J Neurol Sci. Author manuscript; available in PMC 2017 July 15.

Published in final edited form as:

J Neurol Sci. 2016 July 15; 366: 240–245. doi:10.1016/j.jns.2016.05.034.

Self-reported Physical Activity in Essential Tremor: Relationship with Tremor, Balance, and Cognitive Function

Elan D. Louis, MD, MS[a,b,c,*], **Kathleen Collins, MA**[a], **Brittany Rohl, BS**[a], **Sarah Morgan, BA**[a], **Daphne Robakis, MD**[a], **Edward D Huey, MD**[d,e,f], and **Stephanie Cosentino, PhD**[d,e]

[a]Division of Movement Disorders, Department of Neurology, Yale School of Medicine, Yale University, New Haven, CT, USA

[b]Department of Chronic Disease Epidemiology, Yale School of Public Health, Yale University, New Haven, CT, USA

[c]Center for Neuroepidemiology and Clinical Neurological Research, Yale School of Medicine, Yale University, New Haven, CT, USA

[d]Department of Neurology, College of Physicians and Surgeons, Columbia University, New York, NY, USA

[e]G.H. Sergievsky Center, College of Physicians and Surgeons, Columbia University, New York, NY, USA

[f]Taub Institute for Research on Alzheimer's Disease and the Aging Brain, Columbia University, New York, NY, USA

Abstract

Background—Physical inactivity may be the result of medical comorbidities. Inactivity itself may also lead to important health consequences, especially in older patients. Essential tremor (ET) patients may have a variety of physical and cognitive problems that could detrimentally impact on level of physical activity. Yet, to our knowledge, there have been no studies of physical activity in these patients.

Methods—Self-reported physical activity was assessed using the Physical Activity Scale for the Elderly (PASE) in 100 ET cases (mean age 80.5 years) enrolled in a clinical study. Additional clinical measures were the total tremor score, Montreal Cognitive Assessment (MOCA) score and number of steps taken off of the straight line during tandem gait (a measure of balance).

Results—Lower PASE score was associated with older age, more tandem gait difficulty, higher total tremor score and lower MOCA score (all $p<0.05$). In a linear regression model that included total tremor score, MOCA score, number of steps off of the straight line during tandem

Correspondence: Elan Louis MD, Yale School of Medicine, Department of Neurology, LCI 710, 15 York Street, PO Box 208018, New Haven CT 06520-8018. Tel: +1 (203) 785-6599, FAX: +1 (203) 785-4085, elan.louis@yale.edu.

Conflict of Interest: None

gait, and age, higher total tremor score (p = 0.046) and more steps off of the straight line during tandem gait (p = 0.014) were independently associated with reductions in physical activity.

Conclusions—Several of the motor features of ET (tremor and imbalance) are independently associated with reductions in level of physical activity.

Keywords

essential tremor; cognition; dementia; physical activity; function; clinical

1. Introduction

Physical inactivity may be the result of medical comorbidities. Conversely, it may in turn lead to important health consequences, especially in elderly and frail patients [1]. Aside from leading to reductions in lean muscle mass and strength, physical inactivity is a risk factor for coronary heart disease, stroke, hypertension, and type 2 diabetes mellitus [2]. Level of physical activity is also a predictor of risk of mortality in the elderly [3]. Hence, in the elderly, level of physical activity is a particularly important health metric.

The Physical Activity Scale for the Elderly (PASE) is a commonly used geriatric self-report scale designed to assess physical activity of older individuals in epidemiological studies [4]; the scale has been used to study patients with cognitive impairment [5] as well as a range of other chronic and progressive neurological disorders of the elderly (e.g., Alzheimer's disease, Parkinson's disease [PD]) [5, 6]. To our knowledge; however, there have been no similar studies of physical activity in patients with essential tremor (ET). Hence, there is a curious gap in knowledge.

ET patients have a variety of physical problems that could impact on level of physical activity. Kinetic tremor itself may interfere with upper limb use and function [7]. A mild form of gait ataxia has also been described in ET, and this has been associated with loss of confidence in balance, and greater propensity for near misses and falls [8–11]. ET patients also have increased frailty compared to their counterparts without the disease [12]. Leaving these motor issues aside, ET patients may also have more cognitive dysfunction than age-matched controls [13–15]. Prior work has established that cognitive function is associated with level of physical activity in the aged [16], with declines in cognition being associated with more limited physical activity.

The goal of this study of ET patients was to examine the relationship between self-reported physical activity and tremor severity, balance, and cognitive function. Our *a priori* hypothesis was that level of physical activity in ET could co-vary as a function of each of these common ET-related problems. There is a complex web of physical and cognitive dysfunctions in many patients with ET, and it is hoped that analyses such as these will allow us to begin to untangle some of the relationships and their broader consequences for the patient.

2. Methods

2.1. Study Design

Cases were enrolled in a longitudinal study of cognitive function in ET (Clinical Pathological Study of Cognitive Impairment in Essential Tremor, NINDS R01NS086736), which commenced enrollment in July 2014. This goal of the study is to clinically and pathologically characterize a cohort of ET patients using motor, neuropsychiatric, and neuropsychological measures. Three assessments (baseline, after 18 months and after 36 months) are planned. For the current analyses, we included baseline data from the first 100 participants, enrolled from July 2014 to October 2015. Cases were recruited using an advertisement posted on a study website and other websites (International Essential Tremor Foundation) that listed the following eligibility criteria: 1. Diagnosis of ET, 2. 55 years old. 3. Did not have deep brain stimulation surgery for ET, 4. Willingness to perform study measures and be a brain donor. The in-person assessment of clinical features, including tremor, cognition, level of physical activity, and gait was conducted by trained personnel in cases' homes (see below). The cognitive test battery was designed by a neuropsychologist (S.C.) specifically for the study. The Yale University and Columbia University Internal Review Boards approved study procedures. Signed informed consent was obtained upon enrollment.

2.2. Study Evaluation

To date, ET cases have enrolled from 37 US states. During the in-person assessment, a trained research assistant (K.C., B.R., S.M.) administered a series of structured questionnaires, which elicited data on demographic and clinical variables.

Self-reported physical activity was measured using the PASE [4]. This is a commonly used and validated geriatric self-report scale designed to assess the physical activity of older individuals. Six items assess leisure activities (e.g., walking, sports), 6 items assess household activities (e.g. housework, gardening), and 1 item assesses paid or volunteer employment. For leisure activities, the PASE asks individuals to indicate how frequently (never, seldom, sometimes, often) and for how many hours each week (<1 hour, 1–2 hours, 2–4 hours, 4+ hours) they engage in the activities. For household activities, the PASE solicits information about household activities in which individuals respond yes or no. Finally, individuals are asked whether or not they work or volunteer outside their home (yes or no) and what degree of physical activity is required at their work (mainly sitting, some walking, handling of light materials, heavy manual work). The total PASE score is computed by summation of weighted item scores combined in an algorithm [4]. The PASE scores range from 0 to 360, with higher scores indicating higher physical activity levels [17].

The Activities-specific Balance Confidence Scale (ABC-6, range of total score = 0 [most impaired] - 100 [no impairment]) was administered. The scale asks subjects to self-rate their confidence in performing functional activities without losing balance or becoming unsteady, assessing a range of 6 situation-specific activities (e.g., reaching on tiptoes for an object, stepping on or off an escalator) [18]. During the assessment, the assistant also asked cases to indicate how many falls they had 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 [19]."

Trained research assistants also administered a 4-hour neuropsychological test battery. We selected tests for the neuropsychological test battery that required minimal motor activity so as to reduce the chance that tremor would affect test scores. The battery included the Montreal Cognitive Assessment [20], which is a general cognitive test, (MOCA, range = 0–30 [higher reflects better cognition]) as well as measures of several cognitive domains, including attention, memory, executive function, visuospatial ability, and language. Cases also designated an informant, usually a close friend or relative, who participated in a short semi-structured interview consisting of questions about each case's behavior. In some cases, an informant was not available. For several of the current analyses, we analyzed cognitive scores that covered the domains of verbal memory and executive functioning. These domains were selected based on their susceptibility to compromise in ET [21, 22] as well as their reported response to physical activity. The memory scores included measures of delayed verbal memory from the California Verbal Learning Test- 2 [23] and the Logical Memory subtest of the Wechsler Memory Scales-Revised [24]. The executive function scores included measures of phonemic fluency (total score) and sorting (total number of free sorts) from the Delis Kaplan Executive Function Systems Test [25]. A composite score was created for each domain by averaging the standardized scores for each measure within the domain.

Cases also completed the Geriatric Depression Scale, a 30-item self-report measure of depressive symptoms [26]. This is a self-administered measure of depressive symptoms designed for use in older persons in which the subject answers yes/no questions regarding symptoms of depression. Higher scores indicate more symptoms of depression. Scores of 10 and above reflect significant depression and scores of 20 or above reflect severe depression [26].

A videotaped neurological examination was performed during the in-person assessment. This included one test for postural tremor and five for kinetic tremor (e.g., pouring, drinking) performed with each arm (12 tests total). A neurologist specializing in movement disorders (E.D.L.) used a reliable [27] and valid [28] clinical rating scale, the Washington Heights-Inwood Genetic Study of ET (WHIGET) tremor rating scale, to rate postural and kinetic tremor during each test: (0 – 3). These ratings resulted in a total tremor score (range = 0–36) [29]. The videotaped assessment also included an assessment of tandem gait. Each case was asked to walk tandem (place one foot in front of the other touching toe to heel) and the number of missteps during 10-steps was counted by the neurologist.

2.3. ET Diagnoses

Each ET patient had received a clinical diagnosis of ET from their treating neurologist. After enrollment, ET diagnoses were then carefully re-confirmed (E.D.L.) using the videotaped neurological examination and WHIGET diagnostic criteria (moderate or greater amplitude kinetic tremor [tremor rating 2] during three or more tests or a head tremor, in the absence of Parkinson's disease, dystonia or another cause) [30]. These criteria have been shown to be reliable [27] and valid [29], and are used routinely in clinical and epidemiological studies of ET [22, 31–33].

2.4. Cognitive Diagnoses

The cognitive test scores and informant interview informed a diagnostic case conference in which trained experts (S.C., E.D.H.) assigned a Clinical Dementia Rating Score (CDR) [34] to each case, and ultimately a cognitive diagnosis (normal cognition, mild cognitive impairment, or dementia); cases with neuropsychological test impairment and a CDR 1 were considered clinically demented whereas those with a CDR score <0.5 and impairment on one test or less were considered normal.

2.5. Statistical Analyses

Data were analyzed in SPSS (Version 22) with standard summary measures presented (Table 1).

In bivariate analyses, we examined the associations between self-reported physical activity (PASE score) and a range of demographic and clinical variables; these analyses used Pearson's correlation coefficients or Spearman's correlation coefficients (when the variable was not normally distributed) (Table 2).

Although we assessed balance in several ways (ABC-6 score, number of falls, tandem steps), only the latter was an objective rather than self-report test. Hence, regression analyses used this more objective metric.

We accounted for age effects in two ways. First, to adjust for the possible confounding effects of age, we used a series of a linear regression models to examine the association between the independent variables (i.e., total tremor score, number of steps taken off of the straight line during tandem gait, or MOCA score in different models) and the dependent variable (i.e., PASE score), adjusting for age. Second, since the age range of our sample was very broad (55–95 years), and age was a major confounder, we repeated these regression analyses using a subsample of cases whose age was more homogeneous, spanning a two-decade period (65–85 years), excluding the youngest (<65 years) and the oldest (>85 years). In this restricted sample, we also performed multivariate linear regression analyses in which all three variables (total tremor score, number of steps taken off of the straight line and MOCA score) were modeled along with age, as predictors of PASE score.

Using a more granular approach, we examined the score of each of the PASE items separately, assessing its correlation with total tremor score, number of steps off of the straight line during tandem gait, and MOCA score in 100 ET cases; these analyses used Spearman's correlation coefficients (Table 3).

We also divided total tremor score, number of steps off of the straight line during tandem gait and MOCA score into tertiles, comparing PASE score (dependent variable) across tertiles in linear regression models that adjusted for age (Table 4).

Finally, extending our analyses of cognitive function beyond the MOCA, we also assessed whether the executive function composite score and memory function composite score were associated with reductions in physical activity (Pearson's r).

3. Results

The 100 ET cases had a mean age of 80.5 years (range = 55–95); 98 of 100 were age 65 and older. The mean total tremor score was 21.5; none had isolated head tremor. The mean age of onset was 39.1 ± 21.2 years (median = 40.0), and was ≤65 years in 95 (95%) cases. Eighty-four cases had a tremor duration ≥3 years; only one had tremor duration <3 years and an age of onset after 65 years. The median number of falls in the past year was 0.5, but ranged from 0–30, and the median number of steps off of the straight line during tandem gait was 6.0 out of 10 (range = 0–10). The mean MOCA score was 23.95 (range = 10–30) (Table 1).

In bivariate analyses, we examined the associations between lower self-reported physical activity (lower PASE score) and a range of demographic and clinical variables (Table 2). Lower self-reported physical activity was associated with older age, lower balance confidence (ABC-6 score), more falls reported in the past year, and more tandem gait difficulty (Table 2). It was also associated with more tremor on examination (higher total tremor score) and lower MOCA score (Table 2).

Age was an important confounder to consider: older age was associated with PASE score (see above), higher total tremor score (Pearson's $r = 0.24$, $p = 0.016$), more steps off of the straight line during tandem gait (Spearman's $r = 0.43$, $p < 0.001$), and lower MOCA score (Spearman's $r = -0.42$, $p < 0.001$). To adjust for the possible confounding effects of age, we used a linear regression model to examine the association between total tremor score and PASE score (dependent variable) while adjusting for age. In that model, older age was associated with reductions in physical activity (beta = −2.67, $p = 0.001$) whereas higher total tremor score was only marginally associated with reductions in physical activity (beta = −1.66, $p = 0.15$). A second linear regression model examined the association between number of steps off of the straight line during tandem gait and PASE score. In that model, number of steps off of the straight line (beta = −4.81, $p = 0.002$) and older age (beta = −2.06, $p = 0.007$) were independently associated with reductions in physical activity. A third linear regression model examined the association between MOCA score and PASE score (dependent variable) while adjusting for age. In that model, older age was associated with reductions in physical activity (beta = −2.37, $p = 0.004$) whereas lower MOCA score was marginally associated with reductions in physical activity (beta = 2.68, $p = 0.08$).

Since adjustment may not ideally encapsulate the effects of a confounder, and in some instances may give undue weight to the effects of these confounders, we used a second approach. Since our sample was very heterogeneous with respect to age (55–95 years), we performed additional analyses with a subsample of cases whose age was more homogeneous (65–85 years), excluding the very young and the very old. This allowed us to additionally account for any age effects. There were 71 cases in this analysis. In the first model, older age was no longer associated with reductions in physical activity (beta = −1.23, $p = 0.36$)

whereas higher total tremor score was significantly associated with reductions in physical activity (beta = −2.56, p = 0.038). In the second model, older age was no longer associated with reductions in physical activity (beta = −1.49, p = 0.21) whereas number of steps off of the straight line during tandem gait was associated with reductions in physical activity (beta = −5.16, p = 0.003). In the third model, older age was no longer associated with reductions in physical activity (beta = −1.40, p = 0.29) whereas lower MOCA score was associated with reductions in physical activity (beta = 3.39, p = 0.05).

In a model (71 cases) that simultaneously included MOCA score, total tremor score, number of steps off of the straight line during tandem gait, and age (i.e., four independent variables), we found that higher total tremor score (beta = −2.27, p = 0.046) and more steps off of the straight line during tandem gait (beta = −4.45, p = 0.014) were each independently associated with reductions in physical activity. In that model, neither MOCA score (beta = 0.52, p = 0.76) nor age (beta = −0.79, p = 0.51) were associated with physical activity. Adding total number of prescription medications to this model did not change the results. Adding the Geriatric Depression Scale score to another model did not change the results either. Furthermore, excluding six cases who were clinically demented did not change the results. When we restricted the sample to cases with CDR score = 0, the strongest predictors of reduced physical activity were total tremor score and steps off of the straight line during tandem gait.

Looking at a more detailed level, we examined the score on each of the PASE items separately, to determine whether it correlated with total tremor score, number of steps off of the straight line during tandem gait, and MOCA score (Table 3). While there were differences, each of the three variables seemed to be associated with reductions in outdoor gardening, lawn work or yard care, and moderate sport and recreational activities, although some p values were only marginally significant (Table 3). Greater tandem gait difficulty and greater cognitive impairment were also associated with reductions in strenuous physical activities and home repairs (Table 3).

In addition to treating them as continuous variables (above), we also divided total tremor score, number of steps off of the straight line during tandem gait and MOCA score into tertiles. Individuals in the highest tertile of total tremor score had severe tremor (total tremor score > 23), those in the highest tertile of tandem mis-steps had marked imbalance (7 or more out of 10 steps off of the straight line), and those in the lowest MOCA tertile had considerable cognitive impairment (MOCA scores ≤23) (Table 4). In these linear regression analyses, which adjusted for age, we show that individuals in the extreme tertiles had PASE scores that were very different (approximately one-half) of those of individuals at the other extreme (Table 4).

Extending our analyses of cognitive function beyond the MOCA, we also assessed whether the executive function composite score and memory function composite score were associated with reductions in physical activity. More impaired executive function (executive function composite score) was not associated with reductions in physical activity (Pearson’s r = 0.15, p = 0.15) but more impaired memory (memory function composite score) was associated with reductions in physical activity (Pearson’s r = 0.22, p = 0.036).

4. Discussion

The goal of this study was to determine whether severity of upper limb tremor, gait/balance difficulty and cognitive difficulties are associated with a reduction in level of self-reported physical activity in patients with ET. While each was associated with the PASE score (i.e., patients with more severe tremor, more balance difficulty, and more cognitive impairment evidenced reductions in their physical activity, and this was independent of age), in the final model, total tremor score and number of steps off of the straight line during tandem gait were the best indicators of reduced level of physical activity. In other words, tremor and the balance issues in ET are correlated with corresponding reductions in level of physical activity.

From prior studies, we know that ET is associated with anxiety [35], depression [36], and social phobia [37], as well as functional difficulties involving the upper limbs [7], greater propensity for near misses and falls [10] and increased frailty [12]. The current data now indicate that, independent of age, several of the features of ET also seems to be associated with reductions in level of physical activity.

One limitation of this study should be emphasized. This was not a case-control study in which we directly compared the level of physical activity in ET cases and a group of age-matched controls. As a result, we cannot conclude that ET is associated with a reduction in physical activity in comparison to age-matched controls. However, we can conclude that the severity of upper limb tremor, imbalance and perhaps cognitive ability in ET are associated with corresponding reductions in physical activity and that this is independent of advanced age in these cases. That is, several of the motor features of ET (tremor and balance) are independently associated with reductions in level of physical activity.

It is difficult to place these findings in context because of the dearth of similar studies. A study of 948 normal older Mexican Americans of slightly older age than our sample (mean age = 82.2 ± 4.5 years) reported a mean PASE score of 78.5 ± 61.6, which is similar to the value of 79.6 ± 63.2, which we now report in ET [3]. Another study of 1,117 elderly men (mean age = 78.2 ± 5.3) reported a mean PASE that was approximately 135, which is higher than ours [38]. However, we know of no other study of ET to which we can compare our data. While a number of studies have been published on gait and balance in ET [19, 39] and on functional activity [7, 40], examining the use of the hands during activities of daily living, there has been no attendant study of level of physical activity.

We examined each of the PASE items separately, assessing its correlation with the three factors of interest: total tremor score, number of steps off of the straight line during tandem gait, and MOCA score. Each of these three factors seemed to be associated with reductions in outdoor gardening, lawn work or yard care, and moderate sport and recreational activities. Greater tandem gait difficulty and greater cognitive impairment were also associated with reductions in strenuous physical activities and home repairs. None of these factors influenced taking walks outside the home or hours/day walking.

What are the clinical implications of these findings? First, the gait and balance difficulty that is present in ET, and which is often viewed as minor or of limited consequence [41], seems to be associated with reductions in level of physical activity. Similarly, the tremor of ET and, to a lesser extent, the cognitive features, seem to be associated with level of physical activity. Level of physical activity is an important health metric and a contributor to/predictor of other morbidities. This metric may be important to monitor in clinical settings, particularly in a frail and elderly patient population such as ET.

This study should be interpreted within the context of certain additional limitations. First, the fact that the data were ascertained from a single time interval precludes direct inferences about causality in the relationship between the variables of interest and physical activity. Second, the sample size, 100 ET cases, is modest; nonetheless, a number of significant differences were noted across a wide range of variables of *a priori* interest. Another clear limitation is that physical activity was assessed with a self-report measure (PASE) rather than an objective measure. In some studies, PASE scores correlate with objective measures of energy expenditure; nonetheless this is not the case with all studies [42]. Despite this limitation, the PASE is a standard and commonly-used measure in a wide range of research contexts [4–6], having been employed in more than 150 studies of physical activity. Finally, the mean age of our participants was 80.5 ± 8.1 years. It would be of value to see whether our findings could be generalized to a patient group that included young and middle-aged adults.

This study had several strengths. These included (1) the prospective enrollment of study subjects using a pre-specified study protocol (i.e., this was not a retrospective chart review), (2) the use of a range of measures ranging from subjective (self-reported physical activity), objective (number of steps taken off of straight line during tandem gait), and performance-based-clinical assigned (total tremor score), (3) the simultaneous consideration of a number of diverse contributors, both motor and non-motor, to physical activity, while adjusting for other potential confounders such as age and use of prescription medications.

In summary, tremor and the balance issues in ET are correlated with corresponding reductions in level of physical activity. Level of physical activity is an important health metric and a contributor to/predictor of other morbidities. This metric may be important to monitor clinically, particularly in a frail and elderly patient population.

Acknowledgments

Dr. Louis has received research support from the National Institutes of Health: NINDS R01 NS042859 (principal investigator), NINDS R01 NS39422 (principal investigator), NINDS R01 NS086736 (principal investigator), NINDS R01 NS073872 (principal investigator), NINDS R01 NS085136 (principal investigator) and NINDS R01 NS088257 (principal investigator).

References

1. Autenrieth CS, Kirchberger I, Heier M, Zimmermann AK, Peters A, Doring A, et al. Physical activity is inversely associated with multimorbidity in elderly men: results from the KORA−Age Augsburg Study. Prev Med. 2013; 57:17–9. [PubMed: 23485795]
2. Logan SL, Gottlieb BH, Maitland SB, Meegan D, Spriet LL. The Physical Activity Scale for the Elderly (PASE) questionnaire; does it predict physical health? Int J Environ Res Public Health. 2013; 10:3967–86. [PubMed: 23999546]

3. Ottenbacher AJ, Snih SA, Karmarkar A, Lee J, Samper−Ternent R, Kumar A, et al. Routine physical activity and mortality in Mexican Americans aged 75 and older. J Am Geriatr Soc. 2012; 60:1085–91. [PubMed: 22647251]
4. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. J Clin Epidemiol. 1993; 46:153–62. [PubMed: 8437031]
5. Watts AS, Vidoni ED, Loskutova N, Johnson DK, Burns JM. Measuring Physical Activity in Older Adults with and without Early Stage Alzheimer's Disease. Clin Gerontol. 2013; 36:356–74. [PubMed: 24062599]
6. Bryant MS, Hou JG, Collins RL, Protas EJ. Contribution of Axial Motor Impairment to Physical Inactivity in Parkinson Disease. Am J Phys Med Rehabil. 2015 Epub ahead of print.
7. Bain PG, Mally J, Gresty M, Findley LJ. Assessing the impact of essential tremor on upper limb function. J Neurol. 1993; 241:54–61. [PubMed: 8138823]
8. Kronenbuerger M, Konczak J, Ziegler W, Buderath P, Frank B, Coenen VA, et al. Balance and motor speech impairment in essential tremor. Cerebellum. 2009; 8:389–98. [PubMed: 19452239]
9. Hoskovcova M, Ulmanova O, Sprdlik O, Sieger T, Novakova J, Jech R, et al. Disorders of Balance and Gait in Essential Tremor Are Associated with Midline Tremor and Age. Cerebellum. 2013; 12:27–34. [PubMed: 22535593]
10. Rao AK, Gilman A, Louis ED. Balance confidence and falls in nondemented essential tremor patients: the role of cognition. Archives of physical medicine and rehabilitation. 2014; 95:1832–7. [PubMed: 24769121]
11. Louis ED, Rao AK, Gerbin M. Functional correlates of gait and balance difficulty in essential tremor: balance confidence, near misses and falls. Gait Posture. 2012; 35:43–7. [PubMed: 21930384]
12. Louis ED, Benito-Leon J, Vega S, Bermejo-Pareja F. Frailty in elderly persons with essential tremor: a population-based study (NEDICES). Eur J Neurol. 2011; 18:1251–7. [PubMed: 21426443]
13. Benito-Leon J, Louis ED, Mitchell AJ, Bermejo-Pareja F. Elderly-onset essential tremor and mild cognitive impairment: a population-based study (NEDICES). J Alzheimers Dis. 23:727–35. [PubMed: 21304183]
14. Bermejo-Pareja F, Louis ED, Benito-Leon J. Risk of incident dementia in essential tremor: A population-based study. Mov Disord. 2007; 22:1573–80. [PubMed: 17516478]
15. Benito-Leon J, Louis ED, Bermejo-Pareja F. Population-based case-control study of cognitive function in essential tremor. Neurology. 2006; 66:69–74. [PubMed: 16401849]
16. Eggermont LH, Milberg WP, Lipsitz LA, Scherder EJ, Leveille SG. Physical activity and executive function in aging: the MOBILIZE Boston Study. J Am Geriatr Soc. 2009; 57:1750–6. [PubMed: 19702618]
17. Ellis T, Boudreau JK, DeAngelis TR, Brown LE, Cavanaugh JT, Earhart GM, et al. Barriers to exercise in people with Parkinson disease. Phys Ther. 2013; 93:628–36. [PubMed: 23288910]
18. Peretz C, Herman T, Hausdorff JM, Giladi N. Assessing fear of falling: Can a short version of the Activities-specific Balance Confidence scale be useful? Mov Disord. 2006; 21:2101–5. [PubMed: 16991140]
19. Louis ED, Rao AK. Functional Aspects of Gait in Essential Tremor: A Comparison with Age-Matched Parkinson's Disease Cases, Dystonia Cases, and Controls. Tremor Other Hyperkinet Mov (N Y). 2015 May 27.5 pii: tre-5–308. eCollection 2015. doi: 10.7916/D8B27T7J
20. Nasreddine ZS, Phillips NA, Bedirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005; 53:695–9. [PubMed: 15817019]
21. Bermejo-Pareja F. Essential tremor--a neurodegenerative disorder associated with cognitive defects? Nat Rev Neurol. 2011; 7:273–82. [PubMed: 21487422]
22. Gasparini M, Bonifati V, Fabrizio E, Fabbrini G, Brusa L, Lenzi GL, et al. Frontal lobe dysfunction in essential tremor: a preliminary study. J Neurol. 2001; 248:399–402. [PubMed: 11437162]
23. Delis, DCKJ.; Kaplan, E.; Ober, BA. California Verbal Learning Test. 2. San Antonio, TX: Psychological Corporation; 2000. (CVLT - II)
24. Wechsler, D. Wechsler Memory Scale - Revised. NY: Psychological Corporation; 1987.

25. Delis, DCKE.; Kramer, JH. Delis Kaplan Executive Function System (DKEFS) Examiner's manual. San Antonio, TX: 2001.
26. Yesavage JA. Geriatric Depression Scale. Psychopharmacol Bull. 1988; 24:709–11. [PubMed: 3249773]
27. Louis ED, Ford B, Bismuth B. Reliability between two observers using a protocol for diagnosing essential tremor. Mov Disord. 1998; 13:287–93. [PubMed: 9539343]
28. Louis ED, Wendt KJ, Albert SM, Pullman SL, Yu Q, Andrews H. Validity of a performance-based test of function in essential tremor. Arch Neurol. 1999; 56:841–6. [PubMed: 10404986]
29. Louis ED, Pullman SL. Comparison of clinical vs. electrophysiological methods of diagnosing of essential tremor. Mov Disord. 2001; 16:668–73. [PubMed: 11481690]
30. Louis ED, Ottman R, Ford B, Pullman S, Martinez M, Fahn S, et al. The Washington Heights-Inwood Genetic Study of Essential Tremor: methodologic issues in essential-tremor research. Neuroepidemiology. 1997; 16:124–33. [PubMed: 9159767]
31. Louis ED, Marder K, Jurewicz EC, Watner D, Levy G, Mejia-Santana H. Body mass index in essential tremor. Arch Neurol. 2002; 59:1273–7. [PubMed: 12164723]
32. Louis ED, Ford B, Wendt KJ, Lee H, Andrews H. A comparison of different bedside tests for essential tremor. Mov Disord. 1999; 14:462–7. [PubMed: 10348470]
33. Inzelberg R, Mazarib A, Masarwa M, Abuful A, Strugatsky R, Friedland RF. Essential tremor prevalence is low in Arabic villages in Israel: door-to-door neurological examinations. J Neurol. 2006; 253:1557–60. [PubMed: 17006631]
34. Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. Neurology. 1993; 43:2412–4. [PubMed: 8232972]
35. Chandran V, Pal PK, Reddy JY, Thennarasu K, Yadav R, Shivashankar N. Non-motor features in essential tremor. Acta Neurol Scand. 2012; 125:332–7. [PubMed: 21777207]
36. Li ZW, Xie MJ, Tian DS, Li JJ, Zhang JP, Jiao L, et al. Characteristics of depressive symptoms in essential tremor. J Clin Neurosci. 2011; 18:52–6. [PubMed: 20888237]
37. Schneier FR, Barnes LF, Albert SM, Louis ED. Characteristics of social phobia among persons with essential tremor. J Clin Psychiatry. 2001; 62:367–72. [PubMed: 11411820]
38. Cousins JM, Petit MA, Paudel ML, Taylor BC, Hughes JM, Cauley JA, et al. Muscle power and physical activity are associated with bone strength in older men: The osteoporotic fractures in men study. Bone. 2010; 47:205–11. [PubMed: 20466088]
39. Earhart GM, Clark BR, Tabbal SD, Perlmutter JS. Gait and balance in essential tremor: variable effects of bilateral thalamic stimulation. Mov Disord. 2009; 24:386–91. [PubMed: 19006189]
40. Louis ED, Barnes L, Albert SM, Cote L, Schneier FR, Pullman SL, et al. Correlates of functional disability in essential tremor. Mov Disord. 2001; 16:914–20. [PubMed: 11746622]
41. Louis ED, Galecki M, Rao AK. Four Essential Tremor Cases with Moderately Impaired Gait: How Impaired can Gait be in this Disease? Tremor Other Hyperkinet Mov (N Y). 2013 Nov 4.3 pii: tre-03-200-4597-1. eCollection 2013.
42. Hagiwara A, Ito N, Sawai K, Kazuma K. Validity and reliability of the Physical Activity Scale for the Elderly (PASE) in Japanese elderly people. Geriatr Gerontol Int. 2008; 8:143–51. [PubMed: 18821997]

Highlights

- Physical activity is an important health metric to monitor in elderly persons.
- Lower physical activity can have assorted medical consequences.
- Level of physical activity has not been studied among ET patients.
- Tremor and imbalance correlated with reductions in level of physical activity.
- Several of the motor features of ET negatively impacted level of physical activity.

Table 1

Demographic and clinical characteristics of 100 ET cases

Current age in years	80.5 ± 8.1 (55–95)
Female gender	55 (55.0%)
Education in years	15.8 ± 3.4
Current smoker	2 (2.0)
Ever smoker (past or current)	49 (49.0)
Family history of ET (self-report)	50 (50.0)
Age of onset of tremor in years	39.1 ± 21.2 (1–83)
Takes daily medication for ET	58 (58.0)
Total number of prescription medications	5.9 ± 4.4 (0–26) Median = 5.0
Total tremor score	21.5 ± 5.8 (8.5–36)
ABC-6 total score	50.4 ± 28.7 (0–95.5)
Number of falls in past year	1.8 ± 3.7 (0–30) Median = 0.5
Number of steps off of the straight line during tandem gait	5.6 ± 4.0 (0–10)Median = 6.0
MOCA score	23.95 ± 4.2 (10–30) Median = 25.0
CDR Score *	
0	51 (63.8)
0.5	23 (28.8)
1	4 (5.0)
2	2 (2.5)
Geriatric Depression Scale Score	7.4 ± 5.9 (0 – 28) Median = 6.0
PASE score	79.6 ± 63.2 (0–360)

ABC-6 (Activities-specific Balance Confidence Scale), CDR (Clinical Dementia Rating Score), ET (essential tremor), MOCA (Montreal Cognitive Assessment), PASE (Physical Activity Scale for the Elderly)

* Data not available on some cases because there was no informant.

Table 2

Correlation of PASE score with demographic and clinical variables

	Correlation with PASE score or Mean ± standard deviation PASE score
Current age in years	$r_p = -0.37$, $p < 0.001$
Gender	
Male	85.8 ± 66.9
Female	74.4 ± 60.0
	p = 0.38 [a]
Education in years	$r_p = 0.04$, $p = 0.70$
Current smoker	
Yes	57.6 ± 46.1
No	80.1 ± 63.9
	p = 0.62 [a]
Ever smoker (past or current)	
Yes	75.2 ± 51.5
No	83.7 ± 72.6
	p = 0.51 [a]
Family history of ET (self-report)	
Yes	83.0 ± 70.4
No	76.1 ± 55.2
	p = 0.59 [a]
Age of onset of tremor in years	$r_p = -0.01$, $p = 0.91$
Takes daily medication for ET	
Yes	83.0 ± 66.8
No	75.0 ± 58.2
	p = 0.54 [a]
Total number of prescription medications	$r_s = -0.19$, $p = 0.088$
Total tremor score	$r_p = -0.21$, $p = 0.038$
ABC-6 total score	$r_p = 0.45$, $p < 0.001$
Number of falls in past year	$r_s = -0.26$, $p = 0.01$
Number of steps off of the straight line during tandem gait	$r_s = -0.42$, $p < 0.001$
MOCA score	$r_s = 0.31$, $p = 0.002$
Geriatric Depression Scale Score	$r_s = -0.19$, $p = 0.07$

r_p = Pearson's correlation coefficient

r_s = Spearman's correlation coefficient

[a]Student's t test

ABC-6 (Activities-specific Balance Confidence Scale), ET (essential tremor), MOCA (Montreal Cognitive Assessment), PASE (Physical Activity Scale for the Elderly)

Table 3

Correlation of score on each PASE item with total tremor score, tandem gait, and MOCA score

PASE item	Total tremor score	Number of steps off of the straight line during tandem gait	MOCA score
2. Take a walk outside your home or yard	r = −0.12, p = 0.26	r = −0.10, p = 0.32	r = 0.15, p = 0.13
2a. Hours/day walking	r = −0.20, p = 0.10	r = −0.02, p = 0.88	r = 0.02, p = 0.88
3. Engage in light sport or recreational activities such a bowling, golf…	r = −0.06, p = 0.59	r = −0.16, p = 0.12	r = 0.12, p = 0.24
3b. Hours/day engaged in light sport or recreational activities	r = −0.44, p = 0.18	r = −0.06, p = 0.88	r = 0.12, p = 0.72
4. Engage in moderate sport and recreational activities such as doubles tennis, ballroom dancing…	**r = −0.22, p = 0.03**	r = −0.19, p = 0.08	**r = 0.23, p = 0.02**
4b. Hours/day engaged in moderate sport and recreational activities	r = −0.17, p = 0.65	r = 0.03, p = 0.94	r = 0.49, p = 0.15
5. Engage in strenuous sport and recreational activities such as jogging, swimming…	r = −0.10, p = 0.34	**r = −0.34, p = 0.001**	**r = 0.27, p = 0.006**
5b. Hours/day engaged in strenuous sport and recreational activities	r = 0.08, p = 0.74	r =0.01, p = 0.96	**r = 0.50, p = 0.03**
6. Do exercises specifically to increase muscle strength and endurance such as lifting weights…	r = −0.04, p = 0.66	r = −0.12, p = 0.26	r = 0.10, p = 0.32
6b. Hours/day doing exercises specifically to increase muscle strength and endurance	r = −0.19, p = 0.16	r = 0.05, p = 0.75	r = −0.04, p = 0.82
7. Light housework such as dusting or washing dishes	r = −0.04, p = 0.73	**r = −0.25, p = 0.015**	r = 0.14, p = 0.18
8. Heavy housework or chores such as vacuuming, scrubbing floors, washing windows, carrying wood	r = −0.17, p = 0.085	**r = −0.24, p = 0.02**	r = 0.13, p = 0.21
9a. Home repairs like painting, wallpapering, electrical work, etc.	r = −0.067, p = 0.51	**r = −0.28, p = 0.006**	**r = 0.22, p = 0.03**
9b. Lawn work or yard care, including snow or leaf removal, chopping wood, etc.	**r = −0.199, p = 0.047**	r = −0.19, p = 0.06	**r = 0.27, p = 0.007**
9c. Outdoor gardening	**r = −0.20, p = 0.04**	**r = −0.37, p = <.001**	**r = 0.32, p = 0.001**
9d. Caring for another person, such as children, dependent spouse….	r = −0.04, p = 0.66	**r = −0.27, p = 0.008**	r = 0.10, p = 0.32

All correlations coefficients are Spearman's correlation coefficients. Bolded items are statistically significant with $p < 0.05$.

MOCA (Montreal Cognitive Assessment), PASE (Physical Activity Scale for the Elderly)

Table 4

PASE score by tertiles of total tremor score, tandem gait and MOCA score

	PASE score
Total tremor score tertile	
1 (≤18.5)	113.2 ± 69.7
2 (19–23)	84.4 ± 52.1
3 (23.5–36)	58.6 ± 44.0
	p = 0.006 *
	p = 0.007 **
Number of steps off of the straight line during tandem gait tertile	
1 (0–1)	113.4 ± 59.3
2 (2–6)	83.0 ± 45.3
3 (7–10)	62.8 ± 50.1
	p = 0.004 *
	p = 0.008 **
MOCA score tertile	
1 (≤23)	76.1 ± 53.7
2 (24–27)	74.7 ± 76.5
3 (28–30)	119.7 ± 75.9
	p = 0.066 *
	p = 0.07 **

* Linear regression model with dependent variable = PASE score. Model adjusts for age. Independent variable = tertile (including all three tertiles).

** Linear regression model with dependent variable = PASE score. Model adjusts for age. Independent variable = tertile (only including highest vs. lowest tertile).

MOCA (Montreal Cognitive Assessment), PASE (Physical Activity Scale for the Elderly)