White matter volume mediates the relationship between self-efficacy and mobility in older women

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Abstract

Background—With our aging population, understanding determinants of healthy aging is a priority. One essential component of healthy aging is mobility. While self-efficacy can directly impact mobility in older adults, it is unknown what role brain health may play in this relationship.

Methods—We conducted a cross-sectional pilot analysis of community-dwelling women ($n = 80$, mean age = 69 years) to examine whether brain volume mediates the relationship between falls-related self-efficacy, as measured by the Activities-specific Balance Confidence (ABC) scale, and mobility, as measured by the Timed Up and Go (TUG) test. Age, depression, education, functional comorbidities, and Montreal Cognitive Assessment (MoCA) were included in the model as covariates.

Results—We report that total white matter volume, specifically, significantly mediates the relationship between self-efficacy and mobility, where higher self-efficacy was associated with greater white matter volume ($r=0.28$), which in turn, was associated with better mobility ($r=-0.30$).

Conclusions—Our pilot study extends our understanding of the psychosocial and neurological factors that contribute to mobility, and provides insight into effective strategies that may be used to improve functional independence among older adults. Future prospective and intervention studies

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are required to further elucidate the nature of the relationship between self-efficacy, mobility, and brain health.

Keywords

Mobility; Self-efficacy; Aging; Brain health; White matter volume

INTRODUCTION

With a large proportion of our baby boomer population approaching older adulthood, understanding determinants of healthy aging is an increasing priority. Mobility is a key component of healthy aging; it is essential for maintaining functional independence and quality of life (e.g., Albert, Bear-Lehman, & Anderson, 2014; Andersson, Marcusson, & Wressle, 2014). Notably, in a cross-sectional study, gait speed was significantly associated with both clinical and subclinical disease (Newman, Haggerty, Kritchevsky, Nevitt, & Simonsick, 2003); further, in an eight year longitudinal study, decline in gait speed was associated with mobility and mortality (White et al., 2013). While physical capacity, such as balance and lower extremity strength, undoubtedly contribute to mobility, psychosocial and neurological factors, such as self-efficacy (e.g., Liu-Ambrose et al., 2006; Maki, Holliday, & Topper, 1991) and brain health (e.g., Nagamatsu, Boyd, Hsu, Handy, & Liu-Ambrose, 2013; Nagamatsu, Hsu, Handy, & Liu-Ambrose, 2011; Woollacott & Shumway-Cook, 2002), may also play an important role in our ability to maintain postural control and move safely through the environment. However, our current understanding of how these factors impact mobility is limited.

One psychosocial factor that appears to play a critical role in mobility is self-efficacy (e.g., Sessford, Jung, Brawley, & Forbes, 2014). Self-efficacy refers to our confidence in our ability to perform a given activity or task. Importantly, self-efficacy has been shown to be a potent predictor of behavioural performance; indeed, according to Bandura's Social Cognitive Theory (Bandura, 1977), perceived self-efficacy influences a host of factors that will determine whether a behaviour is successfully performed, including confidence, expectations, coping efforts, persistence, and effort. In the context of mobility, high falls-related self-efficacy, as measured by the Activities-specific Balance Confidence (ABC) scale, is significantly associated with postural sway and gait speed (Myers et al., 1996). However, what remains unknown is *how* self-efficacy may impact mobility. Specifically, might higher self-efficacy result in better mobility mediated by a measure of brain health, such as volume?

Why might brain volume mediate the relationship between self-efficacy and mobility? First, the notion that psychosocial factors and brain volume are linked was substantiated by Jackson and colleagues (2011), who demonstrated that individuals with higher neuroticism demonstrated significantly reduced brain volume in prefrontal and medial temporal regions compared with individuals who displayed higher conscientiousness. In addition, Pruessner and colleagues (2005) found that high self-esteem moderated age-related patterns in cognitive decline, cortisol regulation, and global brain volume decline in older adults aged 60 to 84 years old. Lastly, we previously found that self-efficacy was independently

associated with global brain volume (Davis, Nagamatsu, Hsu, Beattie, & Liu-Ambrose, 2012). Specifically, in a sample of community-dwelling older women, both greater grey matter ($r = 0.401$) and total brain volume ($r = 0.352$) were associated with higher falls-related self-efficacy, as measured by the ABC scale. Collectively, this evidence suggests that psychosocial factors, such as self-efficacy, may be closely linked with brain volume.

In addition to their connection with self-efficacy, structural integrity and volume of the brain are known to be important for mobility as well. For example, volume of white matter hyperintensities (WMH) have been shown to be significantly associated with falls (for a review, see Zheng, Delbaere, Close, Sachdev, & Lord, 2011) and gait speed (standardized betas for women = 0.12; $r^2 = 0.08 - 0.16$) (Rosano et al., 2010; Wakefield et al., 2010). Importantly, Rosano and colleagues (2007) reported that smaller cerebellar (13.8% difference between those with high versus low mobility) and prefrontal (5–6% difference between those with high versus low mobility) volumes in the brain were associated with slower gait speed in a sample of 327 older adults. While bivariate associations have been established between self-efficacy, brain volume, and mobility, elucidating the nature of the relationship between these variables would provide valuable information to guide future strategies aimed at improving mobility in older adults at-risk for falls – and consequently, circumventing disability and loss of functional independence.

To address the current gap in the literature regarding the specific effect of self-efficacy on mobility, we conducted a cross-sectional analysis of older women to examine whether brain volume mediates the relationship between self-efficacy and mobility. Within our proposed mediation framework, we predict that increased self-efficacy will not only directly result in better motility, but also influence brain health, which in turn, will positively impact mobility. Furthermore, our study aimed to ascertain the unique contribution that grey versus white matter volume may have on the relationship between self-efficacy and mobility. Our pilot study aims to ascertain whether such relationships between these variables exist; upon the accumulation of convincing evidence, future prospective and intervention studies can be conducted to provide support for the direction of these relationships.

METHODS

Participants

Our current study is a cross-sectional analysis of baseline data collected from a subset of participants who consented to participate in a 12-month randomized controlled trial (RCT) (NCT00426881) that examined the effects of resistance training on executive functions (Liu-Ambrose et al., 2010; Liu-Ambrose, Nagamatsu, Voss, Khan, & Handy, 2011). Details of the intervention have been reported elsewhere (Liu-Ambrose et al., 2010; Liu-Ambrose et al., 2011). Briefly, community-dwelling women were included if they: 1) were aged 65 to 75 years; 2) had a Mini-Mental State Examination (MMSE) score ≥ 24 ; 3) had a visual acuity of at least 20/40, with or without corrective lenses. Participants were excluded if they: 1) had a diagnosed neurodegenerative disease (e.g., AD) and/or stroke; 2) were taking psychotropic drugs; 3) did not speak and understand English; 4) had moderate to significant impairment with ADLs as determined by interview; 5) were taking cholinesterase inhibitors within the last 12 months; 6) were taking anti-depressants within the last six months; or 7) were on

estrogen replacement therapy within the last 12 months. Only women were recruited for the main RCT because the effects of exercise on cognition are known to differ between the sexes (e.g., Colcombe & Kramer, 2003). This study was approved by the Vancouver Coastal Health Research Institute and the University of British Columbia's Clinical Research Ethics Board. All participants gave written informed consent.

Measures

Descriptive variables—Demographic information was ascertained via questionnaire. Global cognition was assessed using the MMSE (Folstein, Folstein, & McHugh, 1975) and Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005). We used the 15-item Geriatric Depression Scale (GDS) (Yesavage, 1988) to screen for depression. Functional Comorbidity Index was calculated to estimate the degree of comorbidity associated with physical functioning (Groll, To, Bombardier, & al., 2005). This scale's score is the total number of comorbidities.

Self-efficacy—Falls-related self-efficacy was assessed using the Activities-specific Balance Confidence (ABC) scale (Powell & Myers, 1995). The ABC requires participants to self-report how confident they would be, on a scale from 0–100%, to complete each of 16 separate activities without losing their balance or falling (e.g., going up an escalator, walking on an icy sidewalk). The average for all items is computed, with higher scores indicating higher falls-related self-efficacy. The ABC scale has high internal consistency and high test-retest reliability, accurately discriminates between those with high versus low mobility (Powell & Myers, 1995), and is associated with psychological consequences of low self-efficacy, such as fear of falling (Myers et al., 1996).

Mobility—Mobility was assessed using the valid and reliable Timed Up and Go (TUG) test (Podsiadlo & Richardson, 1991). Participants were required to stand from a seated position, walk a distance of three metres, return to their chair, and sit back down. The average time to complete each of two trials was recorded in seconds, with faster times (i.e., smaller values) indicating better performance. Performance on the TUG is an ideal measure of mobility for our study, given that it predicts behaviours relevant for functional independence, including falls (Shumway-Cook, Brauer, & Woollacott, 2000) and instrumental activities of daily living (IADLs) (Donoghue, Savva, Coronin, Kenny, & Horgan, 2014).

Brain volume—Eligible participants completed magnetic resonance imaging (MRI) scanning at the UBC hospital on a 3.0T Intera Achieva MRI scanner (Philips Medical Systems Canada, Markham, Ontario, Canada). Brain volume was measured via high-resolution, T1-weighted structural MRI images (TR = 8 ms, TE = 3.7 ms, bandwidth = 2.26 kHz, voxel size = 1 x 1 x 1 mm). Brain tissue volume, normalized for subject head size, was estimated with SIENAX (Smith, De Stefano, Jenkinson, & Matthews, 2001; Smith et al., 2002), part of FSL (FMRIB's Software Library, Version 4.1.4) (Smith et al., 2004). SIENAX starts by extracting brain and skull images from the single whole-head T1 image (Smith, 2002). The brain image was then affine-registered to Montreal Neurological Institute (MNI) 152 space (Jenkinson, Bannister, Brady, & Smith, 2002; Jenkinson & Smith, 2001). Next, tissue-type segmentation with partial volume estimation was carried out (Zhang, Brady, &

Smith, 2001) in order to calculate total volume of brain tissue, total grey matter volume, and total white matter volume.

Statistical analysis

We computed partial correlations to determine the relationship between our variables of interest (self-efficacy as measured by the ABC scale, grey and white matter volumes, and mobility as measured by the TUG), while covarying for relevant descriptive variables (age, depression, education, functional comorbidities, and MoCA). We then conducted two separate mediation analyses to examine both: 1) grey matter volume and 2) white matter volume as a mediator for the relationship between self-efficacy and mobility, after accounting for relevant covariates (as above). First, we examined the relationships between self-efficacy and brain volume (path a), brain volume and mobility (path b), and self-efficacy and mobility (path c). Next, we used the INDIRECT macro (Preacher & Hayes, 2008) for SPSS (Version 21, Mac) to bootstrap the indirect effects with 5000 resamples to compute 95% confidence intervals. This quantifies the amount of reduction in the relationship between self-efficacy and mobility, when accounting for brain volume (path c'). Alpha was set at $p = 0.05$.

RESULTS

Descriptive characteristics of our sample are reported in Table 1. Of the 155 women who were recruited and randomized for the RCT, a total of 88 participants completed MRI scanning at baseline. MRI data from seven participants was excluded due to image quality issues at acquisition; one participant did not complete the TUG. Hence, the sample for this secondary study includes a total of 80 participants.

Correlations

Correlation coefficients are reported in Table 2. Self-efficacy was significantly correlated with age, depression, education, functional comorbidities, and MoCA (all p 's < 0.04). Higher self-efficacy, as assessed by the ABC scale, was associated with better mobility, as assessed by the TUG ($r = -0.45$), and greater grey ($r = 0.36$) and white matter volumes ($r = 0.28$), all p 's < 0.02 , controlling for age, depression, education, comorbidities, and MoCA. Likewise, better mobility was also associated with greater grey ($r = -0.23$) and white matter volumes ($r = -0.30$), all p 's < 0.05 , controlling for the above covariates.

Mediation

Results from the mediation analysis are presented in Figure 1. Our overall model for predicting mobility through self-efficacy, white matter volume, and relevant covariates accounted for 36.24% of the variance and was significant $F(7,72) = 5.85$, $p < 0.001$. As can be seen in Figure 1, the direct paths between our variables of interest were all significant (i.e., paths a, b, and c, all p 's < 0.05). The indirect effect of self-efficacy on mobility through white matter volume as a mediator (path c') was also significant, 95% CI $[-0.0160$ to $-0.0001]$. In contrast, grey matter volume was not a significant mediator in the relationship between self-efficacy and mobility, 95% CI $[-0.0121$ to $0.0032]$.

DISCUSSION

In this cross-sectional pilot study, we found that white matter volume mediates the relationship between self-efficacy and mobility in older community-dwelling women. In other words, while self-efficacy certainly has a direct impact on mobility, it also appears that high self-efficacy may indirectly improve mobility through increased white matter volume. This finding aligns with biopsychosocial models, where a psychological entity, such as self-efficacy, can influence health outcomes, including brain health and mobility. This study extends our understanding of the psychosocial and neurological factors that contribute to mobility, and provides insight into effective strategies that may be used to improve functional independence among older adults. Within this context, several noteworthy points of discussion follow.

First, our study found that white matter volume, specifically, mediated the relationship between self-efficacy and mobility. We previously demonstrated that self-efficacy is independently related to grey matter volume in this sample (Davis et al., 2012). Here, we also show this independent relationship, but extend it by providing evidence that only white matter volume significantly mediates the relationship between self-efficacy and mobility. Thus, our current results suggest that while self-efficacy and brain health may be closely linked, white matter volume is more relevant in the context of mobility compared with grey matter. This directly supports research presented above regarding the relationship between white matter integrity and mobility-related issues, such as falls (e.g., Zheng et al., 2011).

Second, why might higher self-efficacy lead to greater white matter volume? One possible explanation comes from the consequences of low self-efficacy. Low self-efficacy is a form of psychological stress. When faced with a challenging everyday cognitive-behavioural task, healthy older adults with low self-efficacy experience greater stress, as demonstrated by an exaggerated response of the hypothalamic-pituitary-adrenal axis and increased production of glucocorticoids, compared with those without low self-efficacy (e.g., Seeman et al., 1995). Without intervention, low self-efficacy is also persistent psychological state. Chronic stress can lead to poor habituation of the HPA axis and dysregulation of glucocorticoids release. Documented central effects of chronic psychological stress include shortening of dendrites, loss of spine synapses, suppression of neurogenesis, and reduced brain volume (e.g., McEwen, 2006). Importantly, self-efficacy has previously been shown to be modifiable with relevant training. These include guidance with personal goal setting (e.g., West, Thorn, & Bagwell, 2003) and practicing strategies aimed at improving self-efficacy and task performance (e.g., West, Bagwell, & Dark-Freudeman, 2008). Such increases in self-efficacy then lead to actual improvements in task performance (e.g., West et al., 2008). Directly relevant to our study here, if mobility is impacted by self-efficacy – both directly and indirectly – then interventions aimed at improving self-efficacy itself may improve mobility in older adults. This may be particularly helpful for older adults at risk for falls, who are known to have reduced self-efficacy and fear of falling (e.g., Myers et al., 1996).

We recognize the limitations of our study. First, while our mediation model implies directionality, we appreciate that many of these relationships are likely bi-directional. For example, better mobility certainly may feedback into increasing self-efficacy. Further, there

are likely other contributing variables to this model involving complex constructs. For instance, self-efficacy is critical for engaging in and maintaining health-related behaviours, such as regular physical activity (e.g., McAuley et al., 2011), which will positively impact both mobility and brain health. In order to determine the exact nature of these relationships, future prospective and intervention studies are required. In addition, our current study is limited to the analysis of total white matter and grey matter volumes, rather than segmenting specific brain regions. Thus, future studies should examine whether this relationship may be driven by specific brain regions, rather than global volumes, as we have reported here. Lastly, the interpretation of our results is limited to healthy community-dwelling women, and thus cannot be generalized to men or older adults with impaired physical or cognitive functioning.

Although self-efficacy and mobility have a well-established relationship, our study is the first to provide evidence that this effect is mediated by white matter volume in the brain. Of key importance, self-efficacy is a modifiable risk factor, suggesting that psychosocial interventions have the potential to improve mobility and reduce falls risk in older adults – and thereby positively impact functional independence and quality of life in this at-risk population.

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References

- Albert SM, Bear-Lehman J, Anderson SJ. Declines in Mobility and Changes in Performance in the Instrumental Activities of Daily Living Among Mildly Disabled Community-Dwelling Older Adults. *The journals of gerontology. Series A, Biological sciences and medical sciences*. 2014; doi: 10.1093/gerona/glu088
- Andersson LB, Marcusson J, Wressle E. Health-related quality of life and activities of daily living in 85-year-olds in Sweden. *Health & Social Care in the Community*. 2014; 22(4):368–374. DOI: 10.1111/hsc.12088 [PubMed: 24313868]
- Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*. 1977; 84(2):191–215. [PubMed: 847061]
- Colcombe S, Kramer AF. Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychological Science*. 2003; 14(2):125–130. [PubMed: 12661673]
- Davis JC, Nagamatsu LS, Hsu CL, Beattie BL, Liu-Ambrose T. Self-efficacy is independently associated with brain volume in older women. *Age and Ageing*. 2012; 41(4):495–501. [PubMed: 22436405]
- Donoghue OA, Savva GM, Coronin H, Kenny RA, Horgan NF. Using Timed Up-and-Go and usual gait speed to predict incident difficulty in daily activities among community-dwelling adults aged 65 and older. *Archives of Physical Medicine and Rehabilitation*. 2014 Epub ahead of print.

- Folstein MF, Folstein SE, McHugh PR. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*. 1975; 12:189–198. [PubMed: 1202204]
- Groll DL, To T, Bombardier C, et al. The development of a comorbidity index with physical function as the outcome. *Journal of Clinical Epidemiology*. 2005; 58(6):595–602. [PubMed: 15878473]
- Jackson J, Balota DA, Head D. Exploring the relationship between personality and regional brain volume in healthy aging. *Neurobiology of Aging*. 2011; 32(12):2162–2171.
- Jenkinson M, Bannister P, Brady M, Smith S. Improved optimization for the robust and accurate linear registration and motion correction of brain images. *Neuroimage*. 2002; 17(2):825–841. S1053811902911328 [pii]. [PubMed: 12377157]
- Jenkinson M, Smith S. A global optimisation method for robust affine registration of brain images. *Medical Image Analysis*. 2001; 5(2):143–156. S1361841501000366 [pii]. [PubMed: 11516708]
- Liu-Ambrose T, Khan KM, Donaldson MG, Eng JJ, Lord SR, McKay HA. Falls-related self-efficacy is independently associated with balance and mobility in older women with low bone mass. *Journal of Gerontology: A-Biol*. 2006; 61(8):832–838.
- Liu-Ambrose T, Nagamatsu LS, Graf P, Beattie BL, Ashe M, Handy TC. Resistance training and executive functions: A 12-month randomized controlled trial. *Archives of Internal Medicine*. 2010; 170:170–178. [PubMed: 20101012]
- Liu-Ambrose T, Nagamatsu LS, Voss MW, Khan KM, Handy TC. Resistance training and functional plasticity of the aging brain: A 12-month randomized controlled trial. *Neurobiology of Aging*. 2011; 33(8):1690–1698. [PubMed: 21741129]
- Maki BE, Holliday PJ, Topper AK. Fear of falling and postural performance in the elderly. *Journal of Gerontology*. 1991; 46(4):M123–M131. [PubMed: 2071833]
- McAuley E, Mullen SP, Szabo AN, White SM, Wojcicki TR, Mailey EL, ... Kramer AF. Self-regulatory processes and exercise adherence in older adults: Executive function and self-efficacy effects. *American Journal of Preventive Medicine*. 2011; 41(3):284–290. [PubMed: 21855742]
- McEwen BS. Protective and damaging effects of stress mediators: central role of the brain. *Dialogues of Clinical Neuroscience*. 2006; 8(4):367–381.
- Myers AM, Powell LE, Maki BE, Holliday PJ, Brawley LR, Sherk W. Psychological indicators of balance confidence: relationship to actual and perceived abilities. *Journal of Gerontology: Medical Sciences*. 1996; 51A(1):M37–M43.
- Nagamatsu LS, Boyd LA, Hsu CL, Handy TC, Liu-Ambrose T. Overall reductions in functional brain activation are associated with falls in older adults: An fMRI study. *Frontiers of Aging Neuroscience*. 2013; 5:1–7.
- Nagamatsu LS, Hsu CL, Handy TC, Liu-Ambrose T. Functional neural correlates of reduced physiological falls risk. *Behavioral and Brain Science*. 2011; 7:37.
- Nasreddine ZS, Phillips NA, Bedirian V, Charbonneau S, Whitehead V, Collin I, ... Chertkow H. The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*. 2005; 53(4):695–699. [PubMed: 15817019]
- Newman AB, Haggerty CL, Kritchevsky SB, Nevitt MC, Simonsick EM. Walking performance and cardiovascular response: associations with age and morbidity -the Health, Aging, and Body Composition Study. *Journal of Gerontology: A-Biol*. 2003; 58(8):715–720.
- Podsiadlo D, Richardson S. The timed "up and go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*. 1991; 39(2):142–148. [PubMed: 1991946]
- Powell L, Myers A. The Activities-Specific Confidence (ABC) Scale. *Journal of Gerontology*. 1995; 50A(1):M28–M34.
- Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*. 2008; 40(3):879–891. [PubMed: 18697684]
- Pruessner JC, Baldwin MW, Dedovic K, Renwick R, Mahani NK, Lord C, ... Lupien S. Self-esteem, locus of control, hippocampal volume, and cortisol regulation in young and old adulthood. *NeuroImage*. 2005; 28(4):815–826. [PubMed: 16023372]

- Rosano C, Aizenstein HJ, Studentski S, Newman AB. A regions-of-interest volumetric analysis of mobility limitations in community-dwelling older adults. *Journal of Gerontology: A-Biol.* 2007; 62(9):1048–1055.
- Rosano C, Sigurdsson S, Siggeirsdottir K, Phillips CL, Garcia M, Jonsson PV, ... Launer LJ. Magnetization transfer imaging, white matter hyperintensities, brain atrophy and slower gait in older men and women. *Neurobiology of Aging.* 2010; 31(7):1197–1204. [PubMed: 18774624]
- Seeman TE, Berkman LF, Gulanski BI, Robbins RJ, Greenspan SL, Charpentier PA, Rowe JW. Self-esteem and neuroendocrine response to challenge: MacArthur studies of successful aging. *Journal of Psychosomatic Research.* 1995; 39(1):69–84. [PubMed: 7760305]
- Sessford JD, Jung M, Brawley LR, Forbes JL. Do Older Adults' Beliefs About Their Community Mobility Predict Walking Performance? *Journal of Aging and Physical Activity.* 2014; doi: 10.1123/japa.2013-0235
- Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up and Go test. *Physical Therapy.* 2000; 80(9):896–903. [PubMed: 10960937]
- Smith SM. Fast robust automated brain extraction. *Human Brain Mapping.* 2002; 17(3):143–155. DOI: 10.1002/hbm.10062 [PubMed: 12391568]
- Smith SM, De Stefano N, Jenkinson M, Matthews PM. Normalized accurate measurement of longitudinal brain change. *Journal of Computer Assisted Tomography.* 2001; 25(3):466–475. 00004728-200105000-00022 [pii]. [PubMed: 11351200]
- Smith SM, Jenkinson M, Woolrich MW, Beckmann CF, Behrens TE, Johansen-Berg H, ... Matthews PM. Advances in functional and structural MR image analysis and implementation as FSL. *Neuroimage.* 2004; 23(Suppl 1):S208–219. S1053-8119(04)00393-3 [pii]. DOI: 10.1016/j.neuroimage.2004.07.051 [PubMed: 15501092]
- Smith SM, Zhang Y, Jenkinson M, Chen J, Matthews PM, Federico A, De Stefano N. Accurate, robust, and automated longitudinal and cross-sectional brain change analysis. *Neuroimage.* 2002; 17(1): 479–489. S1053811902910402 [pii]. [PubMed: 12482100]
- Wakefield DB, Moscufo N, Guttmann CR, Kuchel GA, Kaplan RF, Pearlson G, Wolfson L. White matter hyperintensities predict functional decline in voiding, mobility, and cognition in older adults. *Journal of the American Geriatrics Society.* 2010; 58(2):275–281. [PubMed: 20374403]
- West RL, Bagwell DK, Dark-Freudeman A. Self-efficacy and memory aging: the impact of a memory intervention based on self-efficacy. *Aging, Neuropsychology, and Cognition.* 2008; 15:302–329.
- West RL, Thorn RM, Bagwell DK. Memory performance and beliefs as a function of goal setting and aging. *Psychology and Aging.* 2003; 18(1):111–125. [PubMed: 12641316]
- White DK, Neogi T, Nevitt MC, Petoquin CE, Zhu Y, Boudreau RM, ... Zhang Y. Trajectories of gait speed predict mortality in well-functioning older adults: the Health, Aging, and Body Composition study. *Journal of Gerontology: A-Biol.* 2013; 68(4):456–464.
- Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: A review of an emerging area of research. *Gait and Posture.* 2002; 16:1–14. [PubMed: 12127181]
- Yesavage JA. Geriatric Depression Scale. *Psychopharmacology Bulletin.* 1988; 24(4):709–711. [PubMed: 3249773]
- Zhang Y, Brady M, Smith S. Segmentation of brain MR images through a hidden Markov random field model and the expectation-maximization algorithm. *IEEE Transactions on Medical Imaging.* 2001; 20(1):45–57. DOI: 10.1109/42.906424 [PubMed: 11293691]
- Zheng JJ, Delbaere K, Close JC, Sachdev PS, Lord SR. Impact of white matter lesions on physical functioning and fall risk in older people: A systematic review. *Stroke.* 2011; 42(7):2086–2090. [PubMed: 21636821]

Figure 1. Mediation model. Standardized regression coefficients for the relationship between self-efficacy and mobility (lower mobility scores represent better performance) as mediated by white matter volume. The standardized regression coefficient between self-efficacy and mobility, controlling for white matter volume (c') is in parentheses. $*p < 0.05$.

Table 1

Descriptive variables

Variable	Mean (SD) n = 80
Age, years	69.39 (2.90)
Education, no. (%):	
No high school	1 (1.3)
Grades 9–12 without certificate or diploma	5 (6.3)
High school certificate or diploma	14 (17.5)
Trade or professional certificate or diploma	13 (16.3)
University certificate or diploma	15 (18.8)
University degree	32 (40.0)
Activities-specific balance confidence scale, %	88.61 (12.64)
Timed Up and Go, s	6.45 (1.12)
Mini-Mental State Examination, max. 30	28.74 (1.17)
Montreal Cognitive Assessment, max. 30	25.34 (3.02)
Geriatric depression scale	0.49 (1.52)
Functional comorbidity index	1.98 (1.65)
Grey matter volume, mm ³	734,314.60 (33,690.53)
White matter volume, mm ³	671,947.62 (33,861.40)
Total brain volume, mm ³	1,406,262.22 (58,798.27)

Table 2

Correlation coefficient matrix for ABC, TUG, grey and white matter volumes, and relevant covariates (n = 80)

	ABC	TUG	Grey matter volume	White matter volume
ABC ^I		−0.45 **	0.36 **	0.28 *
TUG ^I			−0.23 *	−0.30 **
Age	−0.26 *	0.21	−0.31 **	−0.12
Education	0.28 *	−0.21	−0.08	−0.10
MoCA	0.24 *	−0.23 *	0.10	−0.06
Depression	−0.26 *	0.07	0.09	0.13
FCI	−0.26 *	0.20	0.16	−0.02

^IPartial correlation controlling for age, education, MoCA, depression, and FCI.*
 $p < 0.05$ **
 $p < 0.01$