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Jumping to overcome freezing of gait while turning in Parkinson's disease

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Freezing of gait (FOG) in Parkinson's disease (PD) is disabling and frequently treatment-resistant [1]. Cueing is initially effective but requires training, special devices and may paradoxically elicit FOG [2]. Turning is the most common FOG trigger [3], however, few studies have focused on strategies specifically targeting FOG while turning (turning-FOG) [4,5]. Here, we present jumping as a potential strategy for selected PD patients to overcome treatment-resistant turning-FOG.

Over one year, FOG questionnaires and postural instability gait dysfunction subscales of the Unified Parkinson's Disease Rating Scale (UPDRS-PIGD) were obtained from nine consecutive PD patients participating in an IRB-approved clinical trial at our institution (ClinicalTrials.gov NCT03462082). These patients had persistent turning-FOG despite optimization of medications, bilateral subthalamic stimulation and rehabilitation strategies. They were assessed for their abilities to jump effectively and relatively safely in order to overcome turning-FOG during their best medication-ON and stimulation-ON states. Quantitative, video-documented, 180-degree pivot turn analyses were then performed with and without vertical jumping with a movement analysis walkway and software (Zeno electronic walkway®, Protokinetics, Havertown, PA, USA). The effects of vertical pivot jumping were evaluated by comparing turning time, number of steps and FOG time during pivot turns with and without jumping. For pivot turns without jumping, turn initiation was defined as the last forward heel strike of the inner foot during straight gait. Turn termination was defined as the first effective forward heel strike of the outer foot during straight gait in the opposite direction. For pivot turns with jumping, turn initiation was defined as the last forward heel strike of the inner foot before jumping. Turn termination was defined as the first effective forward heel strike of the outer foot during straight gait in the opposite direction after jumping. FOG time was calculated between the last effective heel strike and first effective toe-off times. The relative safety of pivot jumping was determined by verticality and lack of postural instability before, during and after jumping (UPDRS-PIGD postural stability item = 0, projected center of mass and center of pressure inside base of support at all times as per movement analysis software). Patients who demonstrated effective and relatively safe vertical pivot jumps tried this strategy at home without further training. Follow-up FOG questionnaires and UPDRS-PIGD subscales were obtained three months later.

Three of nine patients were able to effectively jump in order to overcome turning-FOG (Fig. 1, video 1). Their ages ranged from 35 to 62 years, they were all men and their PD duration was at least five years when undergoing bilateral subthalamic stimulation surgery.

Supplementary video related to this article can be found at https://doi.org/10.1016/j.parkreldis.2019.04.021.

For patient 1, left pivot turn time improved from 2.98 seconds, including 12 steps and 2.20 seconds of FOG, to 2.27 seconds, including seven steps and 0.90 seconds of FOG. For patient 2, right pivot turn time improved from 6.14 seconds, including 15 steps and 5.89 seconds of FOG, to 2.20 seconds, including seven steps and 1.01 seconds of FOG. For patient 3, right pivot turn time improved from 2.88 seconds, including 11 steps and 1.62 seconds of FOG, to 2.03 seconds, including five steps and 0.30 seconds of FOG (Fig. 1, video 1). Three months later, the FOG questionnaire for these patients improved from a median of 12 points (range 10–16) to 10 points (range 8–15) and the UPDRS-PIGD subscale improved from a median of 11 points (range 9–16) to 10 points (range 8–14), including the same or one-point improvement per patient in questions reporting falls.

The other six patients required the use of walking aids, were unable to jump and/or displayed signs of postural instability before, during or after their jumping attempt. Their ages ranged from 58 to 71 years, there were four women and their PD duration was at least nine years when undergoing bilateral subthalamic stimulation surgery.

Patients with PD and FOG perform their turns with abnormally large

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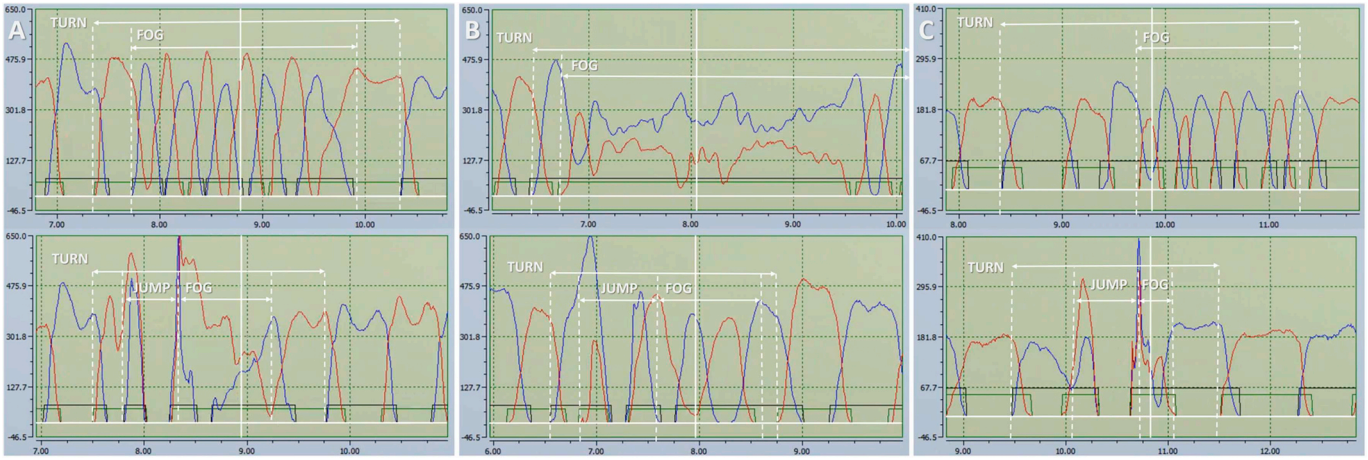

Fig. 1. Quantitative pivot-turn analyses without and with jumping for three patients with treatment-resistant freezing of gait. A quantitative movement analysis walkway and software (Zeno electronic walkway®) comparatively analyzed pivot turns for three patients **(A, B, C)** without **(superior panels)** and with 180-degree jumping **(inferior panels)**. Horizontal Y axes represent time in seconds: doted vertical white lines encompass turning, freezing (FOG) and jump times as depicted by the corresponding horizontal white arrows, vertical white lines are time zero. Vertical X axes represent relative pressure units: red lines represent left foot pressure, blue lines represent right foot pressure, green lines represent left foot contact, black lines represent right foot contact (left foot contact is augmented 50 times and right foot contact is augmented 65 times to improve visibility). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

arcs and small angles. Moreover, reduced truncal rotation preceding and during turns is being increasingly recognized as an important component of their turning deficits [4]. The increased axial rotations occurring before and during pivot jumping, skipping the multi-step arcs and angles usually required for them to turn, as well as avoiding and/or shortening FOG episodes while turning might be associated with the improvements observed in the patients reported in this preliminary series.

In conclusion, vertical pivot jumping may benefit younger PD patients without postural instability and relatively short disease duration with treatment-resistant turning-FOG. Gender differences might be associated with baseline physical fitness. These preliminary findings should be explored in larger studies considering obvious safety concerns and other FOG subtypes.

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Conflicts of interest

The authors declare that there are no conflicts of interest relevant to this work.

Ethical compliance and consent

Written informed consent for publication of the videos has been obtained from all patients.

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