

ORIGINAL ARTICLE

Functional Mobility and Postural Control in Essential Tremor

Sarah L. Parisi, MSc, Martin E. Héroux, MA, PT, Elsie G. Culham, PhD, PT, Kathleen E. Norman, PhD, PT

ABSTRACT. Parisi SL, Héroux ME, Culham EG, Norman KE. Functional mobility and postural control in essential tremor. *Arch Phys Med Rehabil* 2006;87:1357-64.

Objective: To evaluate functional mobility and postural control in participants with essential tremor (ET).

Design: Cross-sectional cohort study.

Setting: Motor performance research laboratory.

Participants: Sixteen participants with ET including head tremor (age, 59.4 ± 12.0 y), 14 participants with ET and no head tremor (age, 57.1 ± 15.9 y), and 28 healthy controls (age, 58.4 ± 12.4 y).

Interventions: Not applicable.

Main Outcome Measures: We assessed the Timed Up & Go, time to ascend and descend stairs, Dynamic Gait Index, and Berg Balance Scale (BBS). Participants completed the Activities-specific Balance Confidence Scale and the Human Activity Profile. We assessed postural control using center-of-pressure measures from force platform recordings of quiet standing in 5 conditions.

Results: Participants with ET including head tremor performed worse than controls on all functional mobility performance and self-report measures ($P < .05$) except the BBS and stair descent time. Mean performance of ET participants without head tremor was intermediate between the other 2 groups. Sway speed measures of postural control showed similar patterns, but no significant group differences in post hoc analysis. There were no statistically significant or clinically important correlations between measures of tremor status and functional mobility status.

Conclusions: Participants with ET show reduced functional mobility, especially those with head tremor.

Key Words: Disability evaluation; Equilibrium; Essential tremor; Musculoskeletal system; Rehabilitation.

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ESSENTIAL TREMOR (ET) is the most common neurologically based movement disorder.¹ It is estimated to affect between 0.4% and 3.9% of the population¹ and, although it can become symptomatic at any age,² there is general agreement that prevalence increases with age.^{1,2} Population-based studies

have estimated the prevalence of ET in people over 70 to be 5% to 7%.^{3,4} ET is characterized primarily by hand tremor; however, tremor of the head, legs, voice, or trunk may also occur.⁵ A diagnosis of ET may be given when visible and persistent postural or kinetic tremor is observed in the hands or forearms (with or without other limbs affected) or in the head,⁶ and other neurologic disorders with similar tremor features (eg, Parkinson's or cerebellar disease) have been ruled out. However, the vast majority of people with ET do not seek specialist medical attention and many remain undiagnosed.^{1,3,4,7}

Because hand tremor is the main feature of classic ET, studies of activity limitations in this population have principally focused on hand function.⁸⁻¹² Nevertheless, limitations in whole body movements have also been reported in people with ET. Bain et al¹³ reported that many ET respondents to a survey reported difficulty with stairs. Furthermore, tandem gait abnormalities in people with ET have been reported^{14,15} and recently have been shown to be similar to tandem gait abnormalities of people with cerebellar disease.¹⁶ These reports led us to hypothesize that there are movement performance impairment and activity limitations in many people with ET. Specifically, we hypothesized that people with ET have altered balance and limitations in functional mobility compared with age-matched control participants.

Our primary objective was to determine if people with ET perform differently than a control group on a wide array of measures of functional mobility and postural control. Because ET is primarily a disorder of older adults, we considered it relevant to include measures that are associated with fall risk. Postural control in ET has recently been examined,¹⁷ but no previous studies of people with ET have investigated any of the other measures we used in this study. Although strength is neither reported nor suspected to be affected in ET, we measured participants' strength in major lower-limb muscle groups because a decrement in lower-limb strength would be a confounding variable in functional mobility tasks.

If people with ET have functional mobility limitations, it is clinically relevant to determine whether the severity of limitations is associated with tremor status. Our secondary objective was therefore to determine—for any measures of functional mobility in which the ET and control groups differed—whether outcomes on such measures correlated with measures of tremor or disease state.

Our study was thus designed as a comparison of 2 groups. However, as participant testing and data processing proceeded, we noted that approximately half of our ET participants demonstrated head tremor. Head tremor may be hypothesized to have a deleterious effect on functional mobility and postural control based on how the head is normally controlled in walking and turning¹⁸ and the fact that extra head motion is likely to render more complicated the task of integrating visual and vestibular inputs for balance. In addition, there has been a recent report¹⁷ of postural control abnormalities in ET participants with head tremor. We therefore expanded our primary objective to perform a 3-group comparison: that is, whether there were differences between control participants, ET participants without head tremor and ET participants with head tremor on the aforementioned measures of functional mobility and postural control.

From the School of Rehabilitation Therapy, Queen's University, Kingston, ON, Canada.

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Reprint requests to Kathleen E. Norman, PhD, PT, School of Rehabilitation Therapy, Queen's University, 31 George St, Kingston, ON K7L 3N6, Canada, e-mail: kn4@post.queensu.ca.

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METHODS

Participants

We recruited community-dwelling persons with ET through the local movement disorders clinic as well as through community advertisements for people with tremor. Prospective participants recruited through the latter route who had not been formally diagnosed with ET had other causes of tremor (eg, hyperthyroidism, medication) ruled out by their physician prior to inclusion. Control participants were recruited through community advertisement and through acquaintances of the investigators. Exclusion criteria for both groups included presence of other neurologic disorders, major musculoskeletal abnormalities or pain, and visual or cognitive impairments severe enough to render a participant unable to read the questionnaires or follow the instructions for the other measures. For the ET group, the use of medications known to affect tremor, other than β -adrenergic antagonists which are commonly prescribed and unlikely to affect coordination, was also an exclusion criterion. A pilot study on hand tremor and postural control showed statistically significant differences in groups with a sample size of 16 per group. To improve generalizability of the results, we aimed to recruit 30 subjects with ET and 30 without. All participants provided informed consent to the protocol that had been approved by the Health Sciences Research Ethics Board of Queen's University and its affiliated hospitals.

Procedures

Intake interview and tremor assessment. We interviewed participants to obtain demographic and relevant medical information, and history of falls or near-misses—the latter defined as the participant's having felt that he/she was going to fall but did not actually do so—in the previous year. In addition, ET participants were questioned about features of their tremor including age of onset and which body parts were currently affected.

We quantified hand tremor by measuring, using laser displacement sensors, the oscillations of a light box held in front of the body as described in a previous publication.¹⁹ In ET participants, we expected to find a predominant peak frequency and a concentration of power in the typical interval for this disorder between 4 and 9 Hz; this was used as a confirmation of diagnosis and an inclusion criterion. While physiologic tremor at the wrist in this task will also include power in this frequency interval, it is without any predominant peak having a high concentration of power. Based on methods also described previously,¹⁹ a measure of postural tremor amplitude was calculated based on the highest summed power in a 1-Hz window surrounding the peak frequency in the power spectrum calculated from the acceleration time series. This was done for each hand, measuring both horizontal and vertical displacement of the box in each of 2 trials, for a total of 8 such values for each participant, the highest of which was used as our measure of tremor severity.

We quantified disability associated with tremor by using the Tremor Disability Questionnaire (TDQ), which has shown to be a valid and reliable tool with people with ET.¹² It was modified so that participants could self-administer the questionnaire and was subsequently scored by the investigators. A total tremor disability score out of 100 was assessed from answers to 36 questions, 31 of which relate almost entirely to the impact of tremor on hand function, and the remainder to tremor in other body parts and overall embarrassment from tremor. Higher scores represent greater disability.

Clinical measures of functional mobility and balance. We used 5 performance-based clinical measures. The Timed Up & Go (TUG) test requires the participant to rise from sitting, walk 3m, turn, and return to sitting.²⁰ A mean time of 2 trials was our outcome measure. The Dynamic Gait Index (DGI) is an 8-item test designed to assess maintenance of balance during gait, each performed while walking down a hallway of 6.1m (20ft).²¹ All DGI items are scored 0, 1, 2, or 3 by an observer; the best possible score is 24. Tasks included items such as turning one's head from side to side and stepping over an obstacle. The Berg Balance Scale (BBS) is a 14-item test in which participants are rated on ability to maintain balance while performing tasks such as standing with eyes closed, turning 360°, and standing on 1 foot.²² All BBS items are scored 0, 1, 2, 3, or 4 by an observer; the best possible score is 56. These 3 measures have demonstrated adequate interrater reliability in other studies.^{20,23,24} In addition, we developed timed tests of stair performance, one each of ascent and descent on a standard flight of 10 stairs, because of the earlier survey report of "difficulty with stairs."¹³ For each test, participants were instructed to "go (up/down) as quickly as you safely can," and participants were free to use the handrails located on either side. A short rest period was provided between the ascent and descent tests. Reliability was not determined for these timed stair tests. For all 5 of these clinical measures, testing was performed in the same settings—that is, same room for the TUG and BBS, same corridor for the DGI, same stairway for stair ascent and descent. All measures were timed or rated by 1 of 3 investigators using a standardized protocol. Blinding to group was not possible.

We asked participants to complete 2 self-report measures. The Activities-specific Balance Confidence (ABC) scale consists of a list of 16 activities.²⁵ For each activity, participants rated on a visual scale between 0% and 100% how confident they felt that they would not lose their balance or become unsteady. The outcome score of the ABC is the mean of all 16 ratings such that 100 is the maximum score and represents high balance confidence. The Human Activity Profile (HAP) is designed to determine a participant's level of physical activity and consists of a list of 94 activities related to self-care, mobility, household tasks, or recreation listed in order of increasing metabolic cost.^{26,27} Participants were assigned an "adjusted activity score" which is the difference between the rank of the most advanced activity reported as "still doing" and the number of activities reported as "have stopped doing" that are lower on the scale.²⁶ The maximum score is 94 and indicates a high activity level. Both the ABC and HAP have demonstrated good test-retest reliability.^{25,28}

Postural control measures. We obtained postural control measures from recordings of participants standing barefoot on a force platform.^a Four 60-second trials were collected at a sampling rate of 500 Hz under each of the following conditions: feet apart with eyes open, feet apart with eyes closed, feet together with eyes open, and feet together with eyes closed. The distance between a participant's feet in the "feet apart" conditions was standardized according to height, with a maximum distance of 30 cm between the bases of the fifth metatarsal bones. Subsequently, tandem stance trials of 30-second duration were recorded, 1 each of right-foot-ahead and left-foot-ahead. Center of pressure (COP) time series were calculated from the force platform outputs and were filtered with a 20 Hz low-pass filter (Butterworth zero-lag, 10th order, in Matlab software^b). Standard deviation (SD) of the COP in both the right-left and anteroposterior (AP) directions was calculated, and used as the outcome measures of overall displacement of the COP. Sway speed of the COP was also calculated based on

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