Fontys University of Applied Sciences

Physiotherapy, English Stream

Bachelor Thesis

What is the effect of Nordic walking, as an exercise modality, for improving exercise capacity in chronic disease patients?
- A literature review

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Version: 1.0

Date: 31.05.2013

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Preface

The bachelor thesis is the final stage of the English Stream Physiotherapy program. After completing this stage, the students are finally allowed to call themselves physiotherapists. The topic had to be related to the field of physiotherapy. The students could choose their own topic of interest or have a topic assigned by the school. The topic for this bachelor thesis was: What is the effect of Nordic walking, as an exercise modality, for improving exercise capacity in chronic disease patients?

Nordic walking is a relatively new form of exercise, especially in the field of research. It all origins back to the 1930s when Finnish cross-country skiers started using ski poles as part of their summer training. The term “Nordic walking” had its official launch as late as 1997 and it is nowadays a well-known form of training, which is growing in popularity. Many people like to walk as part of being physically active and to improve their general condition. Nordic walking is the same as walking only differed by the addition of walking poles, which are supposed to make the training even more effective. This belief is maybe one of the reasons why Nordic walking has become so popular the last couple of years. Due to this, the aim of this literature review is to look at the effect of Nordic walking, and whether it is an effective exercise modality for enhancing exercise capacity in chronic disease patients.

The writing process has been time-consuming and challenging. Guidance, support and feedback from others have been of great value throughout the process and I would not have managed without it. A special thanks goes to my general supervisor René van Saan, who guided me during the process. I am also grateful for the all the feedback I got from my peer reviewers. You really helped me when I was following the wrong path and helped me get back on track again. Lastly, I would like to thank my family and friends for their support.

Abstract

Background information: Previous studies implicate that Nordic walking is an effective exercise modality for improving exercise capacity. However, these findings are based on healthy subjects. Exercise capacity has shown to be a strong predictor for mortality and gives valuable prognostic information. Thus, the aim of this review is to look at the effect of Nordic walking, as an exercise modality, for improving exercise capacity in chronic disease patients.

Hypothesis: Nordic walking is an effective exercise modality for improving exercise capacity in chronic disease patients.

Study design: A literature review was performed. The review targeted longitudinal studies that were randomized clinical trials or controlled clinical trials, which contained between-group comparisons. Nordic walking was compared to either a non-exercising control group or with groups performing other forms of exercise in chronic disease patients. Seven articles were eligible for inclusion in the review.

Results: Four comparisons were performed. The first compared Nordic walking with non-exercising control groups. Three out of four studies reported significant improvements ($p=<0.05$) in the Nordic walking group compared to the control group. In comparison two, Nordic walking was compared with walking. One out of two studies reported significant improvement in the Nordic walking group. Comparison three included one study and investigated the effect of Nordic walking compared with a standard cardiac rehabilitation programme. Significant improvement was reported in the Nordic walking group. In the last comparison, Nordic walking was compared with range of motion exercises. No significant improvement was reported.

Conclusion: Nordic walking appears to increase exercise capacity in chronic disease patients. However, based on the level of evidence, it is difficult to conclude if it can be recommended for practice and if it is preferable over other types of exercise.

Keywords: Chronic disease, Nordic walking, exercise capacity, oxygen uptake, six-minute walking test, metabolic equivalent

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Introduction

Chronic disease (CD) is an umbrella term for several different pathologies. It is defined, by the Australian Institute of Health and Welfare, to have multiple causes and is long lasting. CDs become more prevalent with increasing age and usually have a gradual onset. However they can occur throughout the whole life cycle and are a major cause of physical limitations, disability and a leading cause of premature mortality.[1] According to the World Health Organization,[2] 58 million deaths were expected in 2005, with 35 million of these believed to be caused by a CD. If no action is taken, the projections for 2015 show an increase in deaths caused by chronic diseases of 17 per cent, which would leave the death toll to 41 million per year.[2] Based on these numbers, the urge for effective treatment modalities is vital.

Current treatment of CDs lies in clinical prevention; that is to prevent the disease from manifesting or to reduce the complications of people living with the respective diseases. Numbers of clinical interventions such as pharmacological agents, supporting behaviour change and surgery can improve quality of life and reduce the prevalence of death and complications of the disease.[2]
A good way to reduce the prevalence of CDs is by focusing on primary prevention. Primary prevention has been seen as a good way of lowering the prevalence of CD.[3] However, when CD is already present, different treatment opportunities are available.

One of the treatment forms, which is seen as beneficial for CD patients is exercise therapy. Adopting a more active approach for treatment in different CDs has been demonstrated to improve aerobic capacity, functional capacity and muscle strength.[4] Moreover, exercise therapy has also shown to improve the prognostic risk factor in patients with CDs, this without detrimentally affecting the disease progression.[4] In addition, an article of Pedersen et al.[5] highlights that exercise therapy is directly affecting the pathogenesis. It also improves symptoms of the primary disease as well as increasing physical fitness, strength and quality of life in several different CDs.

Aerobic exercises is a form for exercise therapy, which has been advocated to be effective, easy applicable and a safe way of training for CD patients.[5] There are different forms of aerobic exercises, which can be provided such as: walking, running, swimming and cycling.[6] Another form of aerobic exercise, which shows promising physiological effects, is Nordic walking (NW).

NW has its origin from Scandinavia. It was introduced in central Europe about 20 years ago where it quickly became a popular exercise form.[7] NW is similar to normal walking in terms of low-impact and moderate-intensity but with the addition of handheld poles which actively involve the upper body.[8]
NW has shown promising effects compared to normal walking and similar aerobic activities. Both Porcari et al. and Church et al.[9, 10] reported promising benefits of NW over normal walking. When comparing these the interventions in healthy subjects, NW demonstrated a higher oxygen uptake and an increase in caloric expenditure while the perceived exertion did not increase significantly. Schiffer et al.[11] reported higher oxygen uptake in NW compared to normal walking and jogging at velocities of

1.8 and 2.1 m per second in healthy female subjects. Another study revealed that NW was a safe and feasible exercise form for improving oxygen uptake in sedentary middle-aged women.[12] These studies are implicating that NW is a promising exercise modality, which is efficient for improving physiological factors, such as an individual exercise capacity (EC).

Recently EC has proven to be a strong predictor for mortality in both healthy and unhealthy subjects.[13, 14] According to Goldstein,[15] EC measures *"the maximum amount of physical exertion that a patient can sustain."* Further, Mark et al.[16] reported that EC is regarded as a powerful and important measure worthy of attention for prognostic information in people. In addition, Snader et al.[17] found that low EC was an important predictor for all-cause mortality in a group of low-risk subjects.
In previous literature, EC has been quantified in different ways; as a measurement of oxygen uptake during exercise tests,[18] in form of distance walked during a 6-minute walking test (6MWT),[19] or as estimated metabolic equivalent (MET).[13, 18] These measures are routinely used as procedures for measuring EC and can give an insight of prognostic information of the subjects tested.

Aerobic exercise was chosen as an intervention because it has been proven to be a form of training, which is beneficial for CD patients.[4, 5] NW is a type of aerobic exercise, which is safe and easily accessible for many people and does not require a lot of extra equipment.[7] It also appears to be an effective exercise modality, which displays a good training effect compared to other exercise forms.[9-12] However, there does exist an uncertainty about the effect of NW for improving EC in patients with a CD. That is why this review will investigate whether NW can be recommended as an exercise modality for this patient group.
"What is the effect of Nordic walking, as an exercise modality, on improving EC in CD patients?"

Method

Inclusion criteria

Studies are eligible for inclusion in this literature review if they met the following criteria: Longitudinal studies presented as randomized clinical trials (RCT) or controlled clinical trials (CCT). The participants must be 18 years of age or older and have a form of CD. This review only looks at studies where NW is compared to non-exercising control groups or other forms of exercise. In addition, between-group comparisons must be obtainable. The outcomes measuring EC are presented as maximum VO_2, peak VO_2, MET and 6MWT. Lastly, only articles written in the English language will be included.

Exclusion criteria

Studies are excluded from the literature review if they do not meet the following criteria: The studies must have a PEDro score of four or higher. Furthermore, articles that are not obtainable in full-text will be excluded.

Information about the outcome measures

6MWT

The 6MWT is a helpful tool for measuring EC. This submaximal test is aimed at subjects who at least have a moderately impaired condition. It measures the distance a subject can walk on a flat, hard surface for a working period of six minutes. It also reflects activities of daily life better than other exercise tests.[20]

Maximum VO_2

Measurements of maximum VO_2 (maximum oxygen uptake) is considered as a valuable tool and the best index of quantifying aerobic capacity and the function of the cardiorespiratory system. Maximum VO_2 is measured when VO_2 stops to increase despite an increase in work rate during when performing exercise testing.[18]

Peak VO2

Measurement of peak VO_2 is the highest achieved oxygen uptake during exercise testing. Many clinical studies use peak VO_2 instead of maximum VO_2.[18] It is easier to measure, especially in frail

subjects, who are not able to reach maximum VO_2 because subjective exhaustion occurs before a plateau in oxygen uptake is reached.

Metabolic equivalent

One MET is defined according to Myers et al.[13] *"as the energy expended in sitting quietly, which is equivalent to a body oxygen consumption of approximately 3.5 ml per kilogram of body weight per minute for an average adult."* During exercise testing, a persons exercise capacity is often quantified in METs. The concept of MET is an easy and convenient method to express the use of energy in different physical activities.[21]

Search strategy

The electronic databases PubMed, Cochrane Central Register of Controlled Trials, ScienceDirect, PEDro and CINAHL were searched in the period of March/April 2013.
The search terms listed in table 1 below are used in order to identify RCT and/or CCT. Each database has a filter for identifying only RCT or CCT, which is used whenever found appropriate. The search procedure will be adjusted when needed for each database. An additional manual search of the reference list of the included articles will be performed. This is being done in order to identify additional relevant articles that could be included in the review. The search procedure from PubMed is shown in the table 1 below.

Table 1: Search strategy

Search strategy		
1	Nordic walking	1 OR 2 OR 3 OR 4 OR 5 OR 6
2	Walking with poles	
3	Pole walking	
4	Exerstriding	
5	Nordic poles	
6	Polestriding	

The search is performed by combining the search terms with the Boolean operators AND/OR.

Search string PubMed: "Nordic walking" OR "walking with poles" OR "pole walking" OR "exerstriding" OR "Nordic poles" OR "polestriding"

The search procedure for the different databases can be found in appendix I.

The selection process

The titles are initially screened. After excluding articles based on the titles, abstracts of the remaining articles are screened. Subsequent to this, duplicates are removed and the full text of the remaining articles is independently reviewed to make sure that the inclusion criteria are met. Articles, which do not meet the inclusion criteria, are excluded.

Data collection

The following data will be extracted; (a) study characteristics: Number of subjects in the study, pathology, study design, adherence to training, number of dropouts and feature of intervention (duration of intervention period, frequency and intensity of intervention, supervision of training, terrain, pole type and measures of intensity); (b) patient characteristics: Which CD and age of participants; (c) the outcome measures: which EC measure and between-group comparisons between intervention and co-intervention groups.

Quality assessment

In case the included studies are not already rated by the PEDro website, the author of this review will perform the assessment of the methodological quality of the included studies using the PEDro scale.[22]
The studies are rated and given level of methodological quality based on the following levels: 0-3 points=poor, 4-5 points=reasonably good, 6-8 points=good, 9-10 points=very good.[23]
In this review 0-3 points is considered as low quality, 4-5 points as moderate quality, and 6-10 points as high quality. The criteria are scored with either “yes” or “no”. A “yes” gives one point whereas a “no” gives 0 points. The points will only be awarded when a criterion is clearly satisfied.
In case of doubt, three independent assessors (JK, MO, HH) are brought in to clarify the criteria.

Best evidence synthesis

In this review, the p-value is considered statistically significant if the value is <0.05.
After the methodological quality of the included articles have been assessed, a best evidence synthesis is performed based on the recommendations of Van Tulder et al.[24] This is done in order to come to an overall finding on the level of evidence.
Information of the evidence levels according to Van Tulder et al.[24] can be found in table 2 on the following page.
Different levels of evidence categorize the different studies: 1) strong evidence, 2) moderate evidence, 3) limited evidence, 4) indicative findings, and 5) no evidence.

Table 2: Evidence levels according to Van Tulder et al.[24]

Strong evidence	Consistent and significant findings in outcome measures in a minimum of two high quality RCT`s #
Moderate	Consistent and significant findings in outcome measures in a minimum of one high quality RCT and one low quality RCT or high quality CCT #
Limited evidence	Consistent and significant findings in outcome measures in a minimum of one high quality RCT # or by consistent and significant findings in outcome measures in a minimum of two high quality CCT`s #
Indicative findings	Significant findings in outcome measures in a minimum of one high quality CCT or one low quality RCT #
No evidence	Results of eligible studies, which do not meet the criteria for the above stated levels of evidence, or in case of conflicting results among RCTs and CCTs or no eligible studies.

If the proportion of studies, which show evidence is <50% of the total number of studies in the same category of methodological quality and design, no evidence is stated.

RCT, randomized clinical trial; CCT, controlled clinical trial.

Results

Result of search

Titles of 325 articles were screened after the initial database search. 50 articles remained after screening of the titles and abstracts in the respective databases. 34 duplicates were removed and the full text of sixteen articles remained for full read-throughs. Five articles were excluded because the study design did not match the inclusion criteria. Two articles did not include the appropriate outcome measure. Lastly, two articles were excluded because they had the same subjects and intervention as a one of the included articles but were published under different titles. An additional search of the reference list of the included articles was performed, but no articles could be included. Seven articles met the inclusion criteria and were included in the review. The result from the search procedure is presented in figure 1 below.

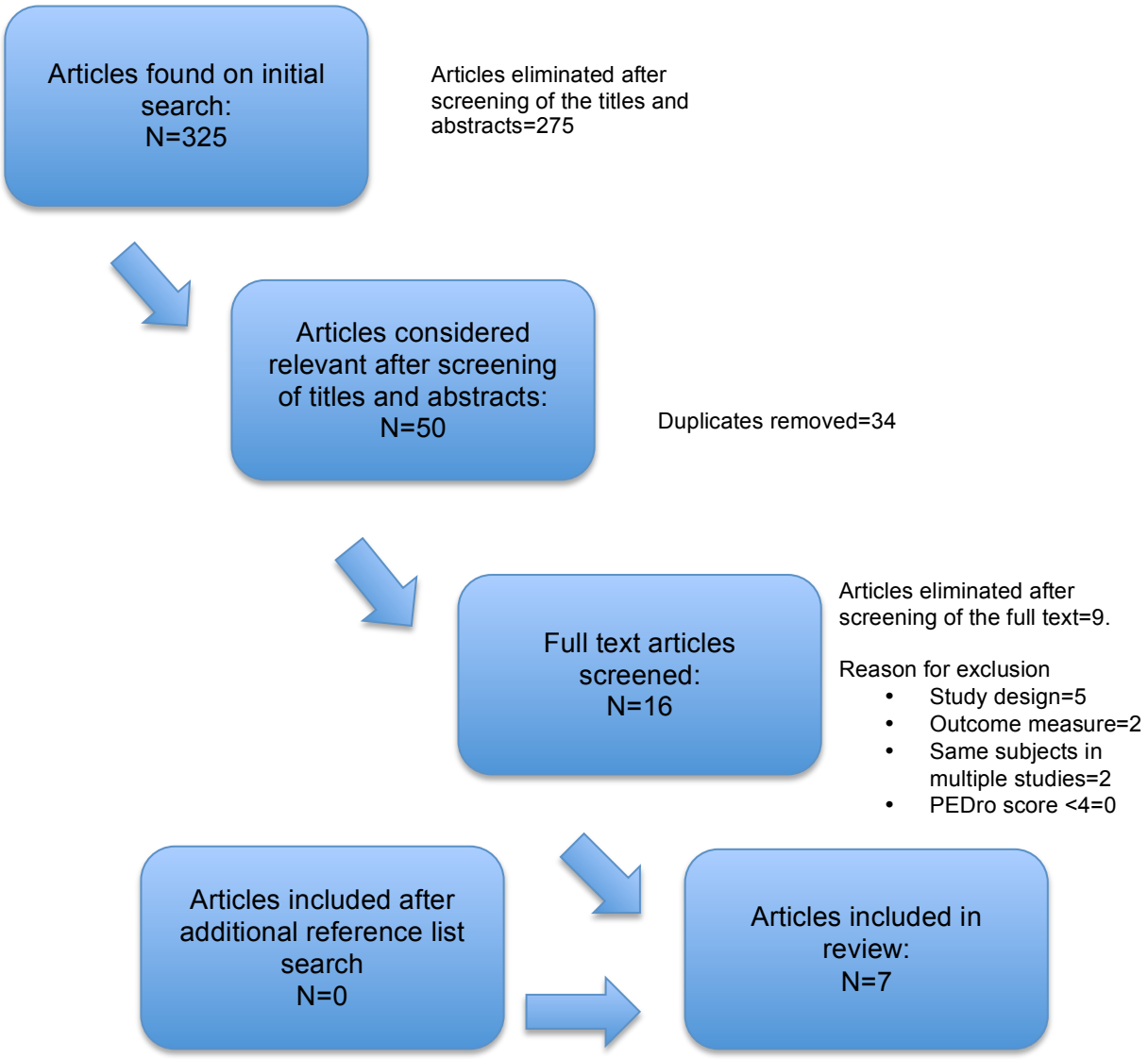

Figure 1: Flowchart from literature search

Quality assessment

The methodological quality of the included studies was consistent and of moderate and high quality. Four of the studies, respectively from Kocur et al.[25], Langbein et al.[26], Breyer et al.[27] and Collins et al.[28] had a PEDro score of 5/10. The two studies, respectively from Strömbeck et al.[29] and Fritz et al.[30], had a PEDro score of 6/10. The last study from Mannerkorpi et al.[31] scored 8/10 on the PEDro score. All of the articles except the study from Fritz et al.[30] had already been scored by the PEDro website. The author performed the score for this study.
The result of the PEDro score of the included articles is presented in appendix II table 5.

Study population

A CD was present in all of the participants in the included studies. Three out of seven studies involved a cardiovascular pathology; in the study from Langbein et al.[26], the participants were diagnosed with peripheral arterial disease; Kocur et al.[25] investigated the effect of NW in participants with a previous episode of acute coronary syndrome, while Collins et al.[28] had participants with a condition of chronic hearth failure. Mannerkorpi et al.[31] worked with fibromyalgia subjects and Fritz et al. [30] investigated the effect of NW in subjects with type 2 diabetes mellitus. Lastly, Breyer et al.[27] observed the effect of NW in patients diagnosed with chronic obstructive pulmonary disease (COPD) and Strömbeck et al.[29] studied the effect of NW in primary Sjögren´s syndrome.
Details about the study population can be found in appendix III table 6.

Nordic walking as intervention

The duration of the NW intervention periods ranged from 3[25] to 24 weeks[26] with a mean of 13,4 weeks. Three training sessions weekly was the most common frequency for the intervention periods.[26-29]
The duration of the training sessions ranged from 20 minutes to 1 hour.
Intensity among the training programs varied. Moderate intensity was most common, but several studies reported higher intensities.[25, 30]
Characteristics of Nordic walking as intervention can be found in appendix IV table 7.

Exercise capacity

Four different comparisons were performed within the included articles of this review.
The results of the interventions can be found in table 3 on the following page.

Table 3: Results of interventions

Study and pathology	Intervention groups	Outcome measure	Between-group comparison
Comparison 1: NW in comparison with non-exercising control groups			
Fritz et al.[30] Type 2 diabetes mellitus	1) NW 2) NCG	Bicycle exercise test Peak VO_2 (ml/kg/min)	P=0.3768
Langbein et al.[26] Peripheral arterial disease	1) NW 2) NCG	Symptom-limited incremental treadmill test Peak VO_2 (ml/kg/min)	P=0.017
Collins et al.[28] Chronic heart failure	1) NW 2) NCG	Naughton protocol Peak VO_2 (ml/kg/min)	P=0.019
Breyer et al.[27] COPD	1) NW 2) NCG	6MWT	P=<0.01 Follow-up 1: P=<0.01 Follow-up 2: P=<0.05
Comparison 2: NW in comparison with walking as an exercise modality			
Mannerkorpi et al.[31] Fibromyalgia	1) NW 2) LIW	6MWT	P=0.09
Kocur et al.[25] Acute coronary syndrome	1) NW+SCRP 2) W+SCRP	Modified Bruce protocol MET	P=>0.05
Comparison 3: NW in comparison with a SCRP			
Kocur et al.[25] Acute coronary syndrome	1) NW+SCRP 2) SCRP	Modified Bruce protocol MET	P=<0.05
Comparison 4: NW in comparison with range of motion exercises			
Strömbeck et al.[29] Primary Sjögren´s syndrome	1) NW 2) ROM	Aastrand Ryhming test Maximum VO_2 (ml/kg/min)	P=0.06

NW, Nordic walking; NCG, non-exercising control group; 6MWT, 6 minute walking test; LIW, low intensity walking; MET, metabolic equivalent; SCRP, standard cardiac rehabilitation programme; ROM, range of motion exercises

Comparison 1: NW in comparison with non-exercising control groups

Four out of seven studies compared NW as an intervention with a non-exercising control group.[26-28, 30] Fritz et al.[30] could not report a significant improvement (p=0.3768) in VO^2 peak (ml/kg/min) for the intervention group in a group of type 2 diabetes mellitus subjects. Breyer et al.[27] observed a significant difference (p=<0.01) in the 6MWT between the two intervention groups at the end of the intervention period. In addition, significant results could also be seen between the groups at two follow-up measurements, respectively 6 months (p=<0.01) and 9 months (p=<0.05). Further, Collins et al.[28] reported a significant improvement (p=0.019) in peak VO^2 (ml/kg/min) in the NW group compared to

the control group. Lastly, in the study from Langbein et al.,[26] peak VO^2 (ml/kg/min) improved significantly (p=0.017) in the NW group compared to the control group.

Comparison 2: NW in comparison with walking as an exercise modality

Two out of seven studies compared NW to walking.[25, 31] Mannerkorpi et al.[31] compared NW to low-intensity walking in subjects with fibromyalgia. The NW group had a significant improvement (p=0.009) in walking distance measured by the 6MWT compared to the low-intensity walking group. Kocur et al.[25] compared NW in combination with a standard cardiac rehabilitation program (SCRP) against walking in combination with a SCRP. The SCRP consisted of endurance training with the use of an ergometer cycle in addition to breathing and stretching exercises. No significant difference in MET (p=>0.05) was reported between the two groups.

Comparison 3: NW in comparison with a SCRP

One study compared NW against a SCRP. Kocur et al.[25] reported a significant difference in MET (p=<0.05) when comparing NW in combination with a SCRP to a SCRP only.

Comparison 4: NW in comparison with range of motion exercises

Strömbeck et al.[29] did not report a significant difference (p=0.06) in peak VO^2 (ml/kg/min) between the NW group and a home-based range of motion exercise program.

Best evidence synthesis

Due to the fact that the included studies operated with different co-interventions, the best evidence synthesis was applied on separate groups that had similar interventions. Four comparisons were performed: 1) NW in comparison with non-exercising control groups; 2) NW in comparison with walking as an exercise modality; 3) NW in comparison with a SCRP; and 4) NW in comparison with range of motion exercises.
Results from the best evidence synthesis can be found in table 5 on the following page.

Table 5: Best evidence synthesis

Study	Study design	Groups	Methodological quality	P-values	Statistically significant
Comparison 1: NW in comparison with non-exercising control groups					
Fritz et al.[30]	RCT	NW vs. NCG	High	P=0.3768	No
Langbein et al.[26]	RCT	NW vs. NCG	Moderate	P=0.017	Yes
Collins et al.[28]	RCT	NW vs. NCG	Moderate	P=0.019	Yes
Breyer et al.[27]	RCT	NW vs. NCG	Moderate	P=<0.01 Follow-up 1: P=<0.01 Follow-up 2: P=<0.05	Yes Yes Yes
Comparison 2: NW in comparison with walking as an exercise modality					
Mannerkorpi et al.[31]	RCT	NW vs. LIW	High	P=0.009	Yes
Kocur et al.[25]	CCT	NW+SCRP vs. W+SCRP	Moderate	P=>0.05	No
Comparison 3: NW in comparison with a SCRP					
Kocur et al.[25]	CCT	NW+SCRP vs. SCRP	Moderate	P=<0.05	Yes
Comparison 4: NW in comparison with range of motion exercises					
Strömbeck et al.[29]	CCT	NW vs. ROM	High	P=0.006	No

RCT, randomized clinical trial; NCG, non-exercising control group; LIW, low intensity walking; CCT, controlled clinical trial; SCRP, standard cardiac rehabilitation programme; ROM, range of motion exercises

Comparison 1: NW in comparison with non-exercising control groups

Even though there were significant differences found, due to the moderate quality of the included studies, there are *indicative findings* of NW improving EC in CD patients compared with non-exercising control groups.

Comparison 2: NW in comparison with walking as an exercise modality

Due to the fact that only one out of two studies reported significant difference, there is *limited evidence* stating that NW improves EC compared with walking as an exercise in CD patients.

Comparison 3: NW in comparison with a SCRP

Even though significant difference was reported, the study was not of high methodological quality. Due to this, there is *no evidence* supporting that NW improves EC compared with a SCRP in CD patients.

Comparison 4: NW in comparison with range of motion exercises

No significant difference was found in this comparison. Due to this, there is *no evidence* supporting that NW improves EC compared to range of motion exercises in CD patients.

Discussion

Main findings

NW in comparison with a non-exercising control group

Based on the result from the best evidence synthesis, there are *indicative findings* of NW being effective for improving EC in CD patients compared with non-exercising control groups. Three out of four studies in this comparison reported significant improvements for NW in comparison to a control group in measures of EC. Langbein et al.[26] reported a p-value of 0.017, Collins et al.[28] reported the p-value to be 0.019 and lastly Breyer et al.[27] reported <0.01.

The last study from Frtitz et al.[30] did not show significant values of between the groups after the intervention period. However, EC was improved and showed significant values in subjects completing >80 per cent or more of the prescribed training. This addresses an important question regarding adherence to training in the abovementioned study from Fritz et al.[30] The low adherence to training is in contrast to the findings of Figard-Fabre et al.[32] who observed high adherence in a study with obese subjects performing NW. The study from Fritz et al.[30] was the only study that lacked supervision during training. This could have influenced the participant's motivation for exercise during the programme and thereby caused the low adherence among the participants performing NW. This relates to previous research, which reported a greater outcome in training effect in a supervised training group compared to an unsupervised group that performed identical interventions.[33] Thus, this can imply that supervision of training should not be underestimated with regards to yield a better training effect.

The study of Langbein et al.[26] reported that NW significantly improves peak VO_2 compared with a non-exercising control group. An intervention period of 24 weeks was the longest of the four studies. According to the authors, this was the first RCT analysing NW as an exercise modality and addressing EC in a group of peripheral arterial disease patients. These findings correlate with previous findings of aerobic exercise intervention for the same type of patients, which reported an improvement in peak VO_2.[34] This indicates the benefit of aerobic exercises in the treatment of peripheral arterial disease patients.

Similar to the study from Fritz et al.[30] adherence to unsupervised training was also low in the study from Langbein et al.[26] Less than 50 per cent of the participants followed the prescribed training. The study was initially based on a combination of supervised and unsupervised training. Due to lack of adherence, the program was converted into a supervised programme since adherence to training was not the primary outcome of the study. It can be argued, based on previous findings, that supervised training is beneficial and yields a better training effect and provides more motivated subjects.[33]

Collins et al.[28] reported a significant increase in peak VO_2 in a group of chronic heart failure patients when compared with a non-exercising control group. A Point to address is the relatively small sample of subjects (NW=12, control group=15), which could have reduced the power of the result of the study. A significant improvement in walking distance from the 6MWT was reported in the study from Breyer et al.[27] This was the first study to investigate the effect of NW in COPD patients. The reason for this choice of intervention was because the authors were searching for an exercise modality that could easily be copied into daily-life activities. This relates to another study,[35] which displayed similar findings using NW as intervention; significant improvements in quality of life and 6MWT measure were reported in the two studies at post-test and at follow-up. Both of the studies argued that NW was a safe, simple and feasible form of aerobic exercise. This favours the belief of NW being an easy applicable and safe intervention form for COPD patients.

NW in comparison with walking as an exercise modality

Based on the best evidence synthesis of studies comparing NW with walking, there are *limited evidence* for recommending NW as an exercise modality for improving EC. When looking at the effect of NW on EC in comparison with walking as an exercise modality, two studies were analysed.

Some of the participants in the study of Mannerkorpi et al.[31] were fast walkers and recorded a high walking distance at baseline testing from the 6MWT. This could be an unfortunate feature when the 6MWT is used to measure EC. Because of this, bias due to a ceiling effect of the test could occur. However, a previous study reported the 6MWT to be a reliable measure for subjects with Fibromyalgia.[36]

The study from Kocur et al.[25] had the shortest duration (3 weeks) of the studies included in this review. They could not find significant differences in MET between the two intervention groups. This is in contrast to Mannerkorpi et al.[31] who reported significant improvement in EC. Duration of the intervention period could have been an influential factor when looking at the discrepant results between the two studies in this comparison. Mannerkorpi et al.[31] operated with an intervention period of 15 weeks. Thus, a longer duration of the intervention could have influenced the outcome.

NW in comparison with a SCRP

According to the best evidence synthesis, there are *no evidence,* which proves the effect of NW in comparison with a SCRP. Kocur et al.[25] found significant improvements in MET after an intervention lasting three weeks. This was the only study in this comparison. The study shows similarities with previous findings, which also reported that the largest improvements of EC occur in the early phase of a training program.[37] However, due to the short intervention period and lack of follow-up, no information about the long-term effect was provided. This study represented one out of the two CCT included in this review. Thus, a selection bias cannot be ruled out.

NW in comparison with range of motion exercises

The best evidence synthesis states that there is *no evidence* of whether NW is an effective exercise modality for improving EC in comparison with range of motion exercises. Only the study from Strömbeck et al.[29] was included in this comparison. An improvement in maximum VO_2 ml/kg/min was close to showing statistical significance (P=0.06). On the other hand, the authors reported an increase in EC despite the small number of subjects (N=21) participating in the study. Another study, which was not included in the review, investigated the effect of aerobic exercise in rheumatic subjects. This study also reported improvements in maximum VO_2 using the same outcome measure (Aastrand-Ryhming test) after performing 12 weeks of training.[38] In addition, measurements of fatigue improved for the subjects in both studies. According to these results, aerobic exercise in form of NW or other low-impact aerobic interventions could be beneficial for subjects with rheumatic diseases.

Methodological quality of studies

It is important to consider the methodological quality of the included studies when interpreting the outcome of the best evidence synthesis. Three studies[29-31] were rated as high-quality articles. The remaining studies were of moderate quality, which limits the level of evidence for the different comparisons performed in the review. Based on the dissimilarities of the exercise interventions, there was a need for splitting up and making of different comparisons. This made the number of studies per best evidence synthesis low and reduced the level of evidence.

Intention-to-treat analysis of the three studies[26-28] reporting significant between-group effects from NW in comparison 1 was not performed. According to Montori et al.[39] the intention-to-treat principle must be applied in order to avoid bias when assessing treatment efficacy in trials. This increases the power effect of the result from studies. Thus, this could have influenced the results leading to flawed estimates due to the fact that frail individuals were excluded from the analysis. Another point to address, is the fact that none of the included studies in this review met the criteria regarding blinding of subjects and therapists on the PEDro scale. On the other hand, these criteria are almost impossible to fulfil due to the fact that NW was used as an intervention. Furthermore, this automatically leads to a lower methodological quality of the included studies in this review.

Information regarding the exercise tests

Due to the fact that various CDs were presented in this review, the question regarding validity and reliability of the different exercise tests arise. In the study from Kocur et al.[25] the modified Bruce protocol was used to determine EC. According to previous findings,[40] the protocol is safe and reliable for measuring maximum VO_2 physiologically or to predict it clinically by the use of predictive equations. This also accounts for subjects with cardiac conditions, which are clinically stable.[40] Furthermore, the 6MWT was used in two of the included studies, with fibromyalgia and COPD as

represented pathologies. Previous findings report that the 6MWT is a reliable measure for subjects represented with fibromyalgia.[36] In addition, another study proved the 6MWT to be valid and demonstrated a high repeatability in subjects with COPD.[41]

Strömbeck et al.[29] used the Aastrand-Ryhming test to estimate maximum VO_2 for subjects with primary Sjögren´s syndrome. Based on the findings of Cink et al.,[42] the Aastrand-Ryhming test displayed a good correlation to a maximal bicycle test measuring maximum VO_2 with use of gas exchange analysis. A point to address is that this study investigated healthy subjects. Moreover, a question occurs of whether this proves the validity of the test. According to Fletcher et al.,[43] a major limitation of bicycle exercise testing is the quick fatigue of the quadriceps muscle in subjects unaccustomed to cycling. Thus, maximum VO_2 is normally 10 to 15 per cent lower compared to treadmill exercise testing. This also questions the exercise testing method in the study from Fritz et al.,[30] which also used a bicycle exercise test when measuring maximum VO_2 by gas exchange analysis. Hence, this could have influenced the true measures of oxygen uptake based on the subject's prior experience to cycling.

Langbein et al.[26] used a treadmill protocol developed for subjects with peripheral arterial disease for his study to obtain measures of VO_2 peak. In spite of this, no information about validity or reliability is available.

Strong and weak points of the study

Using the PEDro scale as an assessment tool helped to determine the methodological quality of the included studies in this review. This also made it easier to acquire information about the internal validity and how the included studies interpreted the results. By using fellow students for peer reviewing, readability of the review was enhanced and methodological flaws were kept to a minimum. NW is a relatively new topic in the field of research and there is a limited number of articles published. This could have made it easier to acquire all the relevant articles for inclusion in the review. Lastly, a point to address is that the author tried to keep an unbiased view when answering the research question.

The fact that various pathologies were investigated, made it hard to come to an overall conclusion regarding the research question. The interventions also differed in terms of duration and frequency, which made it difficult to generalize. Moreover, it also proved to be difficult finding articles stating information regarding the validity and reliability for the different exercise tests and outcome measures of EC related to the various pathologies. This review only included articles written in English language. NW is more widespread and a widely known form of training in Europe. Because of this, there is a chance of studies, which would have met the inclusion criteria if they were written in English language, were left out. Lastly, an inexperienced researcher performed the search procedure. Previous findings has reported that a single reviewer on average misses 8 per cent of reports eligible for inclusion.[44] This could have caused relevant articles to be missed out and not being included in the review.

Future implications for research

NW is a relatively new topic in the field of research and a large part of the research is performed on healthy subjects. Based on this, the number of studies investigating NW and the effect on EC in CD patients are relatively low. Furthermore, there is a lack of studies of high methodological quality. Hence, there is clearly a need for further research, preferably of higher methodological quality investigating the effect of NW on EC in CD patients.

Although supervised exercise is beneficial to the patients and their adherence to the program, it requires time and funding. Supervised training can be costly and difficult to make realistic in the long run. Thus, future research should investigate how to recruit and motivate subjects and thus prevent low adherence to unsupervised training.

This review included seven studies of which only two investigated the difference in effect between NW and walking as interventions. According to previous findings, NW could be more beneficial when compared with walking in terms of improving EC.[9-12] However, these studies investigated healthy subjects. Consequently, there is a need for more research to be performed regarding these two forms of interventions on subjects with CDs.

Future implication for practice

Based on the level of evidence regarding the different comparisons, it is difficult to deduce the efficacy of NW as an exercise modality. Moreover, this implies that it would be difficult to recommend NW over aerobic or other types of exercises in practice. On the other hand, several of the included studies[27, 28, 30] in this review found NW to be a safe, simple and applicable form of training, which could be recommended for various CDs. As a result, NW can be advocated as an alternative to walking for patients that lacks motivation to conduct normal walking training.

Furthermore, when comparing NW with non-exercising control groups, the three studies[26-28] that reported significant differences, operated with a frequency of three exercise sessions per week. Additionally, Mannerkorpi et al.[31] demonstrated a significant difference based on only two sessions per week. Interval training of moderate-to-high intensity was most commonly used amongst the studies and reported positive training effects. Based on this information, a minimum of two exercise sessions with a moderate-to-high intensity could be recommended. When looking at the duration for the intervention period, Kocur et al.[25] found significant differences based on an intervention period of three weeks when comparing NW with a SCRP. According to this, a training period of three weeks could be sufficient to yield a positive training effect.

Conclusion

The findings in this review show that there are indicative findings of NW being effective for improving EC in CD patients in comparison with non-exercising control groups. Limited evidence was found for recommending NW in comparison with walking. Furthermore, there is no evidence for recommending NW over a SCRP. Lastly, when comparing NW with range of motion exercises, no evidence were found. NW in the field of scientific research is in its childhood. There are a limited number of studies available regarding NW and its effect for subjects with a CD. NW as an aerobic form of exercise seems to improve EC in subjects with CDs. It is also a safe, simple and suitable form of training, which can be applied in various forms of CDs. However it is difficult to conclude, based on the level of evidence, whether it can be recommended for practice and if it could be preferred over other types of exercise.

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Appendices

Appendix I:

Search strategies for databases

Search strategy PubMed database		
1	Nordic walking	1 OR 2 OR 3 OR 4 OR 5 OR 6
2	Walking with poles	
3	Pole walking	
4	Exerstriding	
5	Nordic poles	
6	Polestriding	
Search string: "Nordic walking" OR "walking with poles" OR "pole walking" OR "exerstriding" OR "Nordic poles" OR "polestriding"		

Search strategy Cochrane Central Register of Controlled Trials		
1	Nordic walking	1 OR 2 OR 3 OR 4 OR 5 OR 6
2	Walking with poles	
3	Pole walking	
4	Exerstriding	
5	Nordic poles	
6	Polestriding	
Search string: "Nordic walking" OR "walking with poles" OR "pole walking" OR "exerstriding" OR "Nordic poles" OR "polestriding"		

Search strategy ScienceDirect database		
1	Nordic walking	1 OR 2 OR 3 OR 4 OR 5 OR 6
2	Walking with poles	
3	Pole walking	
4	Exerstriding	
5	Nordic poles	
6	Polestriding	
Search string: "Nordic walking" OR "walking with poles" OR "pole walking" OR "exerstriding" OR "Nordic poles" OR "polestriding" Filter: Limited to journals only		

Search strategy CINAHL database		
1	Nordic walking	1 OR 2 OR 3 OR 4 OR 5 OR 6
2	Walking with poles	
3	Pole walking	
4	Exerstriding	
5	Nordic poles	
6	Polestriding	
Search string: "Nordic walking" OR "walking with poles" OR "pole walking" OR "exerstriding" OR "Nordic poles" OR "polestriding" Filter: Limited to journals and trials only		

Six different searches were performed in the PEDro database.

Search strategy PEDro database	
Search term 1:	Nordic walking
Search term 2:	Walking with poles
Search term 3:	Pole walking
Search term 4:	Exerstriding
Search term 5:	Nordic poles
Search term 6:	Polestriding

Appendix II

Table 5: Quality assessment of the studies. Rated according to the PEDro scale[22]

	Kocur et al.[25]	Langbein et al.[26]	Breyer et al.[27]	Collins et al.[28]	Strömbeck et al.[29]	Fritz et al.[30]	Mannerkorpi et al.[31]
Criterion 1: Eligibility criteria	YES	YES	NO	YES	NO	YES	YES
Criterion 2: Random allocation	YES	YES	YES	YES	NO	YES	YES
Criterion 3: Concealed allocation	NO	NO	NO	NO	NO	YES	YES
Criterion 4: Baseline comparability	YES	YES	YES	YES	YES	YES	YES
Criterion 5: Blind subjects	NO	NO	NO	NO	NO	NO	NO
Criterion 6: Blind therapists	NO	NO	NO	NO	NO	NO	NO
Criterion 7: Blind assessors	YES	NO	NO	NO	YES	NO	YES
Criterion 8: Adequate follow-up	NO	YES	YES	YES	YES	YES	YES
Criterion 9: Intention-to-treat analysis	NO	NO	NO	NO	YES	YES	YES
Criterion 10: Between-group comparisons	YES	YES	YES	YES	YES	YES	YES
Criterion 11: Point estimates and variability	YES	YES	YES	YES	YES	YES	YES
PEDro score	5/10	5/10	5/10	5/10	6/10	6/10*	8/10

* Article assessed and scored by the author

Table 6: Characteristics of study population

Study	Pathology	Participants	Age	Adherence to training	Dropouts during intervention
Fritz et al.[30]	Type 2 diabetes mellitus	N: 50	NW: 61.4 C: 61.0	Mean of 3.9 hours out of instructed 5	N: 3
Breyer et al.[27]	COPD	N: 65	NW: 61.9 C: 59.0	No specific information about adherence to training	N: 5
Mannerkorpi et al.[31]	Fibromyalgia	N: 67	NW: 48 C: 50	NW: 62% median attendance rate C: 50% median attendance rate	N: 9
Kocur et al.[25]	Acute coronary syndrome	N: 80	NW+SCRP: 51.4 W+SCRP: 51.3 SCRP: 54.5	No specific information about adherence to training	N: 0
Strömbeck et al.[29]	Primary Sjögren`s syndrome	N: 21	NW: 60 C: 56.5	NW: Median number of 35 NW sessions during 12 weeks C: Median number of 38 ROM sessions	N: 2
Collins et al.[28]	Chronic heart failure	N: 31	NW: 62.7 C: 66.2	No specific information about adherence to training	N: 6
Langbein et al.[26]	Peripheral arterial disease	N: 52	NW: 65.5 C: 68.7	Adherence to supervised NW was almost perfect	N: 6

NW, Nordic walking; C, control group; SCRP, standard cardiac rehabilitation programme; W, walking

Table 7: Characteristics of NW as an intervention

Study	NW as an interventionn			Measures of intensity	Supervision during intervention	Pole type	Terrain
	Duration of intervention period	Frequency	Intensity				
Fritz et al.[30]	4 months	5 hours per week	Exercise that caused slight shortness of breath and perspiration	NM	No supervision	NM	Instructed to walk at home
Breyer et al.[27]	3 months	1 hour x 3 x week	75% of initial maximum heart rate	Monitored with a pulse watch	Supervised throughout the whole intervention period	Power poles (LEKI; Hamburg, Germany)	NM
Mannerkorpi et al.[31]	15 weeks	20 min x 2xweek	Moderate-to-high intensity: 10 min 9-11 RPE, 10-20 min 13-15 RPE	Borg´s rating of perceived exertion scale	Supervised 2xweek	NM	Parks and forests with flat areas and small hills
Kocur et al.[25]	3 weeks	30 min x 5xweek	Low-to-high intensity exercise (20-85% HRR)	Borg scale	Supervised throughout the whole intervention period	NM	Outdoors on a flat asphalt surface
Strömbeck et al.[29]	12 weeks	45 min x 3 x week	<8 weeks: 60-70% APHR >8 weeks: 70-80% APHR	By a telemetric heart rate monitor	Supervised 1xweek	NM	Instructed to walk at home
Collins et al.[28]	12 weeks	45-50 min x 3xweek	50-70% of VO^2 peak tested at baseline. Interval: Exercise-to-rest ratio of 3:1	NM	Supervised 2x week	NM	NW outdoors or indoors on treadmill
Langbein et al.[26]	24 weeks	30-45 min 2-3x week	Interval training with intermittent bouts of exercise	Measuring of heart rate and exertion	Supervised 3 x week 4 weeks, 2x week for 8 weeks, 1 x week 4 weeks, biweekly 4	Exerstrider poles (EXERSTRIDER Products Inc, Madison, Wis)	Changes in terrain

APHR, Age predicted heart rate; RPE, Borg´s Rating of Perceived Exertion; NM, Not mentioned in article; HRR, heart rate reserve

Appendix IV

Appendix V

Addendum

When the thesis-process initially started, my first thought concerning the topic assigned to me by the school, was to compare and look at the difference between NW and normal walking in CD patients. The difference between these two interventions was to be measured in cardiorespiratory fitness. Was NW as good as many people were saying or was it maybe a bit overrated? Throughout the process of planning and the actual writing of the literature review, I had to leave my initial idea about comparing NW and normal walking. The main reason for this was that it occurred to me that I did not have enough material to base my writing on. I had to make a few changes and decided to make a more comprehensive approach. Instead I choose to investigate the effect of NW on exercise capacity compared to no training and other forms of exercise. I decided on exercise capacity because it is a measure, which gives good evidence about mortality amongst both healthy and unhealthy subjects. It also has the feature of providing good prognostic information, which can help clinicians in their work of making people healthier. These changes provided me with a research question I could work with and gave me a chance of beginning the writing process of the literature review.

Appendix VI

Fontys Paramedische Hogeschool

B4 Assessment form project plan

Name: Kristoffer Olsen Student no: 227304

Date: 9-3-2013

Title:

General	
- The project plan is according to format	yes
- Spelling and language are correct	yes
Problem description and problem definition (introduction)	
- The problem description is sufficiently clearly formulated	yes
- The problem description reflects social and paramedical relevance	yes
- A concrete and relevant research question (or questions) can be formulated based on the problem definition, including possible sub questions	yes
Objective	
The objective is:	
- Sufficiently clearly and concretely formulated	yes
- Relevant for a selected target group within the (paramedical) professional practice	yes
- Practically feasible	yes
- Achievable within the set time	yes
Project product	
The project product:	
- Is in line with the problem definition, research question and objective	yes
- Is usable for the selected target group	yes
- Is in line with the client's wishes	yes
- The product requirements are accurately described	yes
Activities/method	
Sufficient insight is given into the type of activities and types of sources for the performance of the research and the realization of the product	yes
Time schedule	
- The time schedule gives a global phasing and time investment for the project as a whole and for the coming weeks an increasingly detailed schedule	yes
- Important moments are recorded in the table (typographically noticeable) (e.g. contact moments, handing-in moments)	yes
- The time schedule gives a global task division of the planned activities	yes

Fontys Paramedische Hogeschool

Estimated costs

Clear insight is given in:

- The costs to be expected concerning money and hours	yes
- The division of these costs (project leader, student, programme)	yes

Literature

- Used and planned literature is specific and mentioned to a sufficient extent	yes
- Relevant and recent literature is referred to	yes
- Literature references, in the text and in the literature list, are made according to the Writer's Guide (Wouters 2012)	yes

Comments:

The NCDS and PA abbreviations are not introduced. Language is sometimes not optimal. Try to avoid terms like: "as mentioned earlier..." The outcome is clearly defined, but you could be better introduced in the tunnel, the introduction is general. Including all kinds of chronic disease patients makes it complex. No personal learning goals in your project plan. Why is it relevant to extract some characteristics. The reference style is not fully consistent.

All points under B3.1 up to and including B3.8 must be answered with a 'yes' in order to receive a GO for the project. The supervisor discusses with the student which points need adjustment.

GENERAL:	**GO**

Name assessor:
Jaap Janssen
René van Saan

Date + Signature
9-3-2013