

Frontal Assessment Battery and Falling Related with Freezing of Gait in Parkinson's Disease

Hiroshi Kataoka* and Satoshi Ueno

Department of Neurology, Nara Medical University, Kashihara, Nara, Japan,

*Corresponding author: Hiroshi Kataoka, Department of Neurology, Nara Medical University, 840 Shijo-cho, Kashihara, Nara 634-8522, Japan, Tel: +81-744-29-8860; Fax: +81-744-24-6065; E-mail: hk55@naramed-u.ac.jp

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Introduction

In Japan owing to the recent growth of the elderly population, the number of patients with Parkinson's disease (PD) is expected to double by 2030 [1]. According to this expectation, the number of patients with PD will increase. Patients with PD are at high risk for falling [2,3], and the risk of fall-related fractures is increasing. Fall-related fractures can lead to serious complications even among patients with good motor ability, and an appreciable number of patients become bedridden or require assistance in daily activities. Thus, "falling" is one of the most disabling features of PD.

Many clinicians use disease severity or motor disability such as walking ability as clues to the risk of future falls. However, disease severity has not been found to be a consistent predictor of falling [2]. Moreover, the mechanisms underlying the relation between gait patterns and falling in PD have not been fully explored. Patients with PD feel too large to pass through confined spaces, even though they were aware that the spaces were designed for human size [3]. Such patients have been shown to have several gait alterations in step length, stride length, gait timing, and step duration, especially before freezing of gait [4].

In 2011, we evaluated factors related to falling, such as walking speed, step number, step time, and step-width alternation, using originally designed, suddenly narrowed paths in 30 patients with Hoehn-Yahr stage III PD [5]. Gait velocity was slower, gait time was longer, or step number was lower in fallers than in non-fallers. We separately calculated gait time, velocity, and step number with the use of a video-based technique according to (1) the section with a path width of 110 cm (2 m, section 1), (2) the transition zone from a path width of 110 to 70 cm (2 m, section 2), including the entrance into the smaller space, and (3) the section with a path width of 70 cm (2 m, section 3) (Figure 1). In the fallers, the gait time for section 3 was significantly longer than that for section 1. The gait velocity for section 3 was slower, and the step number for section 3 was significantly greater than that for section 1. Between sections 2 and 3, the gait time, velocity, and step number did not differ significantly. These findings suggest that gait variability occurred before arrival at a narrowed path, as well as in confined spaces [5].

On cross-sectional analysis, the multiple logistic regression analysis showed that the UPDRS part II score was significantly related to falling [5]. The individual UPDRS part II item that was significantly associated with falling was freezing when walking [5]. Freezing has been linked to step duration variability, shorter step length, or increased gait variability [6]. Fear of falling in this study was related to

falling on single logistic regression analysis [5]. Freezing has also been reported to be related to anxiety [6,7]. The fear of falling might also have been associated with freezing since previous studies reported that freezing accompanying a fear of falling might contribute to falling [6,8].

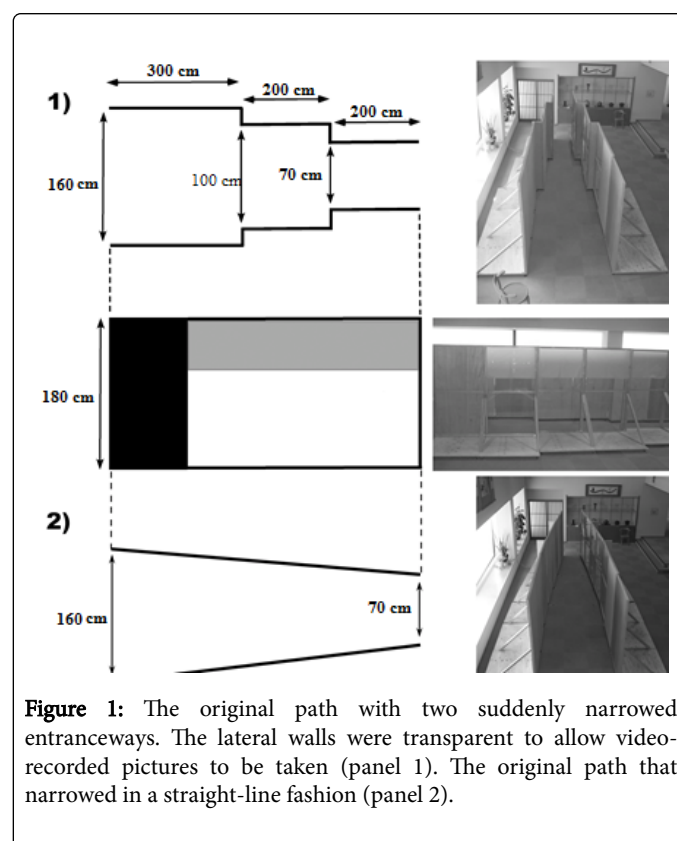


Figure 1: The original path with two suddenly narrowed entrances. The lateral walls were transparent to allow video-recorded pictures to be taken (panel 1). The original path that narrowed in a straight-line fashion (panel 2).

Subsequently, we prospectively studied the same group of patients with Hoehn-Yahr stage III PD [5]. Gait characteristics were analyzed using originally designed, suddenly narrowed paths to determine predictors of falls over the course of 2 years [9]. A lower Frontal Assessment Battery (FAB) score was found to be associated with a greater risk of falling [9]. On the FAB, the scores of "inhibitory control" and "sensitivity to interference" were significantly lower in patients who fell than in those who did not [9]. Previously, the FAB score was evaluated in only three prospective studies [10-12]. One study prospectively observed patients with PD for 1 year, and the results showed that impairment as defined by an FAB score of ≤ 17 was

evident in more fallers than non-fallers, but was not a significant factor on multivariate logistic regression analysis [10]. Another study of 250 patients with PD who were followed up for 6 months reported that an FAB score of ≤ 17 was a risk factor for falling on univariate analysis, but not on multivariate logistic regression analysis [11].

Another study observed 413 patients with PD for 12 to 18 months but did not find the FAB score to be a significant risk factor for falling [12]. "Sensitivity to interference" has been reported to negatively correlate with the score for freezing of gait [13]. Previous studies have suggested that freezing of gait is caused by frontal malfunction or disconnection between the frontal lobe and the basal ganglia [14,15] and is a potential cause of falling [16]. Our originally designed path contained two narrow doorways, which probably resulted in slower gait with freezing. Moreover, stronger impairment of the initial movement plan has been shown to be associated with lower FAB scores for "inhibitory control" and "sensitivity to interference" [5,9].

We previously studied 30 patients with PD with Hoehn-Yahr stage III PD [5,9]. We selected this disease stage because it is associated with postural instability, possibly leading to an increased risk of falling. Whether the FAB score is related to the risk of future falls in patients with other Hoehn-Yahr stages of PD remains unknown. We also prospectively studied 100 patients with various severities of PD over the course of 2.5 years to determine whether the FAB score is a risk factor for future falls [17]. Thirty-one patients (37%) had fallen previously, and 26 (30%) fell for the first time. Again, the FAB score was significantly lower in fallers than in non-fallers. The FAB score was also related to falling on multiple logistic regression analysis [17]. In that study [17], subitem 14 of UPDRS part II, evaluating freezing of gait while walking, was significantly higher in fallers than in non-fallers. Our series of studies [5,9,17] thus showed that the use of the originally designed, suddenly narrowed path was the primary reason for demonstrating for the first time that a low FAB score is a risk factor for future falls.

In our study [5], we had patients who fell walk on a path that narrowed in a straight-line fashion (Figure 1) to determine whether it was possible to improve slow gait with freezing [18]. Gait speed significantly increased, and gait time as well as step number significantly decreased. Slow gait with freezing resolved in one patient, suggesting that our results will provide potential clues suggesting how to effectively prevent future falls in patients with PD. The clues may be associated with visual clues which do not provide feeling of fear to patients with PD. To prevent gait instability caused by gait freezing in patients with PD, it might be useful to remove narrowed entrances, which potentially increase the fear of falling caused by visual perceptual disability of narrow spaces.

We believe that the lower frontal lobe function may elicit the freezing of gait, which can lead to an increased risk of falling. The FAB score can be easily determined at bedside within a short time. Physical therapy increases walking velocity, step length, and stride length in patients with PD who have high FAB scores, but not those who have low FAB scores [19]. Calculation of the FAB score might provide a reliable predictor of the risk of future falls in patients with various severities of PD.

Freezing can be caused by the presence of a visible obstacle in the path, a change in the design of the floor pattern, walking in narrow spaces or crowds, or being rushed or startled [14,15]. In Japan, the risk

of falling may increase substantially after patients with PD return to their homes because Japanese houses have narrowed spaces or multiple corners. Our study showed that slow gait with freezing occurring on a path with two narrow entrances was resolved when walking on a path without narrow entrances [18]. The removal of narrowed entrances or reduction of multiple corners may prevent falling in patients with PD.

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