this study was to examine whether NW exercise can relieve low back pain and change the spine shape in elderly women. The participants were using the Nordic pole when walking on the track with their arms lifted above their shoulders. The experiment lasted for 12 weeks: during weeks 1–6, the walking speed was set to the average (5–6 km/h) of the speeds at which the subjects could comfortably walk 20 laps around a 200 m track in a 40-min period. The exercise intensity prescribed by Karvonen's equation was set at a target heart rate of 50–60 % with a 6-week exercise-monitoring arrangement. During weeks 7–12, the speed of the walking was set to the

average (6–7 km/h) of the speeds at which the subjects could walk 24 laps around a 200 m track in a 40-min period. The exercise intensity prescribed by Karvonen's equation was set at a target heart rate of 60–70 % with a 6-week exercise-monitoring arrangement. This study confirmed that NW training strengthened the paraspinal muscle and consequently could be useful for recovering the normal angle balance of the trunk and relieve back pain. [41].

Conclusion Chronic low back pain, a complaint often received from elderly women, was reduced by pole-induced power walking reduction on the balance of the spine and back. NW as a form of exercise may be of benefit to selected groups of chronic back pain patients. Results in cited articles remain rather speculative—other work in this subject is needed.

Nordic walking in geriatric pulmonology

Chronic obstructive pulmonary disease (COPD)

A study by Breyer et al. [42] investigated the feasibility of NW and determined its short- and long-term effects on COPD patient daily physical activity pattern as well as exercise capacity. Sixty COPD patients were randomly organized into either an NW group or a control group. Patients in the NW group (age 62 ± 9 years) underwent a 3-month outdoor NW exercise program consisting of 1-h walking at 75 % of their initial maximum heart rate three times per week, whereas the control group had no exercise intervention. At the baseline, after 3, 6 and 9 months, daily physical activities (measured by a validated tri-axial accelerometer) and functional exercise capacity (measured by the 6MWT) were evaluated. After the 3-month training period, patients in the NW group showed a significant increase in the time spent walking (+14.9 ± 1.9 min/day) and standing (+129 ± 26 min/day), as well as in the intensity of walking (+0.40 ± 0.14 m/s^2), while time spent sitting decreased (−128 ± 15 min/day) compared to the baseline and control group. Furthermore, the 6MWT significantly increased compared with the baseline (+79 ± 28 m) and the control group. These significant improvements observed in the COPD patients performing NW were sustained at 6 and 9 months after the baseline. In contrast, the control group showed unchanged daily physical activities and 6-min walking distance compared with the baseline at all time points.

Conclusion NW training is a feasible, simple, and effective physical training modality in elderly patients with COPD. NW has proven to positively impact the daily physical activity pattern of COPD patients under short- and long-term observation compared with a COPD group who had no exercise intervention.

Summary

NW is a safe and one of the most effective methods of enhancing patient's physical activity in:

1. Cardiovascular diseases including coronary artery disease, congestive heart failure and peripheral arterial disease;
2. Early stages of metabolic syndrome, preferably with stable arterial hypertension and dyslipidemia but without diabetes;
3. Early stages of Parkinson's disease, however, there are other methods of physical rehabilitation reported, which are more effective;
4. Chronic Obstructive Pulmonary Disease (COPD);
5. Lowering depression in women with Sjögren's Syndrome.

Nordic walking provides an easy, safe, effective, enjoyable, inexpensive way to enhance physical activity in the elderly. The studies reviewed all used the following supervised NW training schedule, which therefore is assumed to be the most effective, the training conducted for 1 h, two to three times per week for a minimum of 3 months. In addition, the positive effects observed after such training are generally sustained for 6–9 months after the training's end.

There are many disorders and problems affecting individuals in their second half of life, such as osteoporosis, tendency to fall, low functional performance and disability, balance disorders, osteoarthritis, edema of lower extremities, hemiparesis due to stroke and rheumatoid diseases, where NW training could also be helpful, however, further studies are needed in these patients.

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Compliance with ethical standards

Conflict of interest None declared.

Statement of human and animal rights Ethics Committee approval was obtained from the local bioethics committee (Bioethics Committee, Wroclaw Medical University, no. 130/2008 KB).

Informed consent All the patients were provided with written information on the purpose and design of the study.

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