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Evaluation of objective and perceived mental fatigability in older adults with vascular risk

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ABSTRACT

Objectives: Mental fatigability refers to the failure to sustain participation in tasks requiring mental effort. Older adults with vascular risk are at particular risk for experiencing mental fatigability. The present study (1) tested a new way of measuring objective mental fatigability by examining its association with perceived mental fatigability; and (2) identified associated psychological, physiological, and situational predictors.
Methods: A cross-sectional study was conducted with 49 community-dwelling participants aged 75+ years with vascular risk. A 20-minute fatigability-manipulation task was used to induce mental fatigability and develop objective and perceived mental fatigability measures. Objective fatigability was calculated by the change of reaction time over the course of the task. Perceived fatigability was calculated by the change of fatigue self-reported before and after the task. A set of potential psychological, physiological, and situational predictors were measured.
Results: There was a significant increase in reaction time and self-reported fatigue to the fatigability manipulation task, indicating occurrence of objective and perceived mental fatigability. Reaction time and self-reported fatigue were moderately, but significantly correlated. Higher levels of executive control and having a history of more frequently engaging in mental activities were associated with lower objective mental fatigability. None of the examined factors were associated with perceived mental fatigability.
Conclusion: Objective and perceived mental fatigability were sensitive to our fatigability-manipulation task. While these two measures were correlated, they were not associated with the same factors. These findings need to be validated in studies with a more heterogeneous sample and a greater variety of fatigability-manipulation tasks.

Introduction

Fatigue is one of the most common complaints in community-dwelling older adults [1]. Its effects include a diminished capacity to maintain activities of daily living, and reduced participation in leisure activities that protect cognitive, physical, and psychosocial well-being [2–4]. Fatigue is a multidimensional concept that can be experienced as general tiredness (i.e., trait, chronic subjective fatigue) or as the expectation and experience of becoming tired in response to activities, which then leads to difficulty in maintaining these activities at a desired level of performance (i.e., acute state, fatigability) [5–8]. Perhaps surprisingly, older adults may not necessarily report more fatigue (i.e., chronic subjective fatigue) than their younger counterparts; however, they do demonstrate a higher likelihood of becoming tired or tiring faster during an activity (i.e., fatigability) [9]. The factors underlying why older adults experience greater functional effects of fatigue are still unclear, but is important to note that chronic subjective fatigue and fatigability are not necessarily correlated. An older adult may complain that he is "tired all the time," but still lead an active life and have near-normal functional capacity while another person who has the same complaint of chronic fatigue may live in a physically and mentally restricted manner and be functionally impaired. These differences may be explained by the variability in an individual's fatigability [10]. Therefore, recent work has begun to focus on fatigability in order to answer the question, "When is fatigue a problem?" A comprehensive understanding of fatigability may help us understand when and how fatigue symptoms translate to poor function in old age.

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Mental fatigability, the failure to remain engaged in tasks or activities requiring sustained mental efforts, is problematic but rarely recognized by the medical community [11–13]. Neurologically, mental fatigability reflects dysfunctional cerebral activity in the basal ganglia, involving contributions from the frontal regions (including the prefrontal cortex (PFC) and the anterior cingulate cortex), thalamus, and the amygdala [14]. Behaviorally, mental fatigability may affect not only mental activities (e.g., motivation, action control) [15], but also the level of physical activities engaged in by an individual [16,17].

The most common approach to measure mental fatigability is via self-report, but numerous issues (e.g., construct contamination, see discussion by Leavitt and DeLuca [18]) may affect the utility of such measures. There is a need for complementary objective measurement that would provide an estimation of fatigability that is free of the issues present in self-report measures. Physical fatigability is measured by performance during a physical task that requires sustained energy (i.e., assessing decreased muscle movements over time) [7,13]. Previous studies of mental fatigability have attempted to directly apply this approach to mental fatigability by measuring declined accuracy during a cognitive task. Unfortunately, results of these attempts have revealed inconsistent associations between self-report mental fatigability and performance during cognitive tasks [18]. Education may greatly compensate for mental fatigability meaning one's accuracy in the cognitive tasks may not necessarily decline over time even though they have become fatigued. Other dimensions of cognitive performance may be more sensitive to the effects of mental fatigability. Two studies in patients with multiple sclerosis identified a significant and consistent relationship between self-report fatigability and speed of processing assessed by cognitive tests requiring sustained mental efforts [19,20]. Another recent study found that accuracy rate in cognitive tasks was only significantly correlated to self-reported mental fatigability in the group whose reaction time (RT) increased across the executive-attention demanding mental tasks [21]. Increased RT may be a more reliable measure for an objective (i.e., performance-based) mental fatigability and incorporating sustained attention tasks may be important when designing a mental task that can induce mental fatigability.

Mental fatigability is likely influenced by multiple factors. Cognitive factors such as executive function have been shown to influence mental fatigability [22]. Physiological factors such as sleep quality may also affect the generation of mental fatigability [23]. A recent conceptual framework proposed that both idiopathic fatigue and disease-related fatigue are influenced by psychological (i.e., both affective and cognitive), physiological (i.e., functional and health related), and situational (i.e., individual's environment related) factors [24,25]. It is unclear whether this conceptual framework can be applied in the context of mental fatigability.

Specific groups of older adults are at particular risk for experiencing mental fatigability. Vascular risk (e.g., type 2 diabetes, hypertension, dyslipidemia, and smoking) is the most common health condition in older adults, affecting at least half of the elderly population in the U.S. [26]. Those with vascular risk factors provide an ideal model to study fatigability in old age since fatigue and fatigability are prevalent in this group [12,27,28]. Additionally, recent work by our group found that older adults with vascular risk factors did not participate in adequate physical and cognitive leisure activities [29], and fatigability was suspected to be a main barrier to the engagement in such activities [7]. Identifying more reliable measures of mental fatigability and understanding the factors associated with this phenomenon is needed to better understand how to identify, prevent, or treat mental fatigability in older adults, especially those with vascular risk.

The objectives of the current study were two-fold. First, we examined the relationship between a novel, objective (i.e., performance-based) measure of mental fatigability that entailed consecutive assessment of RT to a task requiring sustained mental effort and perceived (i.e., self-reported) mental fatigability. We hypothesized that the correlation between the RT measure of mental fatigability and perceived mental fatigability would be greater than the correlation between the accuracy measure of the fatigability-manipulation task and perceived fatigability. Second, we aimed to identify psychological (i.e., subjective chronic fatigue, executive control, and depressive symptoms), physiological (i.e., vascular risk, sleepiness, anti-inflammatory and beta-blocker medications), and situational (i.e., history of mental activities) predictors of objective and perceived mental fatigability.

Methods

Design

An exploratory cross-sectional study was conducted by recruiting participants enrolled in a regional cohort study designed to identify blood-based predictors for incident dementia [30]. Community-dwelling older adults aged 75 years or older were invited to participate in a series of neuropsychological, functional, and neuropsychiatric tests conducted by a group of clinicians. This group of clinicians also reviewed each individual's medication list. Individuals with mild cognitive impairment, dementia due to Alzheimer's disease, or who were cognitively healthy were eligible for participating in the cohort study. Only individuals who were cognitively healthy per cohort study protocol were referred to the present study within one month of their annual cohort study visit. Additional inclusion criteria for the present study were: English speaking, capacity to provide informed consent, presence of at least one of the following vascular risk (hypertension, high cholesterol, diabetes, as confirmed by relevant medications; and self-report smoking), and adequate auditory and visual acuity for testing. Exclusion criteria included self-reported history of stroke, sleep disorder, or major depression. The study was approved by the University of Rochester institutional review board.

A total of 71 individuals from the cohort study were referred to the present study during our eight months recruitment period: 7 declined to participate, 13 were found to be ineligible for the present study, and 2 canceled the study appointment for unknown reasons. Written consent was obtained from the 49 eligible participants and these individuals then completed the study protocol.

Measurements

Mental fatigability

Fatigability-manipulation task (see Fig. 1). In the present study, we employed a component of a popular cognitive training program called the N-back task [31] as the fatigability-manipulation task. Performing the N-back task requires capacity of processing speed, working memory, and sustained attention [32]. We utilized a 20 minute 1-back paradigm, given the following considerations: First, a previous study found that, when examining RT, mental load was similar between 1-, 2-, and 3-back tasks in older adults. More importantly, compared to 2- or 3-back task, 1-back task reflected the greatest efforts in locating resources from the PFC to manage cognitive challenges, which lead to greatest probability of breakdown (i.e., generating of fatigability) of brain function [32]. Conversely, the capacity to perform 2- and 3-back tasks, from the very beginning, may have already been beyond the capacity to activate compensatory function from the PFC in older adults, which may lead to frustrations and confound the interpretation of fatigability [32]. Second, our previous work showed that a laboratory cognitive task lasting less than 20 min was able to induce significantly cardiovascular response (i.e., heart rate variability) in older adults [33]. Meanwhile, performance decrements have consistently been seeing in 20 to 30 minute fatigability manipulation tasks [34]. Thus, we utilized the 20-minute protocol to ensure that we would be able to induce mental fatigability and to secure the safety of participants who had vascular risk.