ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Physical Medicine and Rehabilitation

journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2016;97:372-9

ORIGINAL RESEARCH

Two-Year Trajectory of Fall Risk in People With Parkinson Disease: A Latent Class Analysis

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Abstract

Objective: To examine fall risk trajectories occurring naturally in a sample of individuals with early to middle stage Parkinson disease (PD).

Design: Latent class analysis, specifically growth mixture modeling (GMM), of longitudinal fall risk trajectories.

Setting: Assessments were conducted at 1 of 4 universities.

Participants: Community-dwelling participants with PD of a longitudinal cohort study who attended at least 2 of 5 assessments over a 2-year follow-up period (N = 230).

Interventions: Not applicable.

Main Outcome Measures: Fall risk trajectory (low, medium, or high risk) and stability of fall risk trajectory (stable or fluctuating). Fall risk was determined at 6 monthly intervals using a simple clinical tool based on fall history, freezing of gait, and gait speed.

Results: The GMM optimally grouped participants into 3 fall risk trajectories that closely mirrored baseline fall risk status ($P = .001$). The high fall risk trajectory was most common (42.6%) and included participants with longer and more severe disease and with higher postural instability and gait disability (PIGD) scores than the low and medium fall risk trajectories ($P < .001$). Fluctuating fall risk (posterior probability <0.8 of belonging to any trajectory) was found in only 22.6% of the sample, most commonly among individuals who were transitioning to PIGD predominance.

Conclusions: Regardless of their baseline characteristics, most participants had clear and stable fall risk trajectories over 2 years. Further investigation is required to determine whether interventions to improve gait and balance may improve fall risk trajectories in people with PD.

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Falls are a disabling and problematic occurrence for people with Parkinson disease (PD). Falls occur in 45% to 68% of the PD population annually,[1] a rate double that of the general older population.[2] Falls in people with PD may result in injuries or other adverse consequences, which in turn are associated with prolonged hospitalizations and higher health care costs.[3]

Fall risk in PD is multifactorial, with a positive fall history, history of freezing of gait (FOG), and reduced gait speed identified as among the most potent predictors of a future fall.[4] Additionally, the incidence of falls increases with disease progression,[1,5] until the point at which individuals become relatively immobile and appear to fall less.[6] Nevertheless, the extent to which fall risk in PD might increase without a concurrent

Supported by the Davis Phinney Foundation, the Parkinson's Disease Foundation, National Institutes of Health (NIH) (grant nos. NIH R01 NS077959 and NIH UL1 TR000448), the Massachusetts and Utah Chapters of the American Parkinson Disease Association (APDA), the Greater St Louis Chapter of the APDA, and the APDA Center for Advanced Research at Washington University.

Disclosures: none.

0003-9993/15/$36 - see front matter © 2016 by the American Congress of Rehabilitation Medicine
http://dx.doi.org/10.1016/j.apmr.2015.10.105

change in the level of disease severity, and whether the rate of increase in fall risk might differ according to baseline disease severity, remains unclear. It is also unknown whether fall risk fluctuates during specific periods of disease progression. These questions are relevant, given the mixed results about the efficacy of exercise interventions for fall prevention in PD.[7-11]

Given the progressive neurodegeneration and functional decline associated with PD, knowledge about progression of fall risk over time will assist clinicians to more effectively prevent and manage falls in this population by helping to improve the manner in which fall risk assessment and interventions are used.[1,12] The primary aim of this study, therefore, was to track fall risk longitudinally in people with PD. Secondary aims were to investigate which characteristics differed between the various fall risk trajectories and the characteristics associated with changes in fall risk over time. We hypothesized that over the 2-year follow-up period, most participants classified by a clinical tool at baseline as being at high fall risk would remain at high risk, whereas a proportion of those classified by the tool as being at low or medium risk would have increased their fall risk. We further hypothesized that the postural instability and gait disability (PIGD) subtype of PD would be associated with greater progression of fall risk. Individuals with the PIGD subtype have predominantly bilateral and axial symptoms, including stooped posture, greater gait and balance impairment, and FOG.[13]

Methods

Participants

Community-dwelling individuals aged ≥40 years, who had been diagnosed with idiopathic PD by a neurologist, who were in Hoehn and Yahr stages 1 through 4, and who had Mini-Mental State Examination scores ≥24 were eligible for enrollment in a multicenter longitudinal cohort study focusing on the natural history of functional decline and quality of life.[14] Exclusion criteria included a diagnosis of atypical parkinsonism or previous surgical intervention for PD (eg, deep brain stimulation).

Participants were assessed ON medication at baseline and then every 6 months for a total of 24 months. Trained physical therapists assessed participants according to a manual of standard operating procedures at one of the following locations: 34 participants at the University of Utah, 71 at Boston University, 66 at Washington University in St Louis, and 59 at the University of Alabama at Birmingham. Potential predictors and outcomes were obtained during each assessment session. Participants continued to receive standard medical care over the 2-year study period, including neurology follow-ups and other prescribed medical or allied health interventions.

This study was approved by the ethics committees of all participating sites. All participants provided written informed consent prior to data collection. This study conforms to STrengthening the Reporting of OBservational studies in Epidemiology reporting guidelines.[15]

List of abbreviations:

ANOVA	**analysis of variance**
BIC	**Bayesian information criterion**
FOG	**freezing of gait**
GMM	**growth mixture modeling**
MDS-UPDRS	**Movement Disorders Society sponsored version of the Unified Parkinson Disease Rating Scale**
PD	**Parkinson disease**
PIGD	**postural instability and gait disability**

Clinical characteristics

Fall risk at each assessment was determined to be low, medium, or high based on a validated[16] simple clinical fall prediction tool. Accordingly, weighted scores were assigned for positive fall history in the past year (6 points), positive FOG history in the past month (3 points), and preferred gait speed <1.1m/s (2 points). Total scores range from 0 to 11, with 0 indicating low, 2 through 6 indicating medium, and 8 through 11 indicating high fall risk.[4] Falls were defined as unintentionally coming to rest on the ground or other lower surface without being exposed to overwhelming external force or a major internal event.[17] Fall history over the last 6 months was collected at each assessment using a forced-choice paradigm: none, once, 2 to 10 times, weekly, or daily. History of FOG was determined using question 3 of the FOG Questionnaire[18] (ie, Do you feel that your feet get glued to the floor while walking, making a turn, or when trying to initiate walking [freezing]?); scores ≥1 indicated a positive FOG history. Gait speed was determined by averaging the scores from 2 trials of the 10-m walk test, which participants completed at their comfortable pace.

Age, sex, time since PD diagnosis, levodopa equivalent dose,[19] and PD severity according to the motor section (part 3) of the Movement Disorders Society sponsored version of the Unified Parkinson Disease Rating Scale (MDS-UPDRS)[20] were obtained. Tremor-dominant, PIGD, and indeterminate PD subtypes were determined using relevant items of parts 2 and 3 of the MDS-UPDRS according to published criteria.[13] Dyskinesia was quantified using the sum of items in part 4A of the MDS-UPDRS. Physical activity was quantified using the Physical Activity Scale for the Elderly, for which scores range from 0 to >400, and higher scores indicate higher physical activity levels.[21]

Data analysis

Latent class analysis, specifically growth mixture modeling (GMM),[22] was used to assign groups of participants into a small number of distinct trajectories of fall risk based on participants' level of fall risk at each assessment ascertained with the clinical tool. GMM, which assumes heterogeneity within a population, obtained the smallest number of latent classes (ie, trajectories) that accounted for all associations between the biannual fall risk determinations within the 2-year time period by minimizing within-class variation and maximizing between-class variation.[22] This process allowed for the identification of a primary fall risk trajectory for each individual and whether individuals were stable within their trajectory or fluctuated between trajectories. The posterior probability of belonging to each trajectory was obtained for each individual, with participants allocated to the trajectory for which the probability was the largest.

The GMM was fitted successively, starting with a 1-latent class model that assumed all participants had the same progression of fall risk over time. The optimal number of trajectories subsequently was determined by examining the Bayesian information criterion (BIC), the Lo-Mendel-Rubin likelihood ratio test, and the bootstrapped likelihood ratio test.[23] Although participants did not need to have complete data (ie, data for each assessment) to be included in GMM, we recognized that missing data could influence goodness-of-fit tests. Therefore, the first analysis assessed the