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Handwriting and pre-frailty in the Lausanne cohort 65+ (Lc65+) study

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ABSTRACT

Background: Frailty is detected by weight loss, weakness, slow walking velocity, reduced physical activity or poor endurance/exhaustion. Handwriting has not been examined in the context of frailty, despite its functional importance.
Objective: Our goal was to examine quantitative handwriting measures in people meeting 0, 1, and 2 or more (2+) frailty criteria. We also examined if handwriting parameters were associated with gait performance, weakness, poor endurance/exhaustion and cognitive impairment.
Methods: From the population-based Lc65+, 72 subjects meeting 2+ frailty criteria with complete handwriting samples were identified. Gender-matched controls meeting 1 criterion or no criteria were identified. Cognitive impairment was defined by a Mini-Mental State Examination score of 25 or less or the lowest 20th percentile of Trail Making Test Part B. Handwriting was recorded using a writing tablet and measures of velocity, pauses, and pressure were extracted.
Results: Subjects with 2+ criteria were older, had more health problems and need for assistance but had higher education. No handwriting parameter differed between frailty groups (age and education adjusted). Writing velocity was not significantly slower among participants from the slowest 20th percentile of gait velocity but writing pressure was significantly lower among those from the lowest 20th percentile of grip strength. Poor endurance/exhaustion was not associated with handwriting measures. Low cognitive performance was related to longer pauses.
Conclusions: Handwriting parameters might be associated with specific aspects of the frailty phenotype, but not reliably with global definitions of frailty at its earliest stages among subjects able to perform handwriting tests.

1. Introduction

The term frailty operationalizes the concept of diminished physiological reserve in older people, who are at increased risk of serious adverse outcomes such as cognitive decline, loss of functional ability, falls, hospitalization and death (Clegg, Young, Iliffe, Rikkert, & Rockwood, 2013). Fried and colleagues introduced a model that included indices of weight loss, objective weakness, slowed walking velocity, poor endurance/exhaustion, and diminished physical activity (Fried et al., 2001). Rockwood and colleagues considered an alternate model that summed impairments and illnesses, termed the frailty index (Rockwood, Song, MacKnight, et al., 2005), which predicts outcomes equally well (Woo, Leung, & Morley, 2012). Frailty and its components are common in western (and likely other) older populations and a major public health concern (Danon-Hersch, Rodondi, Spagnoli, & Santos-Eggimann, 2012; Santos-Eggimann, Cuénoud, Spagnoli, & Junod, 2009).

Like walking, handwriting is a continuous cognitive-motor task acquired during development that requires high skill and cerebral activation (Planton, Jucla, Roux, & Démonet, 2013). Overall

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handwriting velocity (Burger & McCluskey, 2011) and legibility (van Drempt, McCluskey, & Lannin, 2011) decrease with age. Change in writing velocity with age includes both increased "on-tablet time" (in contact with a writing tablet) and "air time" (time not writing with the writing implement off the writing surface), while completing a writing task (Rosenblum & Werner, 2006). Moreover, writing improves with practice (Dixon, Kurzman, & Friesen, 1993) and older individuals use visual cues to assist in handwriting (Slavin, Phillips, & Bradshaw, 1996). Thus, changes are not immutable. Importantly, handwriting is not specifically included in the definition of frailty and thus it might provide an "independent" index that might be linked to distinct aspects of frailty.

The Lc65+ study is a population-based longitudinal study designed to examine the impact of frailty on aging and to determine its precursors and correlates. A previous study from the cohort showed that pre-frail individuals accounted for 25% of participants, while frail individuals accounted for only 2.5% of those at baseline (Danon-Hersch et al., 2012). The current study focuses on subjects who completed two triennial follow-up evaluations, taking the advantage of the introduction of quantitative measures of handwriting at 6-year follow-up. Our primary goal was to determine which aspects of handwriting are associated with Fried's frailty phenotype and to determine if handwriting was associated with specific aspects of frailty or cognitive impairment.

We hypothesized that individuals, meeting 1, or 2 or more criteria of the frailty phenotype in Lc65+ study would exhibit changes in handwriting parameters including velocity, pressure, and pauses. Specifically, we hypothesized that handwriting velocity would be related to gait velocity, that pressure would be related to grip strength, and that pauses would be related to loss of energy. Last we explored the relationship between cognitive dysfunction and handwriting parameters.

2. Methods

2.1. Subjects

Details of Lc65+ have been reported (Santos-Eggimann, Karmaniola, et al., 2008). In brief, the original cohort consisted of 1422 subjects aged 65–70 at the time of study entry in 2004 who were randomly selected from the community and participated in a baseline assessment. The ethics committee of the Faculty of Biology and Medicine of the University of Lausanne has approved the study protocol. The group included in the current analysis was selected from participants assessed during the second follow-up visit (age 72–77 years) who had quantitative handwriting measures recorded. The sample comprised *all* subjects meeting 2 or more frailty criterion (2+) with complete handwriting samples *and* randomly selected sex-matched subjects from the remaining Lausanne 65+ cohort either meeting 1 criterion or having 0 criteria for frailty (see Figure, supplementary materials). Given the restricted age-range of the cohort, age-matching was not performed a priori, but age was compared between groups, and adjusted for in secondary analyses. Basic socio-demographic and anthropomorphic measures included age, sex, education, height and weight (allowing calculation of body mass index, BMI). Self-reported health conditions, including depressive symptoms and functional limitations were recorded.

2.2. Frailty definition and measures

The frailty phenotype was defined as presented in a recent study (Danon-Hersch et al., 2012). Components of frailty are described individually and were derived from standardized assessments (Santos-Eggimann et al., 2008) by analogy with the studies by Fried (Fried et al., 2001). In brief, weight loss was defined by a report of involuntary weight loss in the previous year; grip strength was measured and impaired grip strength was defined as sex and BMI-specific cut-off based on Cardiovascular Health Study (CHS) data (Fried et al., 2001; Mathiowetz et al., 1985); poor endurance/exhaustion was based on answering "much" to the question "did you have feelings of generalized weakness, weariness, lack of energy in the last four weeks?"; slowness was defined by walking time over 20 m based on CHS sex- and height-specific cut-offs (Fried et al., 2001); low activity was based on physical activity self-report of all three of the following: <20 min of sports per week, walking <90 min per week and avoidance of climbing stairs and carrying light loads in daily activities.

We also identified subjects characterized by: weakness, slow gait, or poor endurance/exhaustion by reference to the total cohort. For these analyses we used empirical cut-offs based on all Lc65+ assessments at second follow-up visit. The grip strength cut-off was based on the lowest sex and BMI specific 20th percentile on cut-offs from the overall sample at the time of taking the handwriting sample. Similarly, gait velocity cut-off was based on the slowest gender- and height-specific 20th percentile speed over 20 m.

2.3. Specific health conditions

Self-reported health questions included physician's diagnosis or treatment in the last year of the following: coronary heart disease, other heart disease (congestive heart failure, valvular disease, cardiomyopathy), stroke, diabetes, hypertension, hypercholesterolemia, chronic respiratory disease, osteoporosis, arthritis, cancer, gastrointestinal disease, and depression (Danon-Hersch et al., 2012). We coded subject as having no health problems, one health problem, or two or more problems.

2.4. Cognitive and functional measures

The MMSE is a standard global cognitive measure (Folstein, Folstein, & McHugh, 1975). Subjects with a MMSE score of 25 or lower were considered impaired; this cut-off has very good sensitivity and high specificity for Alzheimer dementia when applied to francophone populations (Nasreddine, Phillips, Bédirian, et al., 2005). In addition, the Trail Making Test Part B is a standard test of executive function requiring motor speed and set-switching (Arbuthnott & Frank, 2000). It has been associated with motor function related to frailty in people living in the community (McGough, Kelly, Logsdon, et al., 2011; Soumaré, Tavernier, Alpérovitch, Tzourio, & Elbaz, 2009). Beside scoring 25 or less on the MMSE, subjects were also considered cognitively impaired if performing in the slowest 20th percentile of the overall sample at Trail Making Test Part B. Need for assistance in instrumental (IADL) and basic activities of daily living (BADL) were recorded via subject questionnaire and subjects were coded as having no need for assistance (0), needing help in IADLs (Clegg et al., 2013) or needing help in BADLs (Fried et al., 2001).

2.5. Handwriting task

Writing was recorded using a writing tablet (WACOM Intuos 4L) with an instrumented pen (model KP-130), which could quantify three-dimensional aspects of copying: writing in the current study was based on measures on the surface of the table (x–y plane) and pressure was based on unit-less measures of pressure on the tablet surface. Participants wrote on a piece of A4 (landscape) paper taped onto the writing tablet linked to a desktop computer running a custom java-script freeware program to allow data-gathering from the tablet. Participants were explained the