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Short communication

Gait velocity and step length at baseline predict outcome of Nordic walking training in patients with Parkinson's disease

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ABSTRACT

Background: The impact of Nordic walking (NW) in Parkinson's disease (PD) has been investigated in several studies but results are inconsistent. This may be due to different cohorts studied and the heterogeneity of their PD symptoms which impact the outcome of NW. This study aimed at determining predictive factors for a positive effect of NW on PD.

Methodology and principal findings: Primary outcome was to define the baseline disease-associated and demographic parameters that distinguish patients who demonstrate improvement in the Unified PD rating scale (UPDRS) motor part following NW training ("U^+") from those patients with no improvement after the same intervention ("U^-"). The potentially predictive parameters were: age, age at onset, disease duration, gait velocity, step length, daily step number, UPDRS-motor part, Berg-Balance-Scale, Parkinson-Neuropsychometric-Dementia-Assessment, verbal-fluency-test and Becks-Depression-Inventory-II. Twenty-two PD patients (H&Y stage 2–2.5) performed twelve weeks of NW training. Eighteen patients were included in the final analysis. Overall, the UPDRS motor part did not improve significantly; however, eight patients had an improvement in the UPDRS motor part from baseline to end of study (U^+). When comparing the potentially predictive factors of the U^+ cohort with those ten patients who did not improve (U^-), there was a notable difference in gait velocity and step length, and showed a significant correlation with an improvement in the UDPRS motor part scores.

Conclusion: Gait velocity and step length can predict the outcome of NW training as determined by the UPDRS motor part, indicating that PD patients with only slightly impaired gait performance benefit most.

1. Introduction

Physical activity has positive effects in general and also in patients with Parkinson's disease (PD).

Nordic walking (also called pole walking) is regarded as an endurance sport. The cyclical motion sequences share similarities with cross-country skiing: Fast walking is supported by two poles. Every time the left heel touches the ground, the right pole should hit the ground, and vice versa. Nordic walking (NW) is a particularly appealing physical activity as it takes place outdoors, can be performed almost everywhere and is safe. The effect of NW in PD patients has been investigated in several studies [1–6]; however results regarding whether PD patients benefit from NW or not are inconsistent. For example, whereas two studies [1,5] found positive effects using the best-accepted outcome measure of PD motor symptoms (the motor part of the Unified PD rating scale (UPDRS)), another study did not [3]. This might, at least partly, be due to differences in the cohorts studied and the heterogeneity of their PD. Based on the wish to develop a more "personalized" treatment

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regimen for chronic diseases including PD [7], we designed this study to determine whether specific demographic, motor, cognitive and behavioral parameters predict a clinical improvement as measured with the UPDRS motor part.

2. Patient and methods

2.1. Ethics

The study protocol was approved by the ethical committee of the University of Tübingen, and all subjects provided written informed consent.

2.2. Subjects

Thirty-four patients were recruited from the neurological outpatient clinic of the University of Tübingen and by newspaper advertisement. Twenty-two met the inclusion criteria and were included in the baseline assessment. They all fulfilled the UK Brain Bank criteria for PD [8], and had an akinetic-rigid or equivalent subtype of PD. Inclusion criteria were walking without assistance, >10 points on the UPDRS motor part during the medication OFF phase, improvement of at least 20 percent of the UPDRS motor part after medication intake, Hoehn and Yahr stage of 2 or 2.5, Schwab and England scale >50%, no previous experience with NW and less than 1.5 h exercise activity per week. Exclusion criteria were: history and presence of concurrent conditions which would influence NW training performance (e.g., musculoskeletal, psychiatric problems, dementia).

3. Assessment

All tests took place in the "OFF" state, i.e. at least twelve hours after the last dose of PD medication. UPDRS motor part was assessed at BL and after twelve weeks of NW.

To determine baseline predictive factors, we assessed age, age at onset, disease duration, Berg Balance Scale (BBS), Parkinson neuropsychometric dementia assessment (PANDA), the verbal fluency test (patients were asked to generate as many S-words as possible during one minute) and the Becks Depression Inventory II (BDI II).

In addition, we performed quantitative testing of gait velocity and step length. The participants were instructed to walk along a six meter path at a comfortable pace in our designated test laboratory. Gait parameters were measured with 6 infrared cameras and a Plug-In-Gait marker placement set, consisting of 39 anatomic markers (VICON®, Oxford Metrics, Oxford, UK). We also calculated the number of steps per day during the study period with a pedometer (*Silva*, Bromma, Sweden) that the subjects wore on the hip. Table 1 provides a summary of these parameters.

All study participants performed three training sessions per week lasting approximately one hour each, for a total of twelve weeks. Two sessions per week were led by a professional NW trainer; the third session was performed without a trainer.

We separated the cohort in two groups A (n = 10) and B (n = 8). Group A trained first, during that time group B received no training and was designated as the control group. At 12 weeks group B started the training sessions.

4. Data analysis and statistics

Data were analyzed with SPSS 22 for Windows (SPSS Inc, Chicago, IL, USA). Because we used primarily ordinal data in this analysis we used median and range to present these data. Significance levels were calculated with the Wilcoxon signed rank or the Mann–Whitney-U tests, and the Spearman's rank correlation coefficient. The decision to use these tests was based on the small numbers of subjects and the fact that almost none of the variables were distributed normally. The uncorrected alpha level was set at P = 0.05 based on the exploratory nature of this study. However, for the correlation coefficient, we also present significance levels after Bonferroni correction because of multiple testing.

5. Results

Of the 22 study participants who were initially included, two had to change their Parkinson's medication during the training period, and 2 missed more than one session per week. Thus we were able to include the data of 18 study participants in the final analysis. Overall, the cohort as a whole showed no significant difference in the UPDRS motor part at BL and post training (BL: 30 (15–44), post training: 27 (13–47)|median (range), P = 0.30), (Table 1). Similar results were found for the controls (group B during the first 12 weeks, BL: 27 (17–40), pre training: 27 (15–44), P = 0.87).

8 study participants (from now on referred to as U^+ cohort), however, did improve from BL to the end of the study (2–13 points), 10 participants (U^-) did not improve (−8 to 0 points).

At BL, the UPDRS motor part of the U^+ BL 27 (17–37) and the U^- BL: 31 (15–44) cohorts did not differ significantly (P = 0.408) but, as expected, was significantly different at the end of the study (post training U^+: 20 (13–30)|U^-: 34 (18–44), P = 0.002), (Table 1). When comparing the potentially predictive factors between U^+ and U^-, gait velocity (uncorrected P = 0.02) and step length

Table 1
Baseline clinical and demographical data, and comparison of potentially predictive factors for a good outcome after a standardized Nordic walking training. For significantly different measures and UPDRS motor part also post training (pT) values are shown.

	Whole cohort [N = 18] median (range)	U^+ [N = 8] median (range)	U^- [N = 10] median (range)	Mann-Whitey-U test U^+/U^- (P value)
Age at onset [Y]	67 (55–75)	68 (55–73)	60 (50–68)	0.114
Disease duration [Y]	3 (0–16)	3 (0–7)	5 (1–16)	0.236
Age [Y]	63 (50–73)	73 (55–75)	66 (58–73)	0.274
Steps per day [N]	4550 (1094–11,982)	5066 (2710–7000)	3272 (1094–11,982)	0.364
UPDRS motor part (0–108)	30 (15–44)	27 (17–37)	31 (15–44)	0.408
	pT:27 (13–47)	pT:20 (13–30)	pT:34 (18–44)	pT:0.002
BBS (0–56)	54 (44–56)	54 (46–56)	52 (44–56)	0.573
verbal fluency [N]	13 (7–24)	13 (7–24)	12 (8–19)	0.633
PANDA (0–30)	25 (9–30)	25 (9–29)	22.5 (16–30)	1.000
BDI II (0–63)	8 (1–24)	5 (1–15)	8 (4–24)	0.315
Gait velocity [m/s]	1.19 (0.95–1.63)	1.27 (1.08–1.63)	1.09 (0.95–1.29)	0.021
	pT:1.19 (0.92–1.67)	pT:1.36 (1.00–1.67)	pT:1.12 (0.92–1.36)	pT:0.08
Step length [mm]	622 (500–767)	650 (544–767)	587 (500–662)	0.043
	pT:607 (504–768)	pT:661 (504–768)	pT:575 (515–658)	pT:0.15

Demographic, motor, cognitive and behavioral parameters from the baseline assessment are presented with respect to − improvement (U^+) or lack of improvement (U^-) on the Unified Parkinson's disease rating scale (UPDRS) motor part after a standardized 12 weeks Nordic walking training. BBS, Berg Balance Scale; BDI, Becks Depression Inventory; .m/s, meter per second; mm, millimeter; N, number; PANDA, Parkinson Neuropsychometric Dementia Assessment; UPDRS, Unified Parkinson's Disease Rating Scale, y, years.