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Daily electromyography in females with Parkinson's disease: A potential indicator of frailty

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ABSTRACT

Females with Parkinson's disease (PD) are at increased risk for frailty, yet are often excluded from frailty studies. Daily electromyography (EMG) recordings of muscle activity can dissociate stages of frailty and indicate functional decline in non-neurological conditions. The purpose of this investigation was to determine whether muscle activity can be used to identify frailty phenotypes in females with PD. EMG during a typical 6.5-h day was examined in biceps brachii, triceps brachii, vastus lateralis and biceps femoris on less-affected PD side. Muscle activity was quantified through burst (>2% maximum exertion, >0.1 s) and gap characteristics (<1% maximum exertion, >0.1 s). Differences across frailty phenotype (nonfrail, prefrail, frail) and muscle (biceps brachii, BB; triceps brachii, TB; vastus lateralis, VL; biceps femoris, BF) were evaluated with a 2-way repeated measure ANOVA for each burst/gap characteristic. Thirteen right-handed females (mean = 67 ± 8 years) were classified as nonfrail (n = 4), prefrail (n = 6), and frail (n = 3) according to the Cardiovascular Health Study frailty index (CHS*fi*). Frail females had 73% decreased gaps and 48% increased burst duration compared with nonfrail. Decreased gaps may be interpreted as reduced muscle recovery time, which may result in earlier onset fatigue and eventually culminating in frailty. Longer burst durations suggest more muscle activity is required to initiate movement leading to slower movement time in frail females with PD. This is the first study to use EMG to dissociate frailty phenotypes in females with PD during routine daily activities and provides insight into how PD-associated motor declines contributes to frailty and functional decline.

1. Introduction

Frailty is a complex geriatric syndrome that is often clinically characterized by five criteria: (1) Weight loss; (2) Reduced endurance; (3) Slowed gait speed; (4) Muscle weakness; and (5) Exhaustion, resulting in functional dependence (Fried et al., 2001). According to Fried et al. (2001), frailty can be assessed in terms of three phenotypes, or categories of frailty severity, which are defined by the sum of the five individual frailty criteria (i.e., 0: *nonfrail*, 1 or 2: *prefrail*, and 3–5: *frail*). Although frailty can exist independently, it may also co-exist in older adults with progressive neurological disorders, such as Parkinson's disease (PD) (Roland, Jakobi, Jones, & Powell, 2012). Co-morbidities and clinical symptoms interact between frailty and PD making identification of frailty in persons with PD challenging to diagnose (Powell, 2008). Few studies have examined how to identify frailty in the PD population (Ahmed, Sherman, & Vanwyck, 2008; Lauretani et al., 2012).

Electromyography (EMG) recordings provide a measure of muscle activity that governs movement associated with sustaining physical function. EMG detects the bioelectrical activity associated with muscle contractions that produce movements and reveals important neural changes associated with aging and decline in physical function (Clark, Patten, et al., 2010; Clark et al., 2011). Previous work from our laboratory has determined portable EMG devices as a viable means to record muscle activity in older adults during daily life and offer a method to detect frailty-, disease- and age-related differences in muscle activity required to execute movement (Harwood, Edwards, & Jakobi, 2011; Howe & Rafferty, 2009; Jakobi, Edwards, & Connelly, 2008; Kern, Semmler, & Enoka, 2001; Roland, Jones, & Jakobi, 2013; Theou, Jones, Vandervoort, & Jakobi, 2010; Theou, Bruce, Roland, Jones, & Jakobi, 2011).

Recent investigations (Theou et al., 2010) have used EMG to quantify periods of muscle quiescence (gaps) and muscle activity (bursts) in frail older females as they went about their routine daily activities. As the level of frailty advanced the number of gaps increased while the duration of gaps decreased, and the number of bursts decreased while the burst duration increased (Theou et al., 2010). This study indicated that EMG can be used to identify persons of different frailty phenotypes. Quantification of muscle quiescence during daily life has also provided insight into

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underlying asymmetric functional decline and differential change in performance in males and females with PD (Roland et al., 2013). EMG recordings of daily muscle activity that detect stages of frailty have not yet been quantified in females with PD. Females with PD are an under-represented group in research, yet they experience greater functional decline (Leveille, Penninx, Melzer, Izmirlian, & Guralnik, 2000; Paganelli et al., 2006; Smith & Baltes, 1998) and often become frail more so than age-matched males (Fried et al., 2001). This suggests there is a need to investigate the implications of frailty on muscle activity during daily function in females with PD. Evidence demonstrates factors that contribute to frailty in non-neurological populations, such as age and physical activity, are not associated with frailty in persons with PD (Roland, Cornett, Theou, Jakobi, & Jones, 2012). Therefore, additional factors should be considered, such as muscle activity to better understand frailty within PD.

This study aims to determine if daily muscle activity differs between frailty phenotype in females with PD to facilitate identification of frailty. It is hypothesized that greater periods of muscle quiescence and shorter periods of muscle activity will occur and this change will be exacerbated as females with PD progress across frailty phenotypes. These changes in muscle characteristics will be observed, despite the presence of PD. Understanding how muscle activity changes across frailty phenotypes may help to inform interventions aimed at delaying frailty progression in females with PD. Application of this new-knowledge may improve clinical practice by providing an indicator of change in muscle activity that precipitates increased disability in PD.

2. Methods

2.1. Study population and design

Females diagnosed with mild to moderate PD (stages I–III; Hoehn & Yahr, 1967) living in their own home were recruited through newsletter advertisement, public presentations and word-of-mouth. Interested females from the Greater Vancouver and Okanagan areas of British Columbia contacted a member of the research team to participate between March 2010 and January 2012. Subjects were right-hand dominant, able to ambulate independently (with or without gait-aid), and in a steady clinical state (i.e. controlled by medication). In females with PD, tremor in the upper limb was controlled with medication and subjects self-reported no freezing of gait or periods of dyskinesia over the course of the day. Further, any reports of rigidity and/or slowness of movement (bradykinesia) were mild and did not restrict routine daily activities. The Clinical Research Ethics Board of the University of British Columbia granted ethical approval for this investigation and subjects provided written informed consent. Continuous EMG was collected for approximately six and a half hours on one testing weekday within the subjects' personal living environment (i.e. home, neighborhood). Health history questionnaire (including disease characteristics), frailty assessment and set-up of portable EMG equipment occurred 1–2 h post-morning anti-Parkinson's medication. The researcher returned approximately six and a half hours later to the subject's home to remove the equipment. Maximal voluntary exertions (MVE) for each muscle group were executed in the morning and at the end-of-day to verify the signal integrity, as well as normalize the daily EMG recording to maximal. MVE consisted of an isometric contraction against manual resistance of the researcher. The subject sat with the joint (i.e., elbow or knee) at 90-degrees. The MVE for each muscle group was tested three times with approximately 1-min of rest between trials to prevent fatigue. The MVE amplitude of the processed waveform at the midpoint for each of the four muscle groups was recorded. The greatest MVE of all trials, regardless of time of day, was used for normalization. During the testing day, subjects were encouraged to go about typical activities, but avoid strenuous or water-based activities that would affect the recording equipment.

2.2. Electromyography

2.2.1. Measurement

Continuous surface EMG was collected over a 6–7 h day as subjects went about their routine daily activities. Surface EMG from the biceps brachii (BB), triceps brachii (TB), vastus lateralis (VL), and biceps femoris (BF) was recorded using a portable EMG device (Biometrics DataLOG P3X8, Gwent, UK). The hair was shaved (if necessary), and skin was abraded and cleaned with alcohol to reduce signal impedance. Surface electrodes with bipolar differential sensors (SX230, Biometrics Ltd, Gwent UK; 20 mm inter-electrode distance) were placed mid-belly on the muscle on the self-reported less affected side and a common ground electrode on the lateral malleolus of the left fibula, as previously described (Harwood et al., 2011; Jakobi et al., 2008; Roland et al., 2013; Theou et al., 2010, 2011). The EMG data logger ($9.5 \times 15.8 \times 3.3$ cm; 380 g) was secured to the left side of a belt worn at the waist. The EMG signals were sampled at 1000 Hz, amplified ($1000\times$), band-pass filtered (20–450 Hz), and stored on a MMC flashcard for offline analysis.

2.2.2. Analysis

Continuous waveforms from the EMG signals were imported into Biometrics software (Biometrics DataLog v.3, Gwent, UK) for preliminary visual inspection and exported into Spike 2 V.5 (Cambridge Electronics Design, Cambridge, UK). Custom-script analysis was utilized to identify periods of muscle quiescence (gap) and muscle activity (burst) as the subject went about their daily routine. Artifacts in the EMG signal were identified through visual inspection of the data by isolating plateaus in the root mean square amplitude of the waveform and then manually removing these sections which were time-locked across all channels for extraction, as previously described (Harwood et al., 2011; Jakobi et al., 2008; Roland et al., 2013; Theou et al., 2010, 2011). Signal waveforms were rectified, smoothed at a time constant of 0.01 s intervals and down-sampled by a factor of 100 (Fig. 1).

Muscle quiescence (gap) and activity (burst) has previously been employed to determine muscle activity over long durations (Harwood et al., 2011; Howe & Rafferty, 2009; Jakobi et al., 2008; Kern et al., 2001; Theou et al., 2010, 2011), and in persons with PD (Roland et al., 2013). In accordance with this previous research, muscle quiescence was represented by a gap in the EMG signal. Gaps were quantified as EMG periods less than 1% of MVE with the continuous EMG period greater than 0.1 seconds (s). Gap characteristics examined included; number of gaps, mean duration of each individual gap (s), and percentage of total recording time occupied by gaps (gap percent). A burst was defined as muscle activity greater than 2% of MVE with the continuous EMG period greater than 0.1 s in duration. Burst characteristics examined included; number of bursts, mean duration of each individual burst (s), average peak amplitude of all bursts (% MVE), and percentage of total time occupied by bursts (burst percent).

2.3. Frailty

The Cardiovascular Health Study frailty index (CHS*fi*) assessment of physical frailty was administered. The CHS*fi* assesses five physical criteria to determine frailty phenotype classification, including; weight loss of greater than 10 lbs in the past 12 months, maximal handgrip strength, time to walk 15-ft at usual pace, self-reported leisure time physical activity, and self-reported exhaustion as