ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2015;96:735-41

BRIEF REPORT

Parkinsonian Gait Ameliorated With a Moving Handrail, Not With a Banister

Ely Rabin, PhD,[a] Aleksandr Demin, DO,[a] Stefania Pirrotta, DO,[a] Jason Chen, DO,[b] Hemal Patel, DO,[a] Ankur Bhambri, DO,[a] Estella Noyola, DO,[a] James R. Lackner, PhD,[c] Paul DiZio, PhD,[c] Joanne DiFrancisco-Donoghue, PhD,[d] William Werner, PT, EdD[e]

From the [a]Department of Biomedical Sciences, New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY; [b]Baylor College of Medicine, Physical Medicine and Rehabilitation, Houston, TX; [c]Ashton Graybiel Spatial Orientation Laboratory, Brandeis University, Waltham, MA; [d]Department of Osteopathic Manual Manipulation, New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY; and [e]Department of Physical Therapy, New York Institute of Technology, Old Westbury, NY.

Abstract

Objective: To determine whether haptic (touch and proprioception) cues from touching a moving handrail while walking can ameliorate the gait symptoms of Parkinson disease (PD), such as slowness and small stride length.

Design: Nonrandomized, controlled before-after trial.

Setting: Physical therapy clinic.

Participants: People with PD (n = 16) and healthy age-matched control subjects (n = 16) with no neurologic disorders volunteered. No participants withdrew.

Interventions: We compared gait using a moving handrail as a novel assistive aid (speed self-selected) versus a banister and unassisted walking. Participants with PD were tested on and off dopaminergic medication.

Main Outcome Measures: Mean gait speed, stride length, stride duration, double-support duration, and medial-lateral excursion.

Results: With the moving handrail, participants with PD increased gait speed relative to unassisted gait by 16% (.166m/s, $P = .009$, $d = .76$; 95% confidence interval [CI], .054−.278m/s) and increased stride length by 10% (.053m, $P = .022$, $d = .37$; 95% CI, .009−.097m) without significantly changing stride or double-support duration. The banister reduced speed versus unassisted gait by 11% (−.097m/s, $P = .040$, $d = .40$; 95% CI, .002−.193m/s) and reduced stride length by 8% (.32m, $P = .004$, $d = .26$; 95% CI, .010−.054m), whereas it increased stride duration by 3% (.023s, $P = .022$, $d = .21$; 95% CI, .004−.041s) and double-support duration by 35% (.044s, $P = .031$, $d = .58$; 95% CI, .005−.083s). All medication × condition interactions were $P > .05$.

Conclusions: Using haptic speed cues from the moving handrail, people with PD walked faster by spontaneously (ie, without specific instruction) increasing stride length without altering cadence; banisters slowed gait. Haptic cues from the moving handrail can be used by people with PD to engage biomechanical and neural mechanisms for interpreting tactile and proprioception changes related to gait speed to control gait better than static cues afforded by banisters.

Archives of Physical Medicine and Rehabilitation 2015;96:735-41

Parkinson disease (PD) impairs balance and gait and leads to falling, which contributes to reduced activity, reduced quality of life, depression, social isolation, and mortality. Parkinsonian gait impairments include decreased stride length, stride duration, gait velocity, and arm swing.[1] Focusing the individual's attention on either themselves (ie, verbal cues such as "take larger steps")[1] or useful visual foot placement cues[2] or auditory cadence cues[3] can increase stride length, cadence, and overall speed. However, interventions involving external sensory cues to improve gait often do not carry over from the clinic to everyday living, and performance returns to preintervention levels,[1,4-6] underscoring the need for permanent cueing devices to focus attention.[7]

Manual contact with a stationary surface at levels too low to provide significant mechanical support ("light touch") provides

Supported by the National Institutes of Health (grant no. R03 HD058150-01A2).
Disclosures: none.

0003-9993/14/$36 - see front matter © 2015 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2014.07.427

haptic (touch and proprioception) cues that improve balance (attenuates sway) in healthy people.[8] In our previous study,[9] people with PD reduced their standing postural sway using manual contact too light to add significant mechanical stability, without practice.

Presently, we tested whether haptic cues improving static balance[9] might be extended to the dynamic situation of improving gait by touching a moving handrail. The moving handrail conveys ongoing gait speed errors relative to it as differences from expected skin deformation and arm configuration: "slow" as a "pull" on the arm, including elbow extension and a corresponding skin stretch on the contact area (palm); and "fast" as elbow flexion and a corresponding skin stretch.

To test whether diminished stride length and walking speed of parkinsonian gait is ameliorated by touching a moving handrail, we compared these outcomes during walking under 3 conditions: unassisted, using a banister, and using our moving handrail at a self-selected speed. To determine how these situations are affected by dopaminergic medication, we tested participants with PD on and off medication.

Methods

Methods were approved by the Institutional Review Board of New York Institute of Technology College of Osteopathic Medicine.

Participants

Sixteen people with PD participated (age range, 45−84y). Two participants were Hoehn and Yahr (H&Y) 3; 11 participants, H&Y 2; and 3 participants, H&Y 1.[10] Unified Parkinson Disease Rating Scale motor section scores (mean ± SD) were 31.56±9.21 on medication and 27.88±9.22 off medication (*t* test, $P<.001$). Nine of these subjects had fallen at least once in the previous 6 months (table 1). Cognitive function assessed with the Columbia modified Mini-Mental State Examination excluded dementia, and the manual sensory discrimination threshold (1g) was far below typical manual forces applied during gait with manual support (see table 1). Participants with PD were tested 1 hour after medication, and 12 hours off medication on a separate day (order counterbalanced). Sixteen healthy control subjects participated (age range, 50−78y; between-group age *t* test, $P=.702$).

Task

Participants were instructed to "walk as well as possible" in all conditions for 20ft with their eyes open. Three experimental conditions participants varied haptic cue during walking: (1) unassisted; (2) touching the moving handrail without movement (using it as a banister); and (3) touching the handrail moving at a self-selected speed. Conditions were repeated 6 times, tested in a pseudorandom order counterbalanced across subjects.

Moving handrail

The moving handrail[a] (fig 1) is a custom-modified conveyor belt, waist-high, alongside which subjects walked while touching the moving surface (width 6in, length 20ft), driven by a Parker Compumotor G3 Dynaserv motor/amplifier[b] and controlled by custom LabView software.[c] For moving handrail trials, subjects were instructed to maintain manual contact with the same place on the moving surface. During the trials, subjects walked parallel to the handrail with their hand in front of them (fig 1D), but trials began with their hand behind them (fig 1B). This starting posture allows the subject to "sample" the handrail speed as the initial handrail motion carried the hand forward, and for gait to "catch up" to the motion of their hand (fig 1C). Subjects indicated their preferred speed for the handrail based on a few practices before any data collection.

List of abbreviations:

H&Y **Hoehn and Yahr**
PD **Parkinson disease**

Measurements

A Vicon-Peak 7-camera system[d] (120Hz) measured the ongoing position of reflective markers placed at the third thoracic vertebra (T3), and bilaterally on the posterior calcaneus (heel) and the distal second metatarsal (toe).

Analysis

Walking speed was derived from the mean velocity of the T3 marker. Toe-off and heel strike were defined as when toe velocity exceeds and heel velocity drops below 90mm/s, respectively. Stride length was defined as the fore-aft difference between toe markers during double support. Stride duration was determined from successive toe-offs. Double-support duration was determined as the time between heel strike and subsequent toe-off. Mean medial-lateral position during gait was calculated as the mean medial-lateral distance of the mean medial-lateral position of the T3 marker.

A split-factor repeated-measures analysis of variance (SPSS, version 2012[e]) evaluated significances of haptic cue (none, banister, moving handrail) and participant group (PD, control) on outcomes, with PD group scores collapsed across medication conditions. A repeated-measures 2×3 analysis of variance evaluated effects and interactions of medication (on, off) and haptic cue (none, banister, moving handrail) on outcomes within participants with PD. Planned pairwise comparisons (least squared difference) between conditions tested the following hypotheses: (1) that gait with the moving handrail would be faster, with a longer stride length, and briefer stride and double-support duration; (2) that the banister would reduce speed and stride length, and increase stride and double-support duration; and (3) that both haptic cues would have a smaller medial-lateral position range compared with unassisted walking. Since medication × haptic cue interactions were not significant, data on and off medication were collapsed for pairwise analyses.

Results

Participants with PD walked slower, with shorter, briefer strides, longer double support, and less medial-lateral movement than healthy controls. Compared with healthy controls across conditions, participants with PD walked ∼68% as quickly (mean ± SD: .968±.141m/s vs 1.240±.118m/s; $F_{1,31}=21.636$; $P<.001$; $\eta^2=.35$) (fig 2A), with ∼82% of the stride length (.522±.034m vs .634±.029m; $F=6.016$; $P=.020$; $\eta^2=.22$) (fig 2B), ∼81% of the stride time (.478±.025s vs .593±.029s; $F=8.343$; $P=.007$; $\eta^2=.29$) (fig 2C), ∼160% of the double support (.154±.013s vs .096±.011s; $F=108.759$; $P<.001$; $\eta^2=.35$) (fig 2D), and 71% of the medial-lateral excursion (.148±.010m vs .208±.012m; $F=13.202$; $P=.001$; $\eta^2=.39$) (fig 2E).