ORIGINAL ARTICLE

Balance Confidence and Falls in Nondemented Essential Tremor Patients: The Role of Cognition

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Abstract

Objectives: To examine (1) the effect of cognitive ability on balance confidence and falls, (2) the relationship of balance confidence and falls with quantitative measures of gait, and (3) measures that predict falls, in people with essential tremor (ET).

Design: Cross-sectional study.

Setting: General community.

Participants: People with ET (n=132) and control subjects (n=48). People with ET were divided into 2 groups based on the median score on the Modified Mini-Mental State Examination: those with lower cognitive test scores (ET-LCS) and those with higher cognitive test scores (ET-HCS).

Interventions: Not applicable.

Main Outcome Measures: Six-item Activities of Balance Confidence (ABC-6) Scale and falls in the previous year.

Results: Participants with ET-LCS had lower ABC-6 scores and a greater number of falls than those with ET-HCS ($P<.05$ for all measures) or control subjects ($P<.01$ for all measures). Quantitative gait measures were significantly correlated with ABC-6 score and falls. Gait speed ($P<.007$) and ABC-6 score ($P<.02$) were significant predictors of falls. Receiver operating characteristic curve analysis revealed that gait speed <0.9m/s and ABC-6 score $<51\%$ were associated with moderate sensitivity and specificity in identifying fallers.

Conclusions: People with ET-LCS have impaired gait and report lower balance confidence and a higher number of falls than their counterparts (ET-HCS) and than control subjects. We have identified assessments that are easily administered (gait speed, ABC-6 Scale) and are associated with falls in ET.

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Essential tremor (ET) is a highly prevalent neurologic disorder with motor and nonmotor impairments.[1-3] Recent work[4-9] indicates that people with ET demonstrate gait and balance impairments greater than that seen in age-matched control subjects. Balance impairment is evident on clinical assessment (tandem walk), in which people with ET demonstrate a higher number of missteps (defined as steps taken in a direction away from a straight line).[4,6,7] Quantitative gait analysis demonstrates that people with ET have lower speed and cadence, decreased consistency of stepping (step time difference), and impaired dynamic balance (time spent in double support).[9] The clinical features of ET can also include cognitive impairments in the domains of attention, executive function, and memory.[10,11] Since functional ambulation often involves concurrent performance of motor and cognitive skills, impairments during dual-task performance may be predictive of falls, as is seen in the elderly.[12,13] Falls may cause injuries, and are associated with nursing home admission and increased mortality.[14]

We recently observed that gait impairments were worse in people with ET when performing a cognitive task during gait.[15] Performance decrement was most prominent in a subset of people with essential tremor with lower cognitive scores (ET-LCS). However, we do not know whether this subgroup (with lower cognitive scores) is at a greater risk of *functional* balance difficulty (ie, lower balance confidence and more falls).

The purpose of this follow-up study was to (1) evaluate in an a priori manner whether balance confidence is lower and falls are

higher in people with ET-LCS than in people with essential tremor with higher cognitive scores (ET-HCS) or in control subjects; (2) examine whether balance confidence and falls are correlated with quantitative measures of gait; and (3) determine measures that are predictive of falls. We collected new retrospective falls data on our cohort of 213 subjects, for whom we had previously only reported quantitative gait data.[9,15]

Methods

Participants

Details about our cohort have been reported previously.[9,15] Briefly, participants were recruited as future brain donors to the Essential Tremor Centralized Brain Repository. We enrolled people with ET and spousal controls living across the United States. A movement disorder specialist confirmed the diagnosis of ET using published diagnostic criteria (moderate or greater amplitude kinetic tremor during $\geq$3 activities, or a head tremor in the absence of Parkinson's disease). Spousal controls were included if they did not have a diagnosis of ET. We excluded people with ET with a Modified Mini-Mental State Examination (mMMSE) score <40, as this is often indicative of underlying dementia.[16-19] Additional exclusion criteria for ET and control participants were the presence of other neurologic disorders (Parkinson's disease, dystonia, stroke), and orthopedic impairments that may have impaired walking. All enrolled participants (N=213; 151 with ET, 62 spousal controls) signed an informed consent form, approved by the institutional review board in accordance with the Declaration of Helsinki.

Assessment

Our original cohort (N=213) was tested at home. All participants underwent a clinical assessment that included collection of demographic and clinical data, a neurologic examination, and quantitative gait analysis. People with ET were also administered the mMMSE (range, 0−57; higher scores indicate better function).[20] This valid and reliable test[16] is an expanded version of the Folstein Mini-Mental State Examination.[21]

As an add-on telephone assessment, 3 to 6 months later, we obtained data on balance confidence and falls. We administered the 6-item Activities of Balance Confidence (ABC-6) Scale.[22,23] The scale asks participants to rate their confidence in performing functional activities without losing balance or becoming unsteady. Scores range from 0 (not confident at all) to 100 (completely confident). The ABC-6 Scale has been validated against the parent Activities of Balance Confidence questionnaire, which consists of 16 items.[22] In addition, we asked patients to indicate how many falls they had during the past year. Falls were defined as "an event which results in a person coming to rest inadvertently on the ground or supporting surface, and other than as a consequence of a violent blow, loss of consciousness or sudden onset of paralysis."[24(p3)] A single experimenter (A.G.)

made all telephone calls. The experimenter has more than 5 years of experience with administering telephonic interviews and was trained by the first author (A.K.R.) in administration of the ABC-6 scale. The experimenter was blinded to the study hypothesis, to avoid biases in the collection of information.

Quantitative gait data were collected with the Gaitrite mat,[a] a 4.6-m-long computerized mat that registers the location and timing of each footfall. The gait mat was placed in the middle of a quiet hallway in participants' homes. We had ascertained that each participant had sufficient space for collecting gait data and have reported the procedure in detail previously.[9,15] We analyzed the following gait measures that were sensitive in differentiating people with ET from control subjects[15]: speed, cadence, step length, step time difference, and percent of gait cycle spent in double support. We also computed the coefficient of variation of stride length and stride time.

Statistical analysis

Analyses were carried out in IBM-SPSS (version 21[b]). We used the Kolmogorov-Smirnov test to examine the normality of data distribution. For data that were normally distributed we used parametric statistics, and for data that were not normally distributed we used nonparametric statistics. Comparison of ABC-6 and falls across groups (ET-LCS, ET-HCS, and control subjects) was conducted with multivariate analysis of variance (ANOVA), with age as a covariate. To examine differences in the number of fallers per group (individuals who reported >2 falls in the previous year[12,25]), we used a nonparametric test, the Jonckheere-Terpstra test of ordered alternatives.[26] The Jonckheere-Terpstra test is useful when the alternative hypothesis includes a priori ordering, as was the case in our study. We hypothesized that the ET-LCS group would have a higher number of fallers than the ET-HCS group who, in turn, would have a higher number of fallers than the control group.

To examine associations between ABC-6 and falls with quantitative gait variables, we used Pearson correlation coefficients. We also conducted linear regression analysis to examine whether the ABC-6 score and gait variables (independent variables in separate analyses) were associated with falls (dependent variable). Finally, we constructed receiver operating characteristic curves for ABC-6 and gait speed in order to determine their diagnostic performance. We chose these variables because they demonstrated a significant correlation with falls and are easy to administer in any clinical setting. The dependent variable was fallers, previously defined as individuals with >2 falls in the previous year.[12,25] We calculated the area under the curve with 95% confidence intervals, and cutoff values that produced optimal sensitivity and specificity.

Results

From the original sample of 213 people, we obtained balance confidence and falls data from 180 subjects (33 subjects were not available). There were no differences in age or sex between these 33 subjects and the 180 who participated (P>.05). People with ET were divided into 2 groups based on the median score (50) on the mMMSE: patients with a score <50 were classified as nondemented ET with a lower cognitive score (ET-LCS), and patients with a score $\geq$50 were classified as ET with a higher cognitive score (ET-HCS). We used the median value of the mMMSE score for several reasons. First, it is mathematically derived and therefore less subject to bias, post hoc manipulation, or both. Second, it

List of abbreviations:

ABC-6	6-item Activities of Balance Confidence
ANOVA	analysis of variance
ET	essential tremor
ET-HCS	essential tremor with higher cognitive test scores
ET-LCS	essential tremor with lower cognitive test scores
mMMSE	Modified Mini-Mental State Examination