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Original Article

Walking Turns in Parkinson's Disease Patients with Freezing of Gait: The Short-term Effects of Different Cueing Strategies☆

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ABSTRACT

Background: This study aimed to evaluate the effects of cueing on circular walking in patients with Parkinson's disease.
Methods: Parkinson's disease patients in the "off" state were asked to walk on a designed route at their preferred speed. The experimental protocol was divided into two sessions. The first session was to be performed with no manual task. During the second session, the participant had to perform a manual task. Each session was measured for each of four conditions performed in the following order: without cues, with a visual cue, with an auditory cue, and with dual cues simultaneously. Temporospatial gait parameters and freezing of gait (FOG) events regarding the cueing-on and cueing-off situations were the main measures of gait performance.
Results: Twelve patients with Parkinson's disease were recruited. Demographic and clinical characteristics of the participants were the following [median (interquartile range)]: age 63 years (57–67.3 years), Hoehn and Yahr stage 3.0 (3.0–3.25), and Unified Parkinson's Disease Rating Scale motor subsection off medication 22.5 (20.3–35.5). Walking turns of 180° in combination with a manual task were the most important triggers for FOG. On circular walking either with or without a manual task, visual or dual cues improved festinating gait patterns and increased step length. Visual or dual cues further improved the velocity of walking with a manual task. All types of cueing decreased FOG scores either with or without a manual task.
Conclusion: Our study suggests that cueing improves festinating gait and decreases the incidence of FOG. Future studies with much larger sample sizes are warranted to support our findings.

1. Introduction

Parkinson's disease (PD) is a common neurologic disease resulting from selective loss of dopaminergic neurons in the substantia nigra[1]. The classic PD symptom triad includes resting tremor, rigidity, and bradykinesia. Gait disorders are among the most disabling symptoms experienced by PD patients. Patients demonstrate a festinating gait pattern with a shortened stride length, reduced overall velocity, limited natural arm swing, and difficulty in initiating their gait. The most impairing gait disruptions are related to postural instability and freezing of gait (FOG) episodes that tend to become resistant to dopaminergic agents[2]. Postural instability within 2 years of PD diagnosis has been found to predict over 80% mortality within 10 years[3]. FOG is a paroxysmal inability to generate effective stepping that typically lasts a few seconds and is associated with a unique sensation: patients feel that their feet are glued to the ground, causing them to remain in place despite making efforts to overcome the motor block. FOG is often triggered by characteristic circumstances such as step initiation, a half or 360° turn, being faced with obstacles or doorways, stress, and distraction[4]. As a result, the ultimate goals to treat gait

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disorders in PD should be to decrease their severity, enhance the ability to carry out of daily activities, and reduce the risk of falling. The most well-known nonpharmacological and nonsurgical treatment of FOG is the use of attentional strategies, which involve instructions to take big steps and offer external cues[5]. Attentional strategies rely more on cognitive mechanisms of motor control and are internally generated. External cueing strategies include the use of visual or auditory stimuli to facilitate movement. Forms of auditory cueing may include strategies such as the use of music, counting, or the beat of a metronome as a rhythmic auditory cue. Auditory cues have been demonstrated to increase velocity[6,7]. Visual cues are found to improve gait parameters in persons with PD. These cues include the use of laser pointers[8], adaptive glasses[9], or lines marked on the floor[10].

Immediate beneficial effects of cueing on straight-line gait in PD have been well documented. Turning in PD is an aspect of functional gait, which is associated with instability, falls, and FOG. Gait analysis of turning in PD is lacking, and evidence is limited for cueing strategies that are applied to alleviate gait problems in turning[11].

Nieuwboer et al[12] reported that rhythmical cueing yielded faster performance of a functional turn in both freezers and nonfreezers. The objective of our study was to evaluate the effects of cueing strategies on circular walking parameters for patients with PD. We hypothesized that FOG events and spatiotemporal gait measures would improve when participants are ambulated (1) with cueing strategies compared with when without and (2) with cueing strategies during a manual task.

2. Materials and methods

2.1. Study design

Patients were referred by their neurologists and were recruited if they met the following inclusion criteria: diagnosis of idiopathic PD (Stage I–IV on modified Hoehn and Yahr scale[13]) according to the UK Brain Bank criteria[14], and an unambiguous gait disorder after overnight PD medication washout ("off" state) but still able to walk along a 12-m walkway repeatedly without assistance. They were excluded if they had overt cognitive impairment, other comorbidity limiting gait, undergone brain surgery, obvious hearing and visual deficits, or severe dyskinesias during the study. Written informed consent was obtained from all participants, according to the Helsinki Declaration, and ethical approval was received from the institutional review board of the Mackay Memorial Hospital (Taipei, Taiwan). During the initial clinical assessment prior to the gait analysis, an experienced movement disorder specialist (P.H.C.) evaluated patients' disease severity using standard clinical tests, including the Unified Parkinson's Disease Rating Scale (UPDRS)[15] and the Hoehn and Yahr score. A measure of postural instability and gait disorders[16] was derived by summing the scores for Items 13–15 and Items 27–30 from the UPDRS. FOG and fear of falling were assessed using the freezing of gait questionnaire (FOG-Q)[17] and the Chinese version of the Activities-specific Balance Confidence (ABC) scale[18], respectively. A video with examples of typical FOG episodes was shown, to ensure that participants understood what was meant by a FOG episode. FOG-Q, a six-item self-reportable questionnaire for the assessment of frequency and duration of FOG, is a reliable tool and FOG-Q Item 3 is effective as a single screening question for the presence of FOG[19]. The ABC scale is a questionnaire that includes a wider variety of activities to measure an aspect of the psychological impact of balance impairment and/or falls[20]. The Chinese version of the ABC scale is a culturally relevant, valid, and reliable tool for measuring self-perceived balance confidence in older Chinese adults[18]. Participants were asked to come for the experimental session without having taken their usual morning PD medications in an "off" state. Patients were instructed on the experiment and explained how they may use the cues to overcome FOG. The experimental protocol was divided into three parts and recorded on digital videos.

Participants are asked to walk on a designed route at their preferred speed (Figure 1). A physician-rating scale (FOG score) is used for the evaluation of FOG to represent normal daily walking[21]. Four situations are chosen to be rated on a four-level interval scale: starting to walk, turning within the floor mark (clockwise and counterclockwise), and passing through the door. The scaling follows a phenomenological distinction: 0 points are given when no festination and no FOG are detected; 1 point is given for the observation of festination or any shuffling steps; 2 points are given for the observation of FOG, which the patient can overcome himself within 3 seconds; and 3 points are given for the observation of FOG lasting longer than 3 seconds or any need of intervention by the examiner. The first session of the trial is to be performed with no additional task. During the second session, the participants have to perform a manual task, i.e., carrying a tray with a plastic cup full of water. Each session is measured for each of four conditions performed in the following order: without cues, with a visual cue, with an auditory cue, and with dual cues simultaneously. Visual cues are transverse green strips placed on the walkway at intervals corresponding to the stride length of a participant matched for height, age, and sex[22]. Auditory cues are supplied with a metronome at a rhythm set at 10% below or above the participant's comfortable step frequency during circular walking[11]. The frequency of the auditory cue is chosen such that each participant is able to synchronize with the cue. Each walking trial is performed three times (twice if consistent results). At the end of the study, patients take their medications and have a debriefing with the researcher regarding the cueing effects on walking. Digital video recordings from one side and the front/back of the participants are used to document the temporospatial gait parameters (cadence, velocity, and step length) regarding circular walking. These values for each trial are averaged to provide individual median data. FOG scores and gait parameters are reconfirmed using an off-line frame-by-frame video. The identification of FOG episodes made by the physician (P.H.C.) served as the gold standard, and another experienced neurologist (S.J.C.) blinded to the medical record used video clips to establish the diagnosis.

2.2. Statistical analysis

Descriptive data including walking speed, step length, and cadence during circular walking were calculated, and SAS version 9.3 for Windows (SAS Institute, Cary, NC, USA) was used for statistical analysis. Baseline characteristics of subgroups were compared using Mann–Whitney rank-sum tests to determine statistically significant differences. Differences between the trials with and without cueing were assessed using the Wilcoxon signed-rank test, given the small sample size and non-normal distribution of data. All continuous variables were expressed as the median (interquartile range 25^{th}–75^{th} percentile). All calculated p values were two tailed, and $p < 0.05$ was considered to be statistically significant.

3. Results

Of the 14 patients with PD being assessed, two were excluded: one failed to complete all trials due to extremely impaired walking and one was disproportionately slow in all conditions. The principal demographic and clinical characteristics (Table 1) of the remaining participants ($n = 12$) were the following [median (interquartile