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RESEARCH PAPER

Nordic walking for geriatric rehabilitation: a randomized pilot trial

Sabrina Figueiredo MSc[1], Lois Finch PhD[2], Jiali Mai PT[2], Sara Ahmed PhD[1,2], Allen Huang PT MD[3] & Nancy E. Mayo PhD[1,2,3]

[1]Faculty of Medicine, School of Physical and Occupational Therapy, McGill University, Montreal, QC, Canada, [2]Division of Clinical Epidemiology, McGill University Health Center, Montreal, QC, Canada, and [3]Faculty of Medicine, Department of Geriatrics, McGill University, Montreal, QC, Canada

***Purpose*: There is a need to identify effective interventions to promote walking capacity in seniors. This study compares nordic walking (NW) and usual overground walking (OW) and estimates the relative efficacy in improving walking capacity (endurance and gait speed) of the elderly. *Method*: Single blind, site-stratified, randomized, pilot trial designed to estimate the amount of change with NW and OW. Main outcomes were distance walked measured by 6-min walk test (6MWT) and comfortable gait speed measured by 5-meter walk test (5MWT). Explanatory variables were age, sex, number of comorbidities, walking aids, balance, pain, and leg function. *Results*: NW and OW participants improved, respectively, 45 and 41 m on 6MWT and increased their gait speed by 0.14 and 0.07 m/s, respectively. NW effect sizes were moderate for 6MWT (ES = 0.53) and large for gait speed (effect size (ES) = 0.68). OW demonstrated moderate effect size for 6MWT (ES = 0.53) but a small one for gait speed (ES = 0.33). Relative efficacy, which was obtained from the ratio of NW and OW effects' sizes, was 1 for 6MWT and 2.06 for gait speed. *Conclusions*: NW is 106% more effective in improving gait speed among elderly than OW.**

Keywords: Elderly, endurance, nordic walking, speed, walking training

Implications for Rehabilitation

- Elderly are the fastest growing segment of the population. With advanced age, greater number of disabilities, and consequently mobility limitations, are observed among this group.
- Nordic walking is a more intensive form of walking, using muscles of upper and lower body. There's evidence that nordic walking leads to greater cardiorespiratory workload without an increase in the level of exertion.
- In this study, nordic walking was 106% more efficient than regular walking in improving gait speed among the elderly.
- Clinicians specialized in geriatric rehabilitation may contribute to improve gait speed of seniors by adding nordic walking, a non-expensive and feasible option, to their physiotherapy sessions.

Introduction

The elderly are the fastest growing proportion of the global population. In 2009, 11% of the world population was over 60 years and this proportion, due to a decline in old-age mortality and low fertility rates, is expected to increase to 22% by 2050 [1].

Advancing age, considered independently of how fit an elder person is, leads to reduction in mobility and physical function, and these changes will ultimately affect the quality of gait and the capacity for functional and safe ambulation [2,3]. Unfortunately, among frail seniors, gait impairments are often severe [2,3].

Focusing on age-related changes affecting gait, alterations in spatial and temporal parameters have been reported as early as age 60 [4]. Several studies have reported significant changes in stride length and cadence [3,5]. Marigold & Patla [6] found that the elderly took shorter steps, resulting in a reduced stride length. A decreased coordination between pelvis and trunk, defined as a reduction in pelvic obliquity and rotation in the axial and sagital planes, is equally observed [5]. This reduction in pelvis and trunk counter-movements impacts gait stability, resulting in increased body rigidity when walking. Finally, decreased range of motion (ROM) of all lower extremity joints is often present [7].

Correspondence: Nancy E. Mayo, PhD Division of Clinical Epidemiology, R4.29 RVH Site of MUHC, 687 Pine Avenue West, Montreal, Quebec, H3A 1A1 Canada. E-mail: nancy.mayo@mcgill.ca
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Gait speed and distance walked, both representing here functional walking capacity, will also deteriorate. Among the senior population, a phenomenon called psychomotor slowing is often observed [8]. Grimby & Saltin [9] and Pollock *et al.* [10]. reported that in the early part of the seventh decade, the decline in gait speed is accelerated. The distance walked in a set time, as well as capacity to walk on uneven surfaces and up inclines or stairs, were found to decrease with age [3,4,11].

Despite all these age-related changes, functional walking capacity remains crucial for participation in personal, family, and societal roles, and unfortunately, distance walked and gait speed are predictors of hospitalization, institutionalization, and perceived and diagnosed health status [12–14]. Thus, since walking independence is of key importance in the elderly, and walking is often the only form of exercise available to them, strategies to promote walking capacity would be of great benefit to elders.

Based on this scenario, rehabilitation professionals are increasingly being charged to use evidence-based practices to improve walking capacity in a geriatric rehabilitation program. Recent studies, however, have demonstrated that no single modality is capable of achieving improvements in walking capacity as walking is a relatively complex activity and the strategies offered are neither intensive nor specific enough [15]. Therefore, it is necessary to identify effective strategies and interventions able to promote and maintain mobility and walking capacity in seniors [16].

A promising walking strategy is nordic walking (NW). When used by the fit, it is an intensive form of walking that uses the muscles of the upper and lower body in a continuous and reciprocal movement [17–23]. The poles used are similar to those used in cross-country skiing but have rubber tips and modified hand grips designed to provide a better platform for the hand during the push phase of poling [17–23]. The poles provide balance as well as promote a more physiological gait pattern, in which the trunk is upright and hip/shoulder countermovement are present, as opposed to the shuffling gait and flexed posture observed in many seniors [17–23]. There is evidence in healthy populations that NW leads to greater cardiorespiratory workload without an increase in the level of exertion [18,19,24]. Subjects are able to exercise longer and harder compared with traditional walking [19].Nonetheless, there is limited evidence for the use of NW in persons with health conditions. The only finding in this population is increased oxygen consumption, increased health-related quality of life, decreased fatigue and depression [25–28]. Moreover, NW has never been tested as a rehabilitation strategy.

The primary objective of this pilot study was to estimate, for elderly persons participating in rehabilitation programs, the relative efficacy of NW and usual overground walking (OW) in improving walking capacity (distance walked and gait speed).

We hypothesized that, without increasing pain, persons performing NW for 6 weeks will show a 20% greater change, than persons receiving usual walking training, in distance walked in 6 min as well as in gait speed.

For the purpose of clarification, in this study, usual OW is defined as moving at a regular pace by lifting and setting down each foot in turn on a flat floor.

Methods

Subjects

Subjects, either inpatients or outpatients, were recruited from two rehabilitation centers from the Greater Montreal Area. Eligibility criteria included: (i) 65 years old or more; (ii) undergoing rehabilitation program in one of the two centers; (iii) medically stable or in their usually state of health. Reasons for exclusions were (i) severe cognitive impairments (brief mini-mental score <14/22); (ii) unable to ambulate a minimum of 15 m with or without aids; (iii) unrestricted mobility as represented by a gait speed >1.2 m/s; (iv) moderate to severe mobility limitation of upper extremity represented by a shoulder flexion ROM <90° and extension ROM <20°; elbow flexion ROM <90°; and with a poor grip judged by the inability to release a can of 5 cm diameter; (v) pathological conditions of the upper extremity; and (vi) individuals who planned time in rehabilitation was <6 weeks. The research ethics committees at both study sites approved the study and all subjects provided informed, written consent.

Evaluations

Evaluations were conducted by trained blinded evaluators at baseline and on completion of the 6th week of intervention.

Measurement

The population was characterized on basic sociodemographic, clinical profile, lower extremity function, and balance. Comorbidities were ascertained from the medical chart and were compiled in a list of 16 prevalent comorbidities commonly encountered among elderly. The lower extremity function scale (LEFS) was used to measure lower extremity function and is a self-report measure of the difficulties one experiences on performing 20 activities of daily living. The Berg balance scale was used to measure functional balance. Participants were required to perform 14 movements required in everyday living [29]. The total score is out of 56 and higher scores reflect a better level of balance ability. The Berg balance scale is well established, valid, and reliable measure [30]. A change of three points is the clinical meaningful change in the Berg balance scale and a score of 45 is the cut-off for identifying those at risk of falling [31]. As the gray literature includes some reports of increased joint pain when the NW technique is performed incorrectly, we included a measure of pain. The Pain visual analogue scale (VAS) was used to measure upper extremity pain which may be an adverse effect. Participants were asked to rate their pain, in which the null value represented no pain and a value of 100 represented the highest level of pain.

Main outcomes were the 6-min walk test (6MWT) and comfortable gait speed over 5 m, both measures of functional capacity.

6MWT

The 6MWT is a well established, valid, and reliable measure for assessing ambulation in the elderly [32–34]. It is a safe, submaximal test, well tolerated, and a simple measure of functional walking capacity in clinical populations [35,36]. In this study, it was performed in a 20-m enclosed corridor and the outcome was the total distance walked during 6 min [36]. Individuals were instructed to walk as far as possible in 6 min at their own pace. Rests were taken as needed but participants were encouraged to resume walking as soon as they were ready to do so. The number and duration of rests, as well as the total distance ambulated were recorded. Perceived exertion was assessed before and immediately after testing. Standardized instructions and encouragements were used.

Comfortable gait speed

The comfortable gait speed test is well established, valid, and reliable measure for assessing ambulation in the elderly [32–34]. Subjects were instructed to walk a 9-m distance at a comfortable pace and were timed using a stopwatch over the middle 5-m section.

Randomization

Subjects were stratified by clinical setting and randomized into one of two groups, NW or OW. Randomization was computer generated using randomization scheme from the website Randomization.com at http://www.randomization.com.The randomization was hidden from investigators and clinicians and revealed only when a subject had consented and been evaluated.

Interventions

Subjects in both groups participated, on average, in 6 weeks of training, twice a week, with a duration of 20 min daily. Six weeks was chosen as this was the most realistic amount of time available for walking training given the usual length of the rehabilitation programs in both centers and the time required for consent and evaluation. Training sessions were individual and were provided by a physiotherapist who was also a certified NW instructor.

Each program was divided into three phases: warm-up, walking, and cool-down. During each session, gait speed was determined by the subject, according to what one felt was a comfortable pace. Therapists walked side by side with the patients, providing encouragement throughout the training sessions. In few cases, patients of both groups were lightly held by their waist belt. Intensity, duration, and participant perception of safety were recorded at every session.

In the NW group, participants were specifically taught how to use the poles with a reciprocal gait pattern. The heights of the poles were calculated individually for each subject according to 70% of their height. Participants in the NW group using walker or canes had no stability or balance issues when using the poles. Participants in the usual OW group were instructed to walk in a corridor. If necessary, they could use their walking aids.

All subjects continued to participate in their regular physiotherapy and occupational therapy programs.

Sample size

Sample size estimates were based on the premise that the NW group would achieve a change in 6MWT distance that was at least 20% greater than the control group (relative efficacy of 1.20 [37]). Based on previous data from one of the Institutions where the study was held, a positive change of 28 m was expected in the control group. An increase of 20% of this change (28 m) is approximately 6 m, thus NW participants were expected to show a change of, on average, 34 m (28 m + 20%). The estimated sample size with 80% power, to detect a within-group change of 34 m, with baseline standard deviation of 67, at α-level 0.05, was 12 subjects completing the study in each group. To allow for a drop-out margin, 15 participants were recruited for each group.

This approach was chosen because NW is a simple and inexpensive type of training that would be beneficial even with marginal gain of 20% [37].

Statistical methods

Data were analyzed on a per protocol basis. First, basic descriptive statistics were used to characterize the participants. Fisher exact and *t*-tests were used to compare the two groups at baseline. For each group separately, means of all outcomes were calculated at baseline and follow-up; mean change was also calculated as were 95% confidence intervals (95% CI) using the formula:

$$Mean \pm 1.96\,\frac{SD}{\sqrt{N}}$$

To calculate the relative efficacy, effect sizes (mean differences/standard deviation at baseline) for each intervention were initially calculated. After that, the ratio from the effects sizes was obtained from:

$$\frac{\text{NW means difference} \div \text{SD at baseline}}{\text{OW means difference} \div \text{SD at baseline}}$$

This approach was used as effect size allows measuring the magnitude of a treatment effect independently of the sample size of the study. Despite the small sample size, Shapiro-Wilk, Skewness, and Kurtosis tests showed that all variables followed a normal distribution. Missing data represented 14% of the data and was related to grave illness or death. Participants with missing data were not included in the analysis of this pilot trial.

Results

Participant flow and handling of missing data

Between January and June 2009, 30 people were enrolled in the study. Fourteen subjects were randomized to the NW intervention and 16 subjects to the OW group.

Table I presents baseline characteristics of the study groups which did not differ between groups. Despite the apparent greater proportion of previous fallers in the NW group (21%)

Table I. Participants' characteristics at baseline.

Characteristics	Nordic walking (*n* = 14)	Overground walking (*n* = 16)
Inpatient/outpatient rehabilitation	65%/35%	63%/37%
Age in years (mean) SD (range)	78 SD 7 (66–88)	78 SD 7 (65–92)
Women	57%	56%
Previous faller	21%	12%
Walking aid users		
No aids	8%	20%
Walkers	78%	67%
Canes	14%	13%
Number of Comorbidities		
0–5	65%	42%
6–10	21%	44%
11–15	14%	6%
>15	0%	6%
Lower extremity function (0/80)	38	38
Balance (0/56)	44	39
Endurance (6MWT) (m)	202	217
Gait speed (m/s)	0.65	0.67
Pain (0/100)	13	15

MWT, minute walk test.

compared with the usual walking group (12%), this difference was not statistically significant in a sample of this size.

Figure 1 presents a flow diagram of participants in the study and provides details of recruitment, withdrawals and missing data. Missing data occurring at follow-up were due to death (*n* = 1), severe illness (*n* = 2) or pain (*n* = 1), and participants' data were not included in the analysis. As this study is a pilot one, the true effect of NW and OW was estimated by analyzing the data from participants who completed all the interventions and assessments (NW = 13; OW = 13).

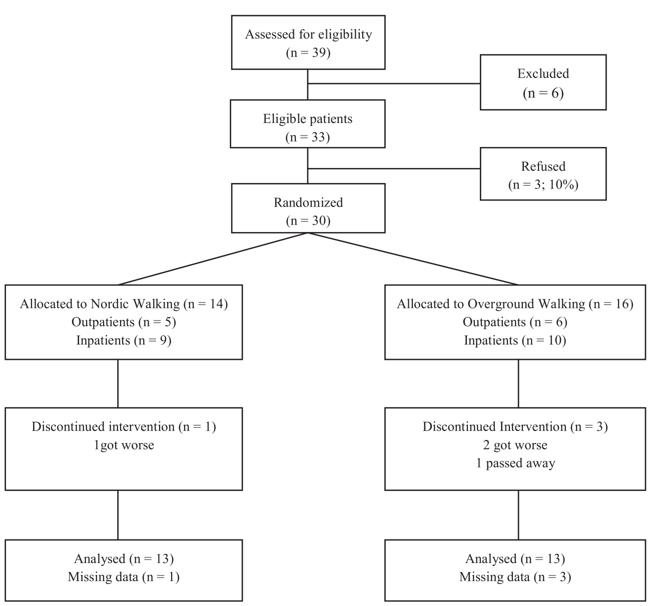

Figure 1. Flow of participants through the trial.

Outcomes and estimation

Table II presents the performance of participants on the 6MWT and comfortable gait speed. Participants from the NW group improved their 6MWT performance by an average of 45 m and reduced the time needed to comfortably walk 5 meters by 1.4 s, for an increase in gait speed of 0.14 m/s. The OW participants improved their walking distance by 41 m, reduced the time to walk 5 m comfortably by 0.8 s, implying a change in gait speed of 0.07 m/s.

Change in comfortable gait speed was statistically significant only for the NW group (95% CI: 0.08–0.3). Changes in the 6MWT were statistically significant for both groups.

Table III represents the performance of the participants on the Berg balance scale, LEFS, and pain-VAS, treated here as the explanatory variables.

Changes regarding lower extremity function and pain, measured respectively by the LEFS and pain-VAS, were not statistically significant for both groups, as the 95% CI includes the null hypothesis. This result therefore suggests gait speed improvements were not affected by these two variables. Changes on the Berg balance scale were similar for both groups. The 95% CI indicates statistically significant changes were observed.

Table IV shows the effects sizes for each intervention and their ratios. The NW group showed a moderate effect size for 6MWT (ES = 0.53) and a large one (ES = 0.68) for gait speed. The OW group showed moderate effects sizes for 6MWT (ES = 0.53) and small ones for gait speed (ES = 0.33).

The ratio of the effects sizes of NW and OW was 1 for 6MWT, and 2.06 for gait speed. Thus, NW was 106% more effective than OW in improving gait speed and was as effective as OW in improving 6MWT.

Adverse events

Throughout the study, a total of 234 walking sessions (132 OW sessions; 102 NW sessions) were conducted. No patients experienced an adverse event such as a fall or injury and there was no increase in pain or deterioration in lower extremity function.

Discussion

A randomized pilot trial was performed to estimate, for elderly persons, the relative efficacy of NW in improving functional walking capacity (distance and speed).

The results of this pilot trial indicate that, for an elderly mobility compromised population, NW was 106% more effective than OW in improving comfortable gait speed. The relative efficacy of NW in improving speed is explained by the fact that NW had a statistically significant and clinically meaningful effect in changing gait speed, whereas OW had no effect, as the confidence interval for gait speed mean change in this group included zero.

One explanation for the significant increase in speed for the NW group is that the poles may act as a force transmitter, propelling the lower limbs and the body forward more effectively. NW also stimulates an increase in arms swing adding

Table II. Walking endurance and comfortable gait speed before and after intervention.

	Nordic walking (n = 13)				Overground walking (n = 13)			
Measures	Mean	SD	Range	95% CI	Mean	SD	Range	95% CI
6-min walk test (m)								
Pre	202	84	(120–460)		217	76	(115–367)	
Post	247	80	(135–474)		258	84	(140–460)	
Change	45	49		(14, 74)	41	49		(11, 71)
5-m walk test (m/s)								
Pre	0.652	0.21	(0.41–1.19)		0.676	0.22	(0.31–0.93)	
Post	0.796	0.18	(0.54–1.23)		0.750	0.26	(0.14–0.91)	
Change	0.144	0.22		(0.08, 0.3)	0.074	0.18		(−0.04, 0.2)

CI, confidence interval.

Table III. Balance, leg function, and pain levels before and after intervention (explanatory variables).

	Nordic walking (n = 13)				Overground walking (n = 13)			
Measure	Mean	SD	Range	95% CI	Mean	SD	Range	95% CI
Berg balance scale (0/56)								
Pre	44	5	(38–55)		39	6	(34–56)	
Post	46	5	(39–56)		46	5	(38–56)	
Change	2	6		(0.4, 8)	7	6		(3, 10)
LEFS (0–80)								
Pre	38	11	(18–53)		38	15	(18–64)	
Post	36	11	(20–60)		39	15	(23–60)	
Change	−2	9		(−6, 3)	1	6		(−0.6, 7)
Pain (VAS-0/100)								
Pre	13	20	(0–60)		15	13	(0–40)	
Post	17	20	(0–50)		22	18	(0–50)	
Change	4	18		(−7, 15)	7	20		(−6, 17)

CI, confidence interval; LEFS, lower extremity functional scale; VAS, visual analogue scale.

Table IV. Interventions' effects size and relative efficacy (ratio between nordic walking and overground walking effects size).

Measure	Effect size of nordic walking	Effect size of overground walking	Relative efficacy
6-min walk test (m)	0.53	0.53	1.00
Comfortable gait speed (s)	0.68	0.33	2.06

additional forward momentum. The combination of a larger step length and a more pronounced arms swing, in contrast to the shuffling gait seen in many seniors, would have a positive effect on gait speed. Participants practicing NW on a regular basis learned and incorporated the technique in their daily lives, which subsequently was translated into greater function even when not using the poles. This is congruent with the results from Wilson *et al.* [20].

When compared to regular walking, numerous authors [18,19,21–23] state that NW is a more efficient and powerful way of walking because it promotes increased oxygen consumption. Kukkonen *et al.* [24] had shown that NW leads to greater workload without an increase in the level of exertion. This difference in intensity between walking activities may be the mechanism that triggered the change seen among NW participants. In addition, as stated by Church *et al.* [19], seniors would be able to exercise longer and harder in comparison to traditional walking methods. This finding on exercise intensity is congruent with a meta-analysis by Lopopolo *et al.* [18], in which high-intensity exercise had a significant effect on gait speed, in contrast to the lack of effect for moderate- and low-intensity exercise or for low-dosage exercise. OW, as performed in our study, was not intensive enough to promote gains in gait speed.

Despite the increase in gait speed experienced by the NW participants reached the minimum clinical significance [38], their gait speed at the end of the study was, on average, 0.79 m/s, a value that is still slower than the minimum needed for safe community ambulation, defined as 0.8–1.2 m/s [39]. Thus, to stimulate greater gains in the clinical setting, either the NW technique should be performed more than twice a week, or it should be combined with other rehabilitations strategies.

In contrast to the effect on gait speed, the improvements in the 6MWT were similar in both groups; thus these two techniques were equally effective in improving endurance. In both groups, the confidence intervals for the change in the 6MWT were statistically significant but with a wide confidence interval due to the small sample size.

As we measured walking endurance via a submaximal text (6MWT) our results cannot be compared with those using maximal oxygen consumption [10,40–43]. In other studies [44–47], however, changes in walking distance are similar, or a little superior, to the 41 and 45 m obtained here. Nevertheless, in those studies the intervention was longer and more frequent. Despite having smaller changes than what was observed in other studies [44–47], the change of 41 and 45 m in the 6MWT was greater than we initially expected.

Perera *et al.* [38] estimated 20 m being the small meaningful change for 6MWT performed by seniors. In our study, the mean (45 m for the NW and 41 m for the OW) and the upper limit (74 for the NW group and 71 for the OW group) of the two-sided 95% CI are greater than the meaningful change, therefore, according to Kieser & Hauschke [48], these estimates are considered as "probably clinically significant". The gains observed in the 6MWT of both groups are likely due to the enhanced walking practice, which was equivalent to an additional 40 min per week. In our preparatory work, walking practice in the rehabilitation centers was estimated to last 4–10 min during a therapy session. Based on the concept of training specificity, to achieve improvements in walking endurance, patients/clients need to walk longer and more often.

We hypothesized that NW would be at least 20% more effective than OW in improving gait speed and endurance. However, this hypothesis has been confirmed only for gait speed. For NW to be 20% more effective in improving endurance, a change of 54 m, 9 m beyond than what was observed, was necessary.

We believe that, to be able to observe this degree of change in the 6MWT, the intervention should be delivered in a higher dose (more than 20 min per week) or, if under the same circumstances, the 2MWT, rather than the 6MWT, should be used.

This conclusion is based on our observation of gait speed across tests. NW participants showed, on average, a gait speed of 0.79 m/s in the 5-meter walk test (5MWT) and an average gait speed of only 0.68 m/s during the 6MWT. This difference in speed is explained by the fact that the 5MWT is a very short test, lasting no more than 10 s. Therefore, it is able to capture changes in speed as participants are able to walk fast for a short period of time. On the other hand, when seniors are asked to walk for a longer period (6 min), they might even start the test with a speed of 0.79 m/s, but after a while, to be able to finish the test, they have to adjust their pace by slowing it down. This adjustment in pace will negatively affect the total distance walked. Thus, to better capture changes in distance walked in a senior population, a 2MWT is a better option.

The use of the poles did not increase shoulder or arm pain or disability in the legs, which is a positive finding given that many elderly people have concomitant arthritis and the use of the arms in the walking exercise could increase shoulder pain. There were statistically significant changes on the Berg balance score among subjects in both groups, owing most likely to the interventions carried out as part of the regular rehabilitation program. Changes on balance, however, were small and not clinically meaningful indicating that change in gait speed cannot be attributed solely to a change in balance. Because the 95% CI for the change was similar for both groups, it might appear that the OW participants had greater improvements on their balance. This could be explained by the fact that these participants had lower baseline values on the Berg balance scale and thus, had more room for improvement.

In addition to the abovementioned findings, the cost-effectiveness and acceptability of NW are two other reasons that would justify its implementation in a geriatric rehabilitation program. The cost of a set of NW poles is minimal, ranging from 40 to 100 dollars depending on hand grip, materials, and height options. As some poles are height adjustable, this would represents a minimal investment for a rehabilitation unit. Comments on the acceptability of NW from the NW participants indicated the training was greatly enjoyed. Participants felt they were using sport-related equipment rather than disability focused assistive devices such as canes and walkers. Some participants went as further as to state they would now go outside using the poles but would not do so with a walker. This information is consistent with that reported by others [25–27,49].

The duration of the intervention, that is 6 weeks, was determined to accommodate the logistics and dynamics of both participating centers, in which patients are discharged upon completing 8 weeks of formal physical rehabilitation. A lengthier intervention could have resulted in drop-outs. Another reason for the 6-week duration was cost. This was a pilot trial, with a low budget, designed to test safety and efficacy.

Although the CIs around the change estimates are wide, these findings can be used to design larger trial to estimate the impact of NW on gait speed, mobility, community participation, and quality of life of persons with or at risk for frailty. Intervention length, frequency, and duration can also be reassessed. In this future large-sampled randomized controlled trial, confirmatory outcomes would be comfortable gait speed and walking endurance, measured respectively by the 5MWT and the 2MWT; explanatory outcomes would potentially be step length, cadence, pain, lower extremity function, and balance; exploratory variables would be fear of falling, quality of life, and health status.

Potential limitations

As in any study there were a number of limitations, the main one being its pilot nature with a small sample size. However, as per Sacket & Cook [50], we can definitely learn from small studies, as the effect sizes of this study demonstrated. The frequency and duration of the intervention were shorter than optimal and varied depending on the duration of stay in the rehabilitation setting, which was outside the control of the study. Finally, without a post-intervention follow-up, maintenance of gains is unmeasured. However, the data from this pilot study is more than adequate to motivate a larger randomized clinical trial to estimate the change in each outcome. In the original protocol, we had planned an intention-to-treat analysis. This would require imputation for missing data which assumes that data are missing at random or completely at random which was not the case here. Hence, for this pilot, we conducted only a per protocol analysis.

Conclusion

Among a mobility-challenged elderly population, NW and OW are as effective in improving endurance. However, NW is 106% more effective in improving gait speed than OW. Moreover NW is a safe, feasible and enjoyable technique. Therapists may want to add NW to a comprehensive rehabilitation program to improve mobility outcomes in the elderly.

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