Exploring the benefits and barriers to Nordic walking in people with Parkinson's disease: a feasibility study

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ABSTRACT

Background: Nordic walking (NW) has shown promising outcomes for people with Parkinson's disease (PwP). **Aims:** To explore the feasibility of the implementation of NW programmes for PwP in the NHS. **Methods:** A literature review and feasibility study were conducted. PwP joined an 8-week NW programme. Attendance and measures of mobility (Timed Up and Go (TUG), 10-metre walk test (10MWT) and quality of life (QoL) (PD non-motor questionnaire) were recorded pre- and post-intervention. Barriers, facilitators and cost were recorded. **Findings:** Eight studies indicated that NW is superior to walking and flexibility/relaxation exercise, with improvements in postural stability and gait. Nine of 10 participants completed the intervention with improvements in mobility (0.16 seconds faster (TUG), 1.27 seconds faster (10MWT) and QoL (better sleep, pain management, constipation, mood, exercising outside) after the intervention. Cost was recorded as £6.50 per participant per session, with no adverse events. **Conclusions:** NW programmes can be safely delivered in the NHS, in partnership with British Nordic walking.

Keywords Nordic walking; Parkinson's disease; motor symptoms

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Nordic walking (NW) was established in the 1930s, when Finnish cross-country skiers used their poles for summer training, with the acronym NW coined in 1997. Evidence suggests a beneficial effect for people with Parkinson's disease (PwP) from NW in improving posture, gait and stability. In a questionnaire aimed at regular Nordic walkers, (Stevinson and Brown, 2019) 411 people responded that NW was a form of exercise that was beneficial, well tolerated and sustainable over many years. It is enjoyed by people with a wide range of long-term health conditions and advancing age, who were reported to be healthier and happier than their age-matched peers (Stevinson and Brown, 2019). Spending time outdoors was the largest reported benefit, with fitness, mental wellbeing and weight management scoring highly. The same study recorded perceived barriers, although at lower rates than identified benefits; time, cost, weather, health and transport to the venue were cited. NW has been endorsed by Parkinson's UK (www. parkinsons.org.uk) and British Nordic Walking (www.britishnordicwalking.org.uk), but there is little research to guide implementation of NW in the NHS or social care settings. Additionally, there are barriers to NW for PwP, such as the cost of poles, the availability of specialist training, time, the stigma of using two poles and it being predominantly a female activity (Stevinson and Brown, 2019). In 2014, a British woman with Parkinson's disease started the first UK NW group for PwP. In 2019, Parkinson's UK and British Nordic walking established an early pilot phase site in Nottinghamshire and trained the first NHS PD nurse in the country as an accredited NW instructor (SM).

Aims

The aims of the present study were to explore the barriers and facilitators to PwP taking up NW, to discover any indication of effectiveness and inform implementation in the NHS. The research questions are:

- Does NW influence mobility in PwP?
- Does NW improve wellbeing?
- What are the barriers to NW?

Methods

This study was carried out in line with the UK government COVID-19 guidelines, both clinical and non-clinical. It is a mixed-methods feasibility study using quantitative data from physical outcome measures and qualitative questionnaires. The data collection period was 10 weeks, with 8 weeks of NW intervention.

A literature review was completed to inform the pre- and post-intervention study. For this paper, the methods

for both stages are presented before the results. Ethical approval was given by the University of Nottingham.

Literature review

The scoping literature review of international research was completed with the following search terms: 'NW', 'PD', 'exercise' and 'mobility'. The following databases were searched from 2008 to 2020: PubMed, CINAHL and the Cochrane Library. Randomised controlled trials, cohort studies and systematic reviews were included. Nine papers were reviewed; one was excluded because the intervention was not delivered using the correct International Nordic walking Federation (INWA) technique, leaving eight studies in the final review.

Participant recruitment

No participants were recruited until all necessary/ethical approvals were in place.

The participants were recruited via two sources: local PD UK social groups and neuro-physiotherapists. The lead researcher (SM) presented the study at PD branch meetings, where leaflets were distributed, and anyone who wanted to take part contacted the research team with their details. The researcher made contact with potential participants and sent them the participant information sheet. The participants met SM to complete the consent and provided their details, including name, age, time since diagnosis, gender, ethnicity, address and email address, to help in defining the sample and to remain in contact with the researcher. Demographic details were collected, but patients' identifiable data was removed. Each participant was assigned a letter (A–I). Consent was given for the use of photographs in this article.

Intervention

Participants were invited to eight (1 hour) sessions of NW at the University of Nottingham campus, led by SM, a PD nurse specialist and trained PD NW instructor. No individual advice was given about medications, but general advice regarding Parkinson's symptoms, management, exercise and lifestyle were offered. Each class included a series of warm-up exercises, instruction on the use of the NW poles and a step-by-step guide to the ten steps of NW, as per the International NW Association guidelines (inwa-nordicwalking.com). Walking with the group included warm-up exercises; specific drills to improve technique, arm swing, good posture and stride length; a guided Nordic walk; and cool down stretches. Classes were tailored to the group's ability and endurance levels. Individual support and advice was given regarding NW technique and the safety of the group was maintained, including weekly emails to remind participants to bring a hat, sun cream, water and their medication. Walking shoes were advised for most surfaces, but the intervention also included experimentation with various terrains, including short grass, longer grass, tarmac and sand. Videos of the participants were used to aid teaching.

The cost of delivering the NW programme was calculated and included the instructor's time and travel, equipment, telephone calls, leaflets and training. There were additional costs due to the COVID-19 pandemic, including hand sanitising gels, clinical wipes and the purchase of additional poles so that each participant had an individual set of poles for the duration of the project. The originally planned larger group was spilt into two smaller groups to comply with government guidelines regarding group size and social distancing. Time taken by the instructor to deliver two sessions increased, as a morning and afternoon group was delivered.

Outcome measures

Participants completed the following standardised quantitative measurements at baseline and at the end of the eight sessions; this took 15–20 minutes to collect. Changes in mobility were assessed with the 10-Metre Walk Test (10MWT), which determines the time taken to walk 10 metres without a walking aid and the number of steps taken to walk 10 metres (Watson, 2002), and the Timed Up and Go (TUG) test (Podsiadlo et al, 1991), in which participants were asked to get out of their chair, walk 3 metres, turn, return 3 metres to the chair and sit down. Wellbeing was partially assessed using the validated and well-used Non-Motor Symptoms Questionnaire (NMSQ) (Chaudhuri et al, 2007) and through the field notes. This questionnaire consists of 30 questions, each answered yes or no. The questionnaire contains items relating to mood, falls, sleep, leg pain, constipation, weight, and so on. Field notes and informal comments were collected by the NW instructor during the classes and written up immediately after the session. They were not digitally recorded. The main conversation topics were barriers and facilitators to the NW programme, but also concerned how participants had coped with the lockdown.

Analysis and data storage

The studies from the literature review were analysed using a narrative approach. The participant sample was described as a group using their personal characteristics, but names and addresses were removed. Data from the outcome measures were stored on an Excel database and analysed using descriptive statistics (mean, median, ranges and standard deviation). Qualitative data from the field notes, non-motor questionnaire and a simple barriers/benefits questionnaire, devised from the literature, were transcribed and analysed using thematic analysis (Braun and Clarke, 2006). The data was checked by a second researcher; this is later presented as a word cloud and then woven into the assessment data

Figure 1. The Nordic walking group

to answer the research questions. Case studies from the NW instructor's field notes are presented.

Results

The literature search found eight randomised controlled trials. A comparative table of results can be seen in Appendix 1. It shows trends across the studies, with most using the same outcome measures: TUG, 10MWT and NMSQ score. These are standardised, published and validated tools, which the authors chose to replicate in the present study.

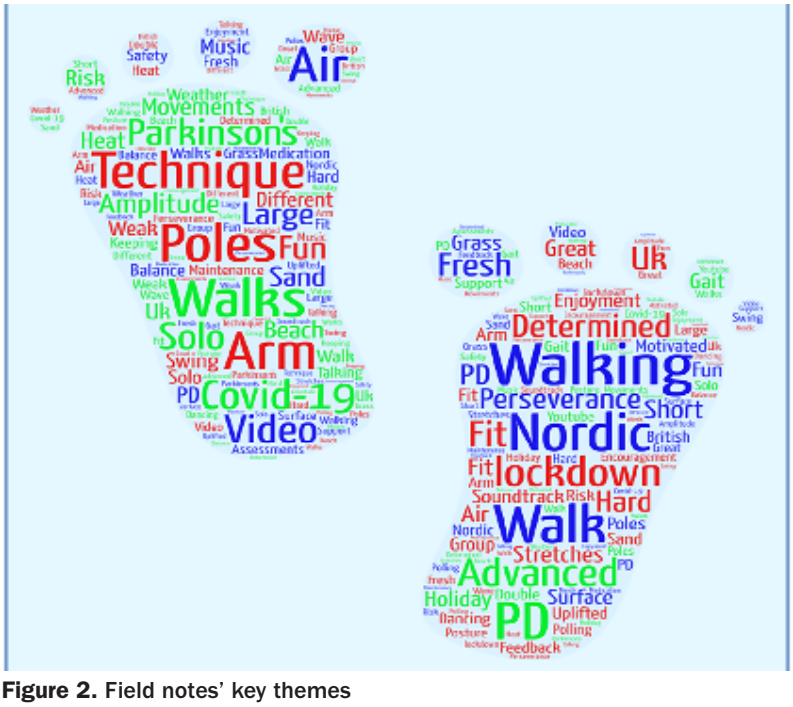

Figure 2. Field notes' key themes

In a Dutch study (van Eijkeren et al, 2008) where subjects were tested at baseline and after 6 weeks of bi-weekly NW intervention, and followed up with at 5 months, there were significant improvements in the 10MWT and TUG tests (Podsiadlo and Richardson, 1991) and in the quality of life questionnaire (PDQ-39) (Jenkinson et al, 1998). Positive results persisted up to the 5 month follow-up assessment. In one paper (Reuter et al, 2011), 90 participants were randomised to three different forms of exercise: flexibility exercises and relaxation, NW, or 'just walking'. Data suggested that NW was superior to the alternatives in improving stride length, gait and balance. Blake (2015) studied 10 participants who had PD and completed a NW programme over 8–10 weeks. Results indicated that NW improved walking ability, with signs of a positive impact on mental health (Blake, 2015). An Italian study (Cugusi, 2015) had similar findings, with improvements from baseline on the TUG test, NMSQ (Chaudhuri, 2007) scores and a 6-metre walk test.

The results of these studies provided an evidence base to the Nottingham feasibility study, with standardised outcome measures from larger clinical trials within the context of PD. The research team identified that the use of these standardised measures would facilitate further future expansion of the study within a different setting.

Feasibility study

Ten people with PD were recruited and consented to participate in the feasibility intervention study. Although eager to take part, one participant was excluded during pre-study health screening because of a disclosure of serious cardiac problems. The final group comprised of nine PwP (three women and six

Table 1. Participant characteristics and outcomes

Participant (age/years)	Baseline 10 m time	Final 10 m time	Baseline 10 m steps	Final 10 m steps	Baseline TUG time	Final TUG Time
A: 51	6.31	5.6 (0.71)	12	12	6.16	5.44 (0.72)
B: 74	7.5	6.4 (1.06)	13	12 (1)	8.19	7.94 (0.25)
C: 60	6.22	6.25 (-0.03)	14	11 (3)	6.62	6.97 (-0.35)
D: 64	6.07	6.53 (-0.46)	11	12 (-1)	6.44	6.91 (-0.47)
E: 62	19	12.09 (6.91)	20	19 (1)	15.32	22.38 (-7.06)
F: 58	7.22	6.9 (0.32)	15	14 (1)	9.21	7.32 (1.89)
G: 51	6.34	5.65 (0.69)	13	11 (2)	7.87	5.62 (2.25)
H: 60	6.18	5.03 (1.15)	13	12	6.47	5.44 (1.03)
I: 77	8.69	7.57 (1.12)	17	15 (2)	11.81	8.59 (3.22)
Mean: 62 years		127 secs		1 step		0.16 secs

men) (Figure 1). The mean age was 62 years, with a mean duration since diagnosis of 5 years. Quantitative outcome measure data are found in Table 1, with the field notes' key themes (high-frequency words) presented in a word cloud (Figure 2). These data highlight the participants' collective positivity: their determination, resilience, perseverance and mutual support. Some participants were also very honest about their struggles with mental health, low mood, anxieties, fear of falling and fear of the COVID-19 virus. Outcome measures, non-motor benefits and the key themes from the field notes have been merged in the text.

Theme 1. Benefits of Nordic walking

All nine participants attended and participated in the NW programme. Some 15 out of 16 planned NW sessions took place, with one cancelled due to a heatwave. Sessions still took place when there was rain forecast.

Participants commented that the benefits far outweighed the barriers. They enjoyed meeting at the university's sports field, and found that the venue was conducive to NW. The programme was conducted during a holiday period, and few people were around as a result. Participants reported that they felt safe from a COVID-19 risk perspective. Parking was free and the venue was easy to find. Coincidentally, three participants were university alumni and were pleased to be back at their former place of education. This could be noted as potential recruitment bias, as they were keen to participate in the research.

'The Nordic poles look sporty and I felt energised and stimulated after the classes.'
(Participant H)

Participants commented that they did not feel silly exercising as a group and enquired about buying their own poles, which can be taken as an indication that they wanted to continue to Nordic walk after the research intervention. Several participants stated that they planned to join a local NW group after the study finished. They specifically said that the poles helped them to maintain a better walking position, upright posture and a longer stride. One participant stated that two poles increased her confidence, while another reported that it took a lot of concentration to coordinate the technique; however, viewing a video of herself and her technique enabled her to see her improvement. People enjoyed exercising regularly in a group and reported the intervention to be a motivating factor.

'I'm not a great lover of exercise, but this is fun, especially in a group.'
(Participant H)

Most of the participants reported enjoyment and satisfaction at the end of each class and said they preferred exercising in the fresh air, rather than partaking in online exercise classes.

'It gives us a legitimate reason to meet together and to exercise when everybody else is stuck inside on Zoom!'
(Participant I)

Case study 1

During a NW session on a hot and humid afternoon, one participant (Figure 3), who could sometimes run when he could not walk, had a significant freezing episode. He took remedial action and was supported by other group members, highlighting the benefits

of peer group support. When asked whether he had enough 'fuel in the tank' (dopamine), he believed that he could run once his medication had taken effect. At this point, SM ran with him to catch up with the group and they reached the terminus first. This highlighted the requirement for a second instructor/INWA-trained physiotherapist/walk leader for larger groups with mixed abilities.

Theme 2: Nordic walking during a COVID-19 lockdown

The first UK lockdown occurred between 23 March and 1 July 2020, overlapping with this study. Field note data indicated that most participants continued to regularly exercise to overcome gaps in their usual routines. However, they preferred exercising outside rather than engaging in online classes. Figure 3 displays reported activities, with the most popular being walking outside. Several participants reported struggles with the early restrictions and social isolation. As a whole, the group reported an enjoyment of the NW classes because it gave them a reason to exercise outside. Notably, one female participant reported:

> 'It's good discipline to go every week; even if I feel tired, I always feel better afterwards.'
> (Participant H)

Participant A took her Nordic poles on holiday and practiced walking on the beach, occasionally with bare feet. People reported that walking on short grass provided improved pole traction and propulsion. Overall, participants reported a sense of fun and pleasure when combining listening to music with NW:

> 'The music was very motivating and uplifting, and it was a sunny day. It helped rhythm, coordination and pace.'
> (Participant A)

This finding suggests that the use of music can facilitate improved rhythm and pace in NW, while enhancing enjoyment.

The chart below is a summary of the exercise that the participants were engaging in during lockdown. Notably, one man (participant C) had tried a few taster sessions of NW, but was still eligible to join the research project.

Theme 3: barriers to Nordic walking

Figure 4 illustrates NW barriers and reflects participants' field note data. However, data suggests that these barriers diminished over time and were hardly mentioned in later field notes. Some participants reported a sense of self-consciousness, frailty and impairment because they used two 'sticks', with a reluctance to exercise alone or in a public area without a group. A perception that the technique would be difficult, due to suboptimal coordination and balance, was also reported. Wet grass and light rain hindered attendance, whereas others enjoyed the opportunity to exercise outside in the summer months with others in a COVID-safe, supportive, green space. Comorbidities and emerging memory problems were a barrier to one male participant perfecting the technique, but participation was facilitated and he enjoyed the sessions. Three people were afraid of falling, but reported that they felt the Nordic technique had helped them with balance, posture and gait.

Figure 3. A participant and park runner

Financial implications

The cost of this intervention was calculated by adding the cost of the instructor's time (one day per week; band 7 Parkinson's nurse specialist) and a proportion of the training cost (British Nordic Walking), the proportion of the cost of equipment (10 sets of poles at £50 per pair) and the cost of the venue, which was then divided by the number of participation (n=9).

Using these calculations, it is estimated that, if the NHS were to provide this intervention, it would cost £12–£15 per person per session. Research participants were not charged for participation; if they subsequently attend an established NW group, they could pay £6.50 per hour (this excluded pole purchase of between £50–£140).

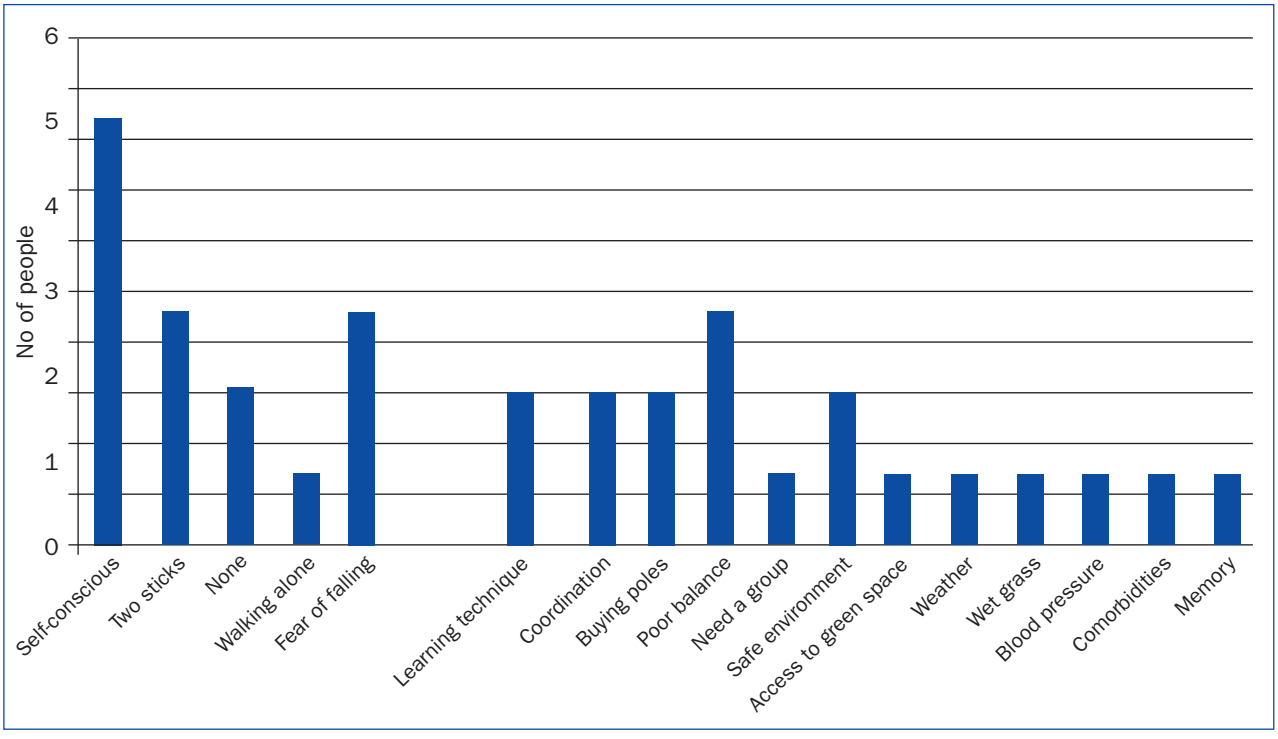

Figure 4. Barriers to Nordic walking

Outcomes: the effect of Nordic walking on mobility and general wellbeing

All participants completed the outcome measures at the start and end of the programme and contributed to the field notes. Seven participants improved on the 10MWT and were faster walkers after the intervention. Later analysis suggested that 10MWT might not be useful as a short-term walking speed measure, but it might produce useful long-term data, perhaps at 6 or 9 months. Most participants improved their times on the TUG test over a distance of 3 metres. Data for all participants is shown in Table 1; these include mean scores for the 10MWT, number of steps and TUG. The numbers in brackets reflect the difference between the baseline and final scores after 8 weeks of NW instruction.

The greatest improvement overall was from the oldest participant (I), at 77 years of age. She was generally very slow in class, but made the most significant improvement in all outcome measures: 3.22 seconds faster during the TUG test, which equals an 27.3% improvement. In the field notes, this participant reported improvements in lower back pain from the regular NW sessions. There was a small overall improvement in the 10MWT, due to significant gains by participant E. He did very well walking in a straight line, but struggled with TUG due to his self-declared cognitive decline and difficulty following instruction. The youngest male (participant G), at 51 years of age, also showed improvement in the TUG test, being 28% faster after 8 weeks of intervention. One participant (male, participant F) reported stumbles and falls at home. He enjoyed the class and improved in all three domains, with a TUG improvement of 21%. He reported that the programme motivated him to exercise on his own, and that he would continue to use his poles after the intervention. One participant (participant E) struggled to follow the instructions, had low blood pressure and was prone to fainting. His wife joined the classes and supported him for his safety, highlighting the benefits of family involvement.

Discussion

The key findings of this study were that PwP were happy to take part this type of study and especially enjoyed the NW programme, even in poor weather. All participants reported a sense of fun, with a positive impact on their health and mobility; all were eager to carry on with NW. Outcome measure data reinforces participant qualitative field note data. Finally, most mobility and quality of life scores improved over time. NW is a relatively low-cost outdoor activity on a pay-as-you-go basis and has the potential to attract low-income or hard-to-reach communities through the absence of membership fees. There is potential for partnership with Parkinson's UK and British Nordic Walking to facilitate widespread access to NW opportunities.

The results from this study are in line with the results from studies by Blake (2015), Cugusi (2017) and Monteiro (2017), which also showed improvements in walking speed, stride length and non-motor symptoms. The results add to the literature, alongside the findings of Stevinson and Brown (2019), regarding the benefits of and barriers to NW.

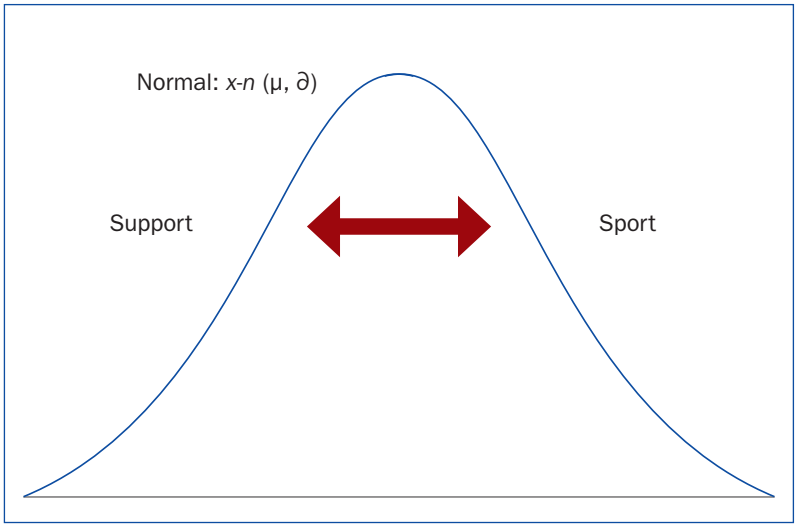

Figure 5. 'Support' to 'sport'

Strengths and limitations

The main limitation from this study was that the outcome measures and field notes were collected by the NW instructor, who also provided the intervention; this holds the potential for positive bias reporting. However, this risk was mitigated by the use of quantitative and standardised outcome measures, which were collected by the lead researcher and a research assistant with the use of published guidelines. Future research should use a blinded researcher. Another limitation was the small sample size, which means that outcome measure generalisability could be compromised.

KEY POINTS

- Nordic walking is well tolerated by people with Parkinson's disease. It is an enjoyable outdoor sport that is relatively affordable, accessible and safe in a post-COVID context
- Nordic walking has been shown to be beneficial to those with Parkinson's, due to improvements in gait, stride length and speed of walking
- There are promising non-motor benefits that might include improvements in sleep, pain (in particular, lower back pain), constipation and mood
- There may be cost benefits to the NHS regarding falls reduction and improved mental health.

CPD REFLECTIVE QUESTIONS

- Do people with Parkinson's disease have access to Nordic walking in your area? If not, what might you do in your practice to facilitate this?
- Given the benefits demonstrated in this research, is Nordic walking something you might suggest to your patients?

A further limitation was that balance and posture outcome measures were not recorded. Future studies should consider such measures, as most participants reported improvements in both domains. Due to the nature of study funding, repeat measures were taken within a short period after the intervention. Future studies should consider a longer term follow-up at 6 and 9 months.

A significant study strength was the recruitment pathway, which was via routine PD groups and NHS services. Provided that the instructor is INWA-trained, this improves the result's generalisability to other NHS settings and appropriate patient groups. Importantly, findings also highlight the necessity for a second trained instructor (NW instructor, walk leader or a NW-trained physiotherapist). The purpose of this additional presence would be to help assess exercise suitability and safety, data collection and group safety.

It is possible that the reported benefits could have occurred as the result of other activities, including advice given within the NW classes. However, the authors consider that the results are useful for people considering setting up a NW group or researchers, adding to other small studies, thus building a foundation to a large randomised controlled trial of NW provided by the NHS.

Another significant strength was that a patient and public involvement representative joined the project. He attended most of the NW classes and was an active member of the project team, offering first-hand experience and critique. He understood the bigger picture and the whole person approach, connecting time spent outdoors and structured exercise to benefit mind and body.

Future implementation and research

Using the results of this study, the research team plan to implement an 8-week rolling programme of NW at the University of Nottingham, working collaboratively with an NHS PD nurse specialist, a physiotherapist and a second NW instructor/walk leader. Participants will be recruited through the local PD branches, physiotherapy colleagues, social prescribing and GPs. Regarding issues with medical and cognitive fitness in learning new techniques and exercises, before engaging in classes, all participants will be assessed using bespoke measures, including postural blood pressure, pulse, oxygen levels, medical/cognitive history, medication history and the Physical Activity Readiness Questionnaire (PAR-Q) (British Columbia Ministry of Health and Multidisciplinary Board on Exercise, 1992). Participants will also benefit from one-to-one technique coaching sessions. In the event of inclement weather, the NW class could be available indoors. Signposting and referral to existing NW programmes (not necessarily PD-specific) at the end of the session will be made, to assist ongoing engagement. Separate

classes for different ability groups will be offered. The same outcome measures will be taken following the intervention, with the addition of balance, using the Berg Balance Scale (Berg et al, 1989), and posture, using the Tragus measurement (Haywood et al, 2004). A 6- and 9-month assessment to check for longer-term effects and engagement will be completed. Once the programme is embedded, we will consider a clinical and economic evaluation in a randomised controlled trial.

Another consideration is whether NW would be effective at reducing the impact of Long COVID, due to the physical and mental health benefits of exercising in a small group outdoors. This would certainly be a novel and timely piece of research, as the COVID-19 pandemic has had a seismic impact upon PwP and their families. Helmich and Bloem (2020) describe the hidden sorrows and emerging opportunities to deliver a different model of Parkinson's service. Technological innovation and outdoor exercise appear to be promising interventions. Figure 5 illustrates the rationale behind the therapeutic benefit of outdoor exercise, especially to those with long-term health conditions, with 'sport' and 'support' theory becoming inextricably linked (Carver-Richardson et al, 2019). In light of the COVID-19 restrictions, which may again be imposed, data suggests NW to be a safe outdoor sport that can be performed in small, socially distanced groups.

Conclusion

This feasibility study provides evidence that NW can be delivered with success by the NHS at relatively low cost per participant. The objective of the recommendations made is to assist clinicians, researchers and policymakers in the formation and delivery of PD services. However, once NW has been implemented as part of a management programme, it will be essential to complete a more comprehensive and larger trial to evaluate clinical and cost effectiveness. BJNN

Appendix 1. Competitive key research papers

Authors and type of research	Country	Number and grouping of participants	Level of disability (H&Y)	Duration of NW	Comparator	Main findings
Bang and Shin (2017) Intensive NW intervention on the balance function and walking ability of individuals with PD: an RCT	Republic of Korea	20: 10 NW 10 TT	1–3	60 minutes Five times/ week 4 weeks	Treadmill training (NW was carried out on treadmill)	All outcomes improved Significant improvement of NW over treadmill in UPDRS, BBS, 10mWT, TUG, 6MWT
Monteiro et al (2016) NW training on functional parameters in PD: an RCT	Brazil	33: 16 NW 17 FW	1–4	35–50 minutes Two times/ week 6 weeks	Free walking	All outcomes improved. NW significantly more improvement in TUGSS, TUGFS, SWS
Cugusi et al (2015) Effects of an NW programme on motor and non-motor symptoms, functional performance and body composition in patients with PD	Italy	20: 10 NW 10 control	1–3	60 minutes Two times/ week 12 weeks	Conventional care/ no exercise	NW group showed significant improvement in all tests: motor symptoms; UPDRS-III H&Y scale; functional performance; 6MWT; FTSST; HGT; BBS; TUG; SRT; BST; anthropometric profile and body composition; QOL and non-motor symptoms; PFS-16; BDI-II; SAS; NMSS

Appendix 1. Competitive key research papers

Authors and type of research	Country	Number and grouping of participants	Level of disability (H&Y)	Duration of NW	Comparator	Main findings
Ebersbach et al (2010) Comparing exercise in PD: the Berlin LSVT® BIG study Ebersbach et al (2014) Impact of physical exercise on reaction time in patients with PD	Germany	58: 19 NW 20 LSVT BIG 19 Home	1–3	NW: 60 min Two times/ week 8 weeks LSVT: 60 min, Four times/ week 4 weeks Home: 4 weeks	LSVT BIG and similar home exercise programme	UPDRS improved by LSVT BIG and mild deterioration in NW group LSVT BIG superior to NW in TUG and 10mWT. No sig difference in QOL. Sig difference in cRT between LSVT BIG group and home group and between NW group and home group. No significant difference between LSVT BIG and NW in cRT
Reuter et al (2011) Effects of a flexibility and relaxation programme, walking, and NW on PD	Germany	90: 30 NW 30 F&R 30 W	2–3	70 minutes Three times/ week 24 weeks	Walking Flexibility and relaxation	Reduction of pain and improvement in QOL. Walking and NW significantly improved stride length, gait variability, 12mWT, 24mWT, MWS at exercise test, and UPDRS-III score. NW was superior to the F&R and W in improving postural stability, stride length, gait pattern and gait variability
Monteiro et al (2016) NW training on functional parameters in PD: a RCT	Brazil	14	1–4	60 minutes Two times/ week 9 weeks	Free walking	NW superior to free walking in improving TUG and SSW
Van Eijkeren et al (2008) NW improves mobility in PD	Netherlands	19 10 NW 9 NW + 5 month retest	1–3	60 min Two times/ week 6 weeks	Baseline, 6 weeks and 5 month follow-up	Significant improvement in 10mWT, TUG, 6minWT and QOL (PDQ-39) in NW arm. Improvements persisted in follow-up testing after 5 months

Key to outcome measures and terms

Hoehn & Yahr stage (H&Y)
Unified Parkinson's disease rating scale (UPDRS)
6 minute walking test (6MWT)
10-metre walking test (10MWT)
Timed up and go test (TUG)
Sit to stand performance (STS)
12-metre walking test (12MWT)
24-metre walking test (24MWT)
Five time sit to stand test (FTSST)
Hand grip-strength evaluation (HGT)
Sit and reach Test (RST)
Back scratch test (BST)
Self-selected speed (SSW)
Locomotor rehabilitation index (LRI)
Parkinson's disease (PD)
PD quality 39 (PDQ-39)
Berg balance scale (BBS)
Parkinson's fatigue scale (PFS)
Beck depression inventory (BDI)
Starkstein apathy scale (SAS)
Non-motor symptoms scale (NMSS)
Quality of life (QOL)

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Note: The outcome data used to support the findings in this study are available from the author upon request.

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