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Review

A systematic review and meta-analysis of cross-sectional studies examining the relationship between mobility and cognition in healthy older adults

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ABSTRACT

Ageing is associated with declines in cognitive function and mobility. The extent to which this relationship encompasses the subdomains of cognition and mobility remains unclear, however. We searched MEDLINE and EMBASE databases for cross-sectional studies examining the association between objective mobility measures (gait, lower-extremity function, balance) and cognitive function (global, executive function, memory, processing speed) in healthy older adults. Of the 642 studies identified, 26 studies met the inclusion criteria, with a total of 26,355 participants. For each feature of physical mobility, the relation to each aspect of cognition was reviewed. In the context of each association, we summarised the results to date and performed random-effects meta-analyses of published data. Reviewed findings suggest that individuals with better mobility perform better on assessments of global cognition, executive function, memory and processing speed. Not all measures of mobility were equally associated with cognitive function, however. Although there was a larger number of gait and lower-extremity function studies, and this may have driven findings, most studies examining balance and cognition measures reported no significant results. Meta-analyses on reported associations supported results by revealing significant, albeit small, effect sizes in favour of a positive association between performance on mobility measures and cognitive assessments. Future research should aim to establish the mechanisms driving this relationship, as this may identify predictors of age-related impairments.

1. Introduction

With a rapidly growing older population, identifying modifiable factors that can contribute to healthy ageing is a public health priority. Mounting evidence has highlighted the importance of maintaining physical mobility in old age. Unfortunately, this is a challenging task given mobility impairments are extremely common in the ageing population [1]. Poor mobility can lead to a cascade of other detrimental factors such as fear of going out, increased social isolation, poor quality of life, and hospitalisations [2,3]. Moreover, there is evidence to suggest that poor mobility may be associated with poor cognitive function [4,5]. Establishing such relationships is important; if associations between mobility and cognition are found this provides a clear rationale for assessing both cognitive and mobility outcomes in interventions targeting either domain, and also argues for developing combination interventions that jointly target both domains.

Both mobility and cognition are umbrella terms that span across multiple measurement domains. Mobility, for example, involves walking through diverse environments, maintaining balance whilst doing so, and being able to rise from beds and chairs. Epidemiological studies have shown that measures of gait, balance and chair rises are predictive of falls [6], functional decline [7], institutionalisation and mortality [8], in older adult populations. Combined, these three features of mobility make up the Short Physical Performance Battery, a validated and widely applied measure of mobility in older adults [8]. Given the importance of these features in the preservation of independence and quality of life in late adulthood, mobility is here defined as the ability to walk, maintain standing balance and rise from a chair (henceforth

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lower-extremity functioning). Whereas all three aspects are critical components of functional mobility, there is evidence to suggest that not all domains are equally associated with cognition. For instance, in a review of longitudinal studies examining changes in mobility and cognition in older populations, gait speed was found to have a stronger correlation with a composite measure of global cognition (including tests of memory, executive functioning and processing speed) than grip strength, lower-extremity function or balance [5].

Likewise, there is reason to believe that not all domains of cognition are equally associated with mobility. First, ageing does not homogeneously disturb cognition [9]. Moreover, mobility relies more strongly on fluid aspects of cognition, such as attention, learning and sensory integration, than crystallised knowledge (e.g. language). Despite the multi-faceted nature of mobility and cognition, previous reviews have either considered multiple mobility features and a single measure of fluid cognition (henceforth referred to as cognition) [5], or a single measure of mobility and multiple cognitive features [10]. We aim to extend these findings to quantitatively analyse both the features of mobility critical for the health and quality of life in older adults and the cognitive domains implicated in ageing. By reviewing each discrete association, we can better understand the broader relationship between mobility and cognition – how far it extends and which measures are most sensitive to the underlying association. The characterisation of the mobility and cognition literature can, in turn, guide interventions targeting either domain, highlighting which measures are pertinent outcomes.

Here, we systematically review studies examining the association between objective measures of mobility and cognitive function in older adult samples. Further, we add to the literature by pooling the strength of the individual associations between these measures. We focus on common measures of mobility (gait, balance and lower-extremity functioning) and cognition (global cognitive function, memory, executive function, processing speed) affected in ageing [9]. Measures of lower-extremity function are here defined as evaluations of functional mobility assessing ability to use lower limbs to stand up from sitting. For the purpose of this review, only single-task measures of gait were included. While dual-task methodology has been widely used to assess cognitive motor interference during walking, the decline in dual-task conditions that occurs with age may be due to either cognitive or physical changes associated with ageing. Further, given the cognitive component of dual-task conditions, examining associations with cognitive tasks would lead to issues of co-linearity. Consequently, it would be unclear to ascertain whether obtained correlations were due to the shared cognitive component, or a relationship between mobility and cognition.

For each feature of physical mobility, the relation to each aspect of cognition is considered in turn. Cognitive tests are classified as executive function (including measures of working memory, selective attention, set shifting, inhibition and cognitive flexibility), memory (measures of recall, learning and recognition) or processing speed (including simple and complex reaction time measures) in accordance with a previous systematic review [11] In the context of each association, we summarise the results to date and perform *meta*-analyses of published data. Our objectives are: 1) to evaluate the evidence for associations between cognition and mobility in healthy older adults, 2) to synthesise the individual associations between aspects of mobility and cognitive domains quantitatively and 3) to explore potential sources of heterogeneity in the findings, including age, sex and differences in assessment paradigms. To the best of our knowledge, this is the first systematic review to consider how these three objective measures of mobility (gait, balance, lower-extremity function) are individually associated with memory, executive function and processing speed.

2. Methods

2.1. Data sources

We searched online for studies examining the association between physical mobility and cognitive function in healthy older adults from 1990 to February 2015 using the EMBASE and MEDLINE databases (Fig. S1). Reference lists from retrieved articles and existing reviews were manually searched for additional studies. Only English-language papers were reviewed.

2.2. Study selection

Two authors (ND & PE) independently reviewed the list of identified citations to assess eligibility for inclusion. Any disagreements were resolved by consensus. The following inclusion criteria were used for this review:

1. Published as a journal, article, or letter.
2. Physical mobility measured using an objective assessment of gait, balance or lower-extremity function. Self-reported measures of ability (e.g. Balance Self-Perception Test), assessments of physical activity, and of gait during dual-task conditions were excluded.
3. Cognitive ability assessed by tests of global cognition, memory, executive function or processing speed.
4. Examined an association between mobility and cognitive measures collected at the same time, a difference in mobility measures between groups that differed in cognitive function, or a difference in cognitive measures between groups that differed in mobility outcomes.
5. Included a sample of healthy adults with a mean age over 60.

2.3. Data extraction and analysis

The following details were extracted using a structured form: aspect of physical mobility examined (gait, balance, lower-extremity function), outcome measure of mobility feature (e.g. gait speed, score on Berg Balance test, Timed Up and Go), the cognitive domain tested (global cognition, memory, executive function and processing speed), participant demographics (sample size, mean age, sex), and results (statistically significant findings at $p < 0.05$, unless otherwise determined by the authors).

Studies with overlapping samples were excluded if the same aspects of mobility (e.g. gait) and cognition (e.g. executive function) were examined in both papers. In such cases, preference was given to the study with the largest sample size. For greater data homogeneity, if a study reported two levels of analysis of the same data, preference was given to the one using continuous as opposed to categorical data, as this was the more commonly used approach. Studies reporting only a composite of physical measures (e.g. gait speed + muscular weakness + fatigue) were not included. Studies that did not test for an association between mobility and cognitive measures (e.g. only used these outcomes as covariates in a model) were also not included. Moreover, measures of gait during dual-task conditions were not included (for review see [12]).

To facilitate comparability, the directions of associations were reversed if lower scores indicated better performance. For example, associations using walking time and the Trail Making Test (e.g. [4,13]), were reversed to match the direction of associations using gait speed and verbal fluency.

When multiple measures of the same construct were included in one study, we first selected the measures most commonly used to maximise comparability between studies. This led to the selection of gait speed whenever possible, and the construct that