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Cognition and mobility show a global association in middle- and late-adulthood: Analyses from the Canadian Longitudinal Study on Aging

Naiara Demnitz[a,b], David B. Hogan[c], Helen Dawes[d], Heidi Johansen-Berg[b], Klaus P. Ebmeier[a], Marc J. Poulin[e,1], Claire E. Sexton[f,g,*,1]

[a] Department of Psychiatry, University of Oxford, Oxford, United Kingdom
[b] Wellcome Centre for Integrative Neuroimaging, FMRIB, John Radcliffe Hospital, University of Oxford, United Kingdom
[c] Division of Geriatric Medicine, Department of Medicine, Cumming School of Medicine, University of Calgary, Canada
[d] Centre for Movement and Occupational Rehabilitation Sciences, Oxford Institute of Nursing, Midwifery and Allied Health Research, Oxford Brookes University, United Kingdom
[e] Department of Physiology and Pharmacology and the Hotchkiss Brain Institute, Cumming School of Medicine and Faculty of Kinesiology, University of Calgary, Canada
[f] Wellcome Centre for Integrative Neuroimaging, Oxford Centre for Human Brain Activity, Department of Psychiatry, University of Oxford, Oxford, United Kingdom
[g] Global Brain Health Institute, Memory and Aging Center, Department of Neurology, University of California, San Francisco, CA, USA

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ABSTRACT

Background: Given our aging population, there's great interest in identifying modifiable risk factors for cognitive decline. Studies have highlighted the relationship between aspects of mobility and cognitive processes. However, cognition and mobility are both multifaceted concepts and their interrelationships remain to be well defined.
Research question: Here, we firstly aimed to replicate cross-sectional associations between objective measures of mobility and cognition. Second, we tested whether these associations remained after the consideration of multiple age-related confounders. Finally, to test the hypothesis that the association between mobility and cognition is stronger in older adults, we examined the moderating effect of age in the association between mobility and cognition.
Methods: In the Canadian Longitudinal Study on Aging, 28,808 community-dwelling adults (aged 45–87; 51% female) completed mobility (gait, balance and chair stands) and cognitive (memory, executive function and processing speed) assessments. General linear models were used to examine mobility-cognition relationships and the moderating effect of age.
Results: Cognitive measures were significantly associated with mobility measures (all $p < 0.001$). Further, age significantly moderated the mobility-cognition relationship, with the strength of the associations generally increasing with age.
Significance: All cognitive measures were related to indices of mobility, suggesting a global association. In our moderation analyses, the mobility-cognition relationship often increased with age. However, the small effect sizes observed suggest that mobility is, in isolation, not a strong correlate of cognitive performance in middle and late-adulthood.

1. Introduction

Age-related neural changes are associated with a decline in various cognitive domains, such as memory, executive function, and processing speed. Similarly, age-related neural and muscular changes often lead to a deterioration in aspects of mobility, such as gait, balance and lower-extremity function. These changes may occur in tandem, as mounting evidence has highlighted the relationship between aspects of cognition and mobility processes [1]. Given that cognition and mobility impairments are a costly burden both to the individual and to society, the drive to identify correlates of healthy ageing warrants a better understanding of cognition-mobility relationships.

Cognition and mobility are both multifaceted concepts, and the interrelationship between their sub-domains is not yet well characterised. Whereas some have suggested that mobility is preferentially associated with executive function [2], a recent meta-analysis of cross-

* Corresponding author at: Oxford Centre for Human Brain Activity, Wellcome Centre for Integrative Neuroimaging, Department of Psychiatry, University of Oxford, Oxford, OX3 7JX, United Kingdom.
E-mail address: claire.sexton@psych.ox.ac.uk (C.E. Sexton).

[1] Joint senior authorship.

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sectional studies on cognition and mobility in healthy older adults found evidence for associations across the board, albeit with small effect sizes [3]. Further, studies have often focused on the association between one mobility and one cognitive measure (e.g. gait and executive function), thus limiting conclusions about the global nature of the mobility-cognition association.

The interdependence between mobility and cognition has been hypothesised to reflect age-dependent changes in shared neural mechanisms [4] and an increased demand for cognitive monitoring in motor control with age [5]. However, previous studies have predominantly focused on older adults, resulting in an unclear understanding of the effect of age on this association. Accordingly, examining the mobility-cognition relationship in a wider age-span may lead to a clearer picture of its development.

The present study aimed to conduct the largest investigation of mobility and cognitive performance to date, through analysis of a population-based dataset with a wide age-span, the Canadian Longitudinal Study on Aging (CLSA). In a component of the CLSA study, psychological and mobility baseline data were collected on over 30,000 adults, aged between 45 and 85. Here, we firstly aimed to replicate cross-sectional associations between objective measures of mobility (walking time, chair stands and balance) and cognition in the baseline CLSA data. Since these associations have typically been studied with sample sizes of $N < 400$, or more recently with samples in the 1000s [6,7], a sample size in the 10,000s may serve as a powerful response to the discrepancies that remain in the mobility-cognition literature. Enabled by our large sample size, we also tested whether these associations remained after the consideration of multiple age-related confounders. Finally, to test the hypothesis that the association between mobility and cognition is stronger in older adults, we examined the moderating effect of age in the association between mobility and cognition.

2. Methods

2.1. Participants

The CLSA is a Canadian multi-centre study of 51,338 people between the ages of 45 and 85 years at the time of recruitment [8]. All CLSA participants provided data on demographic, lifestyle, physical, clinical, psychological and economic measures. A sub-set of CLSA participants (n = 30,097), referred to as the CLSA Comprehensive cohort, visited a local data collection site for additional assessments, including physical performance measures and additional cognitive testing. For the present analysis, only participants from the CLSA Comprehensive cohort (dataset version 2.1) were considered. Participants missing all cognitive or all mobility data and those with a self-reported history of specific neurological illnesses (i.e., dementia, Parkinson's disease, multiple sclerosis or stroke), or a lower-limb prosthetic leg or foot were excluded from the analyses (Appendix 1 in Supplementary materials).

2.2. Mobility measures

Walking time (in seconds) was measured with a stopwatch over a clearly marked straight-line 4-meter course. Participants were instructed to walk at their own pace. *Balance* was measured as time (in seconds) a balance position (one-legged stand, with eyes open) was held, with an upper cut-off of 60 s. Participants were positioned approximately one meter from a wall and instructed to stand on one foot for as long as possible while first lifting the dominant leg to the calf level. The test was then repeated on the other leg. In the present analysis, the longer of the two times was used. In the *chair stands* test, participants were asked to sit on a chair and fold their arms across their chest. Participants were then instructed to stand up and sit down without using their arms five times. The time (in seconds) taken to complete five chair rises was recorded.

2.3. Cognitive measures

Choice reaction time (in seconds), a measure of processing speed, was collected using a touch-screen computer. In this task, a row of 4 plus signs would appear in the centre of the screen. After 1 s, one of the plus signs would be replaced with a square. The participant was instructed to touch the square as quickly as possible. After 10 practice trials, the mean reaction time of correct answers, excluding timeouts, were calculated for the 52 test trials.

The Rey Auditory Verbal Learning Test (RAVLT; [9]) was used to assess immediate and delayed recall of a list of 15 words. In the CLSA, only one learning trial and one delayed trial (with a 5-minute delay) were conducted.

To assess executive function, the Mental Alternation Test (MAT; [10]) the Stroop neuropsychological screening test (Victoria version, [11]) and the phonetic and categorical fluency tests were conducted. In the MAT, participants were instructed to alternate between number and letter (i.e. 1-A, 2-B, 3-C) as quickly as possible for 30 s. The score, ranging from 0 to 51, indicates the number of correct alternations, excluding errors. The Stroop test consisted of 3 parts. First, the participant was instructed to name the colour of each circle, as fast as possible, without making mistakes. The participant was then asked to name the ink colour of each word. In the final condition, the participant is asked to name the ink of the colour words, as quickly as possible. The interference score was calculated by subtracting the time (in seconds) to complete condition 1 from the time (in seconds) taken to complete condition 3. To measure phonological fluency, participants were asked to list as many words as possible beginning with the letters "f", "a" and "s", in 3 60-second trials. For each trial, the score consists of the total number of permitted words given. In the present analysis, the average score from the 3 trials was used. Similarly, in the categorical fluency test a score is given based on the number of animals listed in 60 s. For further reference on the cognitive measures used, please see [12].

2.4. Covariates

Age, sex and education level were recorded for all participants. Education was scored on a six-point scale: (1) no qualifications, (2) completed high-school, (3) trade certificate or diploma (4) community college degree, (5) Bachelor's degree and (6) post-graduate degree.

Additional covariates of interest were selected based on their links with mobility and/or cognition. These included depressive symptoms [13], physical activity [14], social participation [15], BMI [16] and history of arthritis [17]. Depressive symptoms were assessed using the Centre for Epidemiological Studies Depression Scale (CES-D), a clinically validated self-report questionnaire [18]. Physical activity was measured using the Physical Activity Scale for the Elderly (PASE; [20]). The PASE is a self-report questionnaire designed for older adults, and also validated in middle-aged adults, wherein participants report leisure, household, and work-related activities in the last week. Frequency of participation in social activities was measured using questions previously used in the English Longitudinal Study on Ageing [21], which addressed cultural, educational, physical, religious and familial activities participated in the last 12 months. Frequency of participation was scored on a five-point scale, ranging from (0) did not participate in a community-related activity to (4) participated in a community-related activity at least once a day. History of arthritis (rheumatoid or osteoarthritis), was collected through self-report. Finally, BMI was calculated from participant's height and weight.

2.5. Statistical analyses

Descriptive summary measures are presented for all outcomes and covariates of interest. Data distributions were visually screened, and mobility and cognitive outcome values $\pm$ 3 standard deviations from the mean were deemed as extreme outliers and excluded from the