Please read the article, "Associations between physical performance and executive function in older adults with mild cognitive impairment: gait speed and the timed "Up & Go", and answer the following questions in CHINESE (except special terms or abbreviations).

1. What are the purposes of this study? (5%)
2. What is the motivation of authors to conduct this study? (5%)
3. Please illustrate recruitment and characteristics of participants, and dependent variables and independent variables of this study. (10%)
4. Please describe the procedure of data collection. (5%)
5. What is Timed "Up & Go" test? What are executive function measures in this study? (10%)
6. How is Timed "Up & Go" test associated with executive function performance? And, how did the authors explain this association? (10%)
7. What are the limitations of this study according to the authors' own opinion? (5%)

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(背面仍有題目,請繼續作答)

Associations Between Physical Performance and Executive Function in Older Adults With Mild Cognitive Impairment: Gait Speed and the Timed "Up & Go" Test

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Background. Older adults with amnestic mild cognitive impairment (aMCI) are at higher risk for developing Alzheimer disease. Physical performance decline on gait and mobility tasks in conjunction with executive dysfunction has implications for accelerated functional decline, disability, and institutionalization in sedentary older adults with aMCI.

Objectives. The purpose of this study was to examine whether performance on 2 tests commonly used by physical therapists (usual gait speed and Timed "Up & Go" Test [TUG]) are associated with performance on 2 neuropsychological tests of executive function (Trail Making Test, part B [TMT-B], and Stroop-Interference, calculated from the Stroop Word Color Test) in sedentary older adults with aMCI.

Design. The study was a cross-sectional analysis of 201 sedentary older adults with memory impairment participating in a longitudinal intervention study of cognitive function, aging, exercise, and health promotion.

Methods. Physical performance speed on gait and mobility tasks was measured via usual gait speed and the TUG (at fast pace). Executive function was measured with the TMT-B and Stroop-Interference measures.

Results. Applying multiple linear regression, usual gait speed was associated with executive function on both the TMT-B ($\beta = -0.215$, $P = .003$) and Stroop-Interference ($\beta = -0.195$, $P = .01$) measures, indicating that slower usual gait speed was associated with lower executive function performance. Timed "Up & Go" Test scores (in logarithmic transformation) also were associated with executive function on both the TMT-B ($\beta = 0.256$, $P < .001$) and Stroop-Interference ($\beta = 0.228$, $P = .002$) measures, indicating that a longer time on the TUG was associated with lower executive function performance. All associations remained statistically significant after adjusting for age, sex, depressive symptoms, medical comorbidity, and body mass index.

Limitations. The cross-sectional nature of this study does not allow for inferences of causation.

Conclusions. Physical performance speed was associated with executive function after adjusting for age, sex, and age-related factors in sedentary older adults with aMCI. Further research is needed to determine mechanisms and early intervention strategies to slow functional decline.

Mild cognitive impairment (MCI) is considered a transitional state that is less severe than dementia, but beyond that of typical age-related cognitive changes.[1] ***Mild cognitive impairment*** is defined as impairment (adjusted for age and education) in one or more domains of cognition, with relative sparing of global cognitive functions.[2–4] Although MCI is associated with only mild decline in cognition, the onset of dementia is characterized by overt difficulties in multiple domains of cognitive function as well as performance of daily activities.[2] Even in the presence of MCI, reduced function has been identified in executive function tasks,[5,6] instrumental activities of daily living[7,8] and physical performance tasks.[9,10] There are 2 major subclassifications of MCI—amnestic MCI (aMCI) and nonamnestic MCI (naMCI)—the more common of which is aMCI.[4,11] Older adults with aMCI, involving early memory loss, are at higher risk for Alzheimer disease (AD),[4,11] and reduced executive function may be associated with early physical decline in people with aMCI. Identifying whether physical performance decline is associated with reduced executive function is important for developing physical therapy management strategies aimed at slowing the progression of functional decline and associated disability in older adults with aMCI.

The worsening of executive function in older adults with aMCI is associated with the conversion to AD.[5] The degenerative processes in aMCI involve medial temporal lobe structures, as observed in early stages of AD, but also may include the frontal lobe, the part of the brain involved in executive function.[4,5] Executive function involves higher-order cognitive processes necessary for implementation of goal-directed behaviors,[12] and reliance on executive function is elevated with increasing difficulty of motor tasks,[13,14] especially in novel or demanding situations.[15] Medication adherence, cooking, housekeeping, and motor tasks performed in a complex environment are examples of goal-directed activities that are vulnerable to decline in executive function.[12] Executive function is thought to rely strongly on the prefrontal cortex and includes multiple cognitive processes such as planning, tracking, judgment, initiation, scanning, sequencing, problem solving, and cognitive flexibility.[12,16] The notion that executive function is multifaceted in nature is supported by evidence from functional magnetic resonance studies indicating that different aspects of executive function rely on different parts of the prefrontal cortex.[17]

Declining physical performance in conjunction with cognitive decline has been associated with increased risk for dementia and disability in population-based studies of older adults.[18,19] In a prospective, longitudinal study of older adults who were healthy, slower self-selected gait speed was associated with cognitive impairment at the 6-year follow-up.[20] In the Sydney Older Persons Study of people who did not have dementia at baseline, the presence of slowed gait speed in combination with cognitive deficits was associated with increased odds of progression to dementia.[19] The combination of impaired physical performance and executive dysfunction may be more predictive of dementia risk; therefore, it has implications for accelerated functional decline, disability, and institutionalization in older adults with aMCI.

Studies of physical performance in individuals with MCI support the notion that physical performance impairment is present prior to the onset of dementia,[21,22] especially in older adults who demonstrate executive dysfunction.[9,23] Executive dysfunction is predictive of functional decline and increased risk for dementia in community-dwelling older adults.[24,25] Early pathology, consistent with AD, may contribute

The Bottom Line

What do we already know about this topic?

Older adults with mild cognitive impairment (MCI) are at higher risk for dementia and associated disability. Functional decline often is accelerated in the presence of both physical and cognitive impairments.

What new information does this study offer?

In this study of sedentary older adults with amnestic MCI (memory loss), slower physical performance on gait and mobility tasks was associated with lower performance on executive function tasks, such as those involving planning and judgment.

If you're a patient or caregiver, what might these findings mean for you?

Comprehensive prevention and rehabilitation strategies that enhance both cognitive and physical function are important in reducing functional decline and disability in older adults.

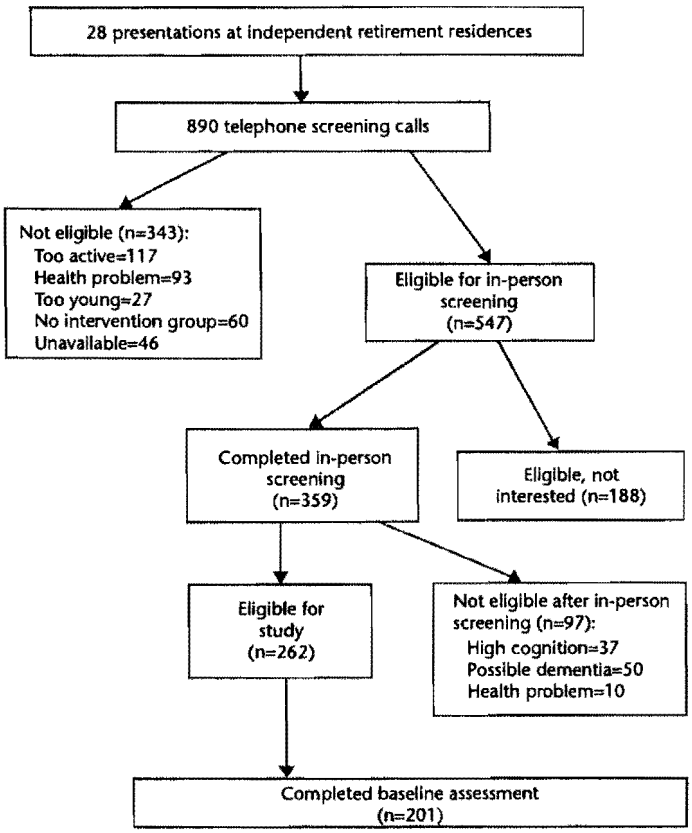

Figure.
Flow chart of participant recruitment and screening.

to physical performance impairment through alterations in memory, attention, and executive function networks.[26,27] Alternatively, age and age-related comorbid conditions may be responsible for declining physical performance and executive dysfunction in older adults with memory impairment. It is unclear whether an association between physical performance and executive function remains after adjusting for age and age-related factors that are known to affect both physical performance and executive function in older adults with aMCI.

Because older adults with both physical and cognitive impairment are at higher risk for dementia and disability,[28] identifying whether physical performance decline is associated with executive dysfunction is important for developing physical therapy early intervention strategies for older adults with aMCI. The purpose of this study was to determine whether performance on 2 tests that are commonly used by physical therapists (usual gait speed and the Timed "Up & Go" Test [TUG]) are associated with performance on 2 neuropsychological tests of executive function (the Trail Making Test, part B [TMT-B], and Stroop-Interference, calculated from the Stroop Word Color Test) in sedentary older adults with aMCI after adjusting for age, sex, depressive symptoms, medical comorbidity, and body mass index (BMI). We hypothesized that slower physical performance speed would be associated with lower executive function after adjusting for factors that are known to affect both physical performance and executive function.

Method

Participants

This study involved analysis of baseline data from the Resources and Activities for Life-Long Independence (RALLI) Study, a longitudinal intervention study of cognitive function, aging, exercise, and health promotion in sedentary older adults with aMCI. Participants were volunteers living in independent retirement residences who reported mild memory problems. Study flyers were distributed, and a presentation was given to residents of 28 independent retirement living centers in the Seattle, Washington, metropolitan region. Residents who were interested in volunteering for the RALLI Study contacted the study coordinator (Figure). The sample size was determined based on a power analysis conducted for the randomized controlled trial.

Participants enrolled in the study were aged 70 years and older, were sedentary, and were classified as having aMCI based on screening interviews and a consensus meeting. Study recruitment and screening consisted of: (1) a telephone screening interview, (2) an in-home screening evaluation that consisted of a semistructured interview and neuropsychological screening tests, and (3) an expert consensus panel to review screening data. Petersen criteria[1,4] were applied using a combination of cognitive test scores, screening interview data, and consensus case review to identify people with memory problems that would be consistent with a clinical

subtype of aMCI (single or multiple domain). Petersen criteria included: (1) memory complaint, (2) impaired memory for age and education, (3) preserved general cognitive function, (4) essentially preserved activities of daily living, and (5) not already diagnosed with dementia. Participants were enrolled in the study from July 2007 through December 2009.

Cognitive function tests and clinical criteria used to determine whether participants met the aMCI classification criteria included: (1) the Mini-Mental State Examination (MMSE) for global cognition,[29] (2) the Wechsler Memory Scale-Revised (WMS-R) Logical Memory I and II subtests for immediate and delayed recall,[30] and (3) the Clinical Dementia Rating Scale for severity rating of cognitive impairment.[31] Memory impairment was determined by a Clinical Dementia Rating Scale score of 0.5 (consistent with MCI), a score on the WMS-R Logical Memory subtests that was 1 standard deviation below age- and education-adjusted norms,[32] problems on the memory recall items of the MMSE, or observed difficulty with everyday recall during the assessment interview. Because the classification of aMCI involves a synthesis of information obtained through neuropsychological assessment, observations of daily activities, and clinical judgment,[2,3] each participant was reviewed through a consensus process to determine eligibility for the study. The above neuropsychological test scores, performance on specific memory tasks, and evidence indicating intact ability to perform activities of daily living were examined by 2 clinical psychologists at a consensus meeting. Because aMCI is a clinical classification for which there is no single, definitive diagnostic test, a series of neuropsychological tests as well as an expert clinician's observations and judgment are critical in identifying people at risk for dementia.[3] *Sedentary lifestyle* was defined as performance of less than 150 minutes of moderate-intensity exercise per week (over the previous month), as recommended by the American College of Sports Medicine and the American Heart Association.[33]

Potential participants were excluded from the study if they: (1) did not meet aMCI criteria; (2) were unable to walk independently with an assistive device; (3) were expecting to move away from the area; (4) had a known terminal illness; (5) were actively suicidal, hallucinating, or delusional; (6) had been hospitalized within the previous 12 months; (7) had an uncontrolled chronic medical condition; (8) were blind or deaf; or (9) had a known central nervous system condition associated with dementia. Upon enrollment in the study, participants completed 2 in-home baseline evaluations administered by trained research assistants. During these evaluations, testing was completed for demographic and health-related information, physical performance measures, and executive function measures as described below. Each participant gave consent prior to the screening process.

Demographic and Health-Related Information

Demographic and health-related information was collected via self-report responses. *Medical comorbidity*, assessed with the Self-Administered Comorbidity Questionnaire,[34] was defined as having any of the following conditions: heart disease, hypertension, diabetes, pulmonary disease, kidney disease, peripheral vascular disease, osteoarthritis, rheumatoid arthritis, or back pain. Symptoms of depression were assessed using the Geriatric Depression Scale (range of scores=0–15).[35] Body mass index (kg/m^2) was calculated using height and weight measured at baseline.

Physical Performance Measures

Usual gait speed was calculated from an 8-foot (approximately 2.4 m) walk test in which participants walked at their comfortable pace. The 8-foot walk test was completed inside the participant's apartment or in a nearby hallway on a level surface with low-pile or indoor/outdoor carpet. The time to walk 8 feet was averaged over 2 trials and converted to gait speed (meters per second). Comfortable walking speed measurements have been reported to be highly reliable (r=.903) in individuals who were healthy and ranging in age from 20 to 79 years.[36] Usual gait speed is comparable to the entire Short Physical Performance Battery in predicting disability in older adults.[37]

The TUG[38] was performed at a fast pace to measure mobility speed.[39] Participants were asked to move as quickly but as safely as possible to rise from an armchair (45.72-cm [18-in] seat height), walk 3 m, turn around a cone, walk back to the chair, and sit down. Time to complete the TUG was averaged over 2 trials. When performed at a comfortable pace, TUG scores have good interrater and intrarater reliability as well as a high correlation with the Berg Balance Scale scores (r=−.81), gait speed (r=−.61) and Barthel Index of Activities of Daily Living scores (r=−.78), and normative values have been reported.[36,40] When performed as quickly and as safely as possible, the TUG has demonstrated high sensitivity and specificity in identifying older adults who are prone to falling.[39]

Executive Function Measures

The TMT-B was used to evaluate the components of executive function that represent complex visual scanning, speed, attention, and ability to shift sets.[41,42] To complete this test, participants used a pencil to connect 25 encircled numbers and letters in

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numerical and alphabetical order, alternating between numbers and letters.[43] The maximum amount of time allowed to complete the TMT-B is 300 seconds; longer times indicate worse performance in executive function. The TMT-B has been widely used in studies of older adults, and normative data have been reported.[44,45] The TMT-B was used in this study because it is considered to be specific to executive function processes due to its requirements for switching sets and mental tracking throughout the task.[46]

The Stroop Word Color Test was used to assess components of executive function representing a person's ability to deal with conflicting stimuli.[47] This test involves pairs of conflicting stimuli that are presented simultaneously, that is, the name of one color printed in another color. There are 3 portions to the Stroop Word Color Test: word naming (W), color naming (C), and color interference (CW). Although there are variations in test length and scoring methods,[48,49] the version selected for this study involved recording the number of correct responses in 45 seconds for each portion of the test.[50] A difference in the number of words printed in black ink compared with colors named correctly for words printed in a different color (ie, blue ink for the word "red") is interpreted as interference of color stimuli. An overall Stroop-Interference score, as introduced by Golden,[51] was calculated for this study using the formula: $[CW - (W \times C)/(W + C)]$. In a previous study comparing older adults with aMCI with older adults with noncognitive impairments and mild AD, those with aMCI performed less well than those who were noncognitively impaired and better than the AD group on the color interference condition.[52] Normative values for the raw scores from the 3 portions of the Stroop Word Color Test have been reported.[44,53]

Data Analysis

We used SPSS statistical software, version 16.0,* for descriptive statistics and data analysis. To examine the association between physical performance and components of executive function, linear regression was applied and model fit was evaluated. A curvilinear relationship was present between the TUG and executive function (both TMT-B and Stroop-Interference measures). With the understanding that the model is not intended for prediction, but rather to determine whether a relationship exists, we made the decision to log transform TUG scores. Upon transformation, we found that a linear relationship was present between log(TUG) and each executive function variable.

To assess whether executive function, as measured by the TMT-B and Stroop-Interference, was associated with usual gait speed after adjusting for age, sex, depressive symptoms, medical comorbidity, and BMI, we created 2 multiple linear regression models. Covariates known to influence both walking speed and cognitive functions, including age, sex, depressive symptoms, medical comorbidity, and BMI, were entered into each model. The covariate variables were added first to each usual gait speed model, followed by the executive function variable. Although performance on the TMT-B and the Stroop Word Color Test have been associated with age and years of education in older adults,[45,53] education was not included as a covariate in the multiple regression analysis because the majority of our sample had 12 years of more of education (97% had >12 years of education, and 79.6% had >13 years of education).

To assess whether executive function, as measured by the TMT-B and Stroop-Interference, was associated with the TUG after adjusting for covariates, 2 models were created using log(TUG) as the outcome. The same covariates as above were entered into each model because they are known to influence both mobility speed and cognitive functions. The covariate variables were added first to each TUG model, followed by the executive function variable.

A dichotomous variable was created for comorbidity (none versus one or more medical conditions). Sex was coded 0 (male) or 1 (female). Correlations and the variance inflation factor for multicollinearity were used to identify whether covariates were strongly correlated. The contribution of the executive function variable in each model was assessed by the change in R^2 values from the model with the covariates only to the model with the covariates and the executive function variable. Residual analysis for each multiple linear regression model included normal probability plots and scatter plots of standardized residuals.

Role of the Funding Source

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Results

Data for demographic and health-related variables are summarized in Table 1. Participants had a mean age of 84.6 years (SD=5.7), were 80.1%

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female, and were 91% Caucasian. The initial sample was composed of 201 participants; however, 19 participants did not complete the TMT-B (16 due to vision problems and 3 due to missing data), and 25 participants did not complete the Stroop Word Color Test (22 due to vision problems or color blindness and 3 due to missing data). There also were missing data on the GDS (n=2), TUG (n=5), usual gait speed (n=2), MMSE (n=1), and logical memory (n=1). After accounting for all data entered into the multiple linear regression models, 179 cases were analyzed for associations between physical performance and the TMT-B, and 173 cases were analyzed for associations between physical performance and the Stroop-Interference measure. Sixteen participants (8.0% of the entire sample and 10.8% of those in the final analysis) reached the maximum time (300 seconds) on the TMT-B.

Table 1.
Descriptive Statistics[a]

Characteristic	n	Mean (SD) or Percentage	Minimum	Maximum
Demographic				
Age (y)	201	84.6 (5.7)	69.7	104.3
Sex, % female	201	80.1		
Ethnicity, % Caucasian	201	91.0		
% living alone	201	68.7		
% high school education	201	97.5		
Physical performance and executive function				
Gait speed (m/s)	199	0.61 (0.18)	0.24	1.08
TUG (s)	196	11.96 (5.54)	5.20	35.70
TUG (log)	196	1.041 (0.17)	0.716	1.553
Trail Making Test, part B	182	148.04 (70.35)	47.0	300.0[b]
Stroop-Interference	176	−81.09 (20.78)	−139.00	−23.00
Clinical				
Geriatric Depression Scale	199	2.48 (2.37)	0	12
WMS-R Logical Memory I	200	19.9 (7.5)	5.0	42.0
WMS-R Logical Memory II	200	14.1 (7.6)	0	35.0
MMSE	200	26.47 (2.56)	18.00	30.00
% CDR 0.5	200	100.0		
% BMI ≥25 kg/m^2	201	59.9		
% medical comorbidity	201	77.6		

[a] TUG=Timed "Up & Go" Test; TMT-B=Trail Making Test, part B; WMS-R=Wechsler Memory Scale–Revised; MMSE=Mini-Mental State Examination; CDR=Clinical Dementia Rating Scale; BMI=body mass index.
[b] 10.8% of participants (n=16) reached the maximum TMT-B time of 300 seconds.

Usual gait speed was statistically significantly associated with executive function in both the unadjusted analysis (Tab. 2) and after adjusting for covariates (Tab. 3). In the unadjusted analysis, usual gait speed was associated with the TMT-B ($\beta=-.267$, $P<.001$) and Stroop-Interference ($\beta=-.214$, $P=.004$) measures. The change in R^2 values attributed to executive function was .07 for the TMT-B and .05 for the Stroop-Interference measure. After adjusting for covariates, the TMT-B ($\beta=-.215$, $P=.003$) and Stroop-Interference ($\beta=-.195$, $P=.01$) findings were statistically significant, indicating that slower usual gait speed was associated with lower executive function performance on both measures. The change in R^2 values attributed to the addition of the TMT-B (the difference between the full model and the model with covariates only) was .044. The overall change in R^2 values was .084; therefore, the full model explained 54.5% more variance than the unadjusted model. The change in R^2 attributed to the addition of the Stroop-Interference measure to the model was .034. The overall change in R^2 values was .102; therefore, the full model explained 67.1% more of the variance than the unadjusted model. In the full model for usual gait speed, age and depressive symptoms were statistically significant when the TMT-B and Stroop-Interference measures were in the models, with slower usual gait speed associated with older age and depressive symptoms.

Log(TUG) was statistically significantly associated with executive function in both the unadjusted anal-

Table 2.
Linear Regression for Usual Gait Speed and Timed "Up & Go" Test (TUG) (Log Transformed)

Physical Performance	Executive Function	
	Trail Making Test, Part B (n=180)	Stroop-Interference Measure (n=174)
Usual gait speed (m/s)	$\beta=-.267$, $P<.001$ ($R^2=.07$)	$\beta=-.214$, $P=.004$ ($R^2=.05$)
Log(TUG)	$\beta=.290$, $P<.001$ ($R^2=.08$)	$\beta=.251$, $P=.001$ ($R^2=.06$)

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Table 3.
Linear Regression for Gait Speed (m/s)

	Explanatory Variable and Covariates	Standardized Coefficient (β)	P	R^{2a}	F
Model 1 (n=179)	Age	−.199	.007		
	Sex	−.08	.27		
	Depressive symptoms	−.182	.01		
	Medical comorbidity	.057	.42		
	Body mass index	−.09	.22	.110	
	Trail Making Test, part B	−.215	.003	.154[b]	5.25 (P<.001)
Model 2 (n=173)	Age	−.173	.03		
	Sex	−.124	.09		
	Depressive symptoms	−.232	.002		
	Medical comorbidity	.081	.26		
	Body mass index	−.071	.35	.118	
	Stroop-Interference	−.195	.01	.152[b]	5.00 (P<.001)

[a] The R^2 value for the model not including the executive function variable.
[b] Change in R^2 value was statistically significant at the .05 level when adding the executive function variable to the model.

ysis (Tab. 2) and after adjusting for covariates (Tab. 4). In the unadjusted analysis, log(TUG) was associated with the TMT-B (β=.290, P=< .001) and Stroop-Interference (β=.251, P=.001) measures. The change in R^2 values attributed to the executive function variable was .08 for the TMT-B and .06 for the Stroop-Interference measure. Log(TUG) was associated with both executive function measures after adjusting for covariates. The TMT-B (β=.256, P<.001) and Stroop-Interference (β=.228, P=.002) findings were statistically significant after adjusting for the other variables, indicating that slower TUG times were associated with lower executive function performance on both measures.

Table 4.
Linear Regression for Timed "Up & Go" Test (Log Transformed)

	Explanatory Variable and Covariates	Standardized Coefficient (β)	P	R^{2a}	F
Model 1 (n=178)	Age	.173	.02		
	Sex	.051	.45		
	Depressive symptoms	.217	.002		
	Medical comorbidity	−.009	.90		
	Body mass index	.264	<.001	.148	
	Trail Making Test, part B	.256	<.001	.211[b]	7.66 (P<.001)
Model 2 (n=173)	Age	.156	.05		
	Sex	.097	.18		
	Depressive symptoms	.245	.001		
	Medical comorbidity	−.036	.61		
	Body mass index	.198	.008	.104	
	Stroop-Interference	.228	.002	.147[b]	5.96 (P<.001)

[a] The R^2 value for the model not including the executive function variable.
[b] Change in R^2 value was statistically significant at the .05 level when adding the executive function variable to the model.

The results indicate that a longer time to complete the TUG was associated with lower executive function, that is, a longer time to perform the TMT-B and higher Stroop-Interference scores. The change in R^2 values attributed to the addition of the TMT-B to the model was .063 (the difference between the full model and the model with covariates only). The overall change in R^2 values was .13; therefore, the full model explained 61.6% more variance than the unadjusted model. The change in R^2 values attributed to the addition of the Stroop-Interference measure to the model was .043. The overall change in R^2 values was .087; therefore, the full model explained 59.2% more of the variance than the unadjusted model. In the full models for log(TUG), age, depressive symptoms, and BMI were statistically significant covariates, with higher values of log(TUG) (and, therefore, slower performance on the TUG) associated with higher values of BMI and depressive symptoms.

Examination of multicollinearity among the explanatory variables using the variance inflation factor resulted in values close to 1, indicating no collinearity. Analysis of residuals for each model using normal q-plots and scatter plots of residuals by the estimated values showed that the model fit the data appropriately.

Discussion

In this study of sedentary older adults with aMCI, an association between physical performance speed and executive function on the TMT-B and Stroop-Interference measures was demonstrated after adjusting for age, sex, depressive symp-

toms, and BMI. Slower usual walking speed was associated with lower performance on a test of mental flexibility (TMT-B) and with reduced ability to manage conflicting stimuli (Stroop-Interference). Similarly, performance on a functional mobility task (TUG at fast pace) was associated with both measures of executive function. The results of this study demonstrate a consistent relationship between 2 commonly used physical therapy assessment tools and 2 measures of executive function. This finding is clinically relevant in older adults with memory impairment because impairments in physical and cognitive domains increase the risk for accelerated functional decline and disability, especially in the presence of executive dysfunction.[24]

The prevalence of slowed gait speed is evident when working memory is challenged in older adults with MCI,[54] thus supporting the notion that gait is not entirely automatic, but instead requires attentional resources.[13,55] Physical performance is particularly challenged when older adults are asked to concurrently perform a cognitive task, suggesting that allocation of attention is necessary in older adults with and without cognitive impairment.[56] Associations between physical performance and cognitive function have been reported in previous studies in the areas of gait speed, balance, and fall risk in older adults with MCI,[9,57] and they are especially robust in the presence of executive dysfunction.[23] Declining executive function may be an early indicator of overall functional decline in older adults. For example, in a prospective study of older women with intact cognition at baseline, executive function decline occurred 3 years prior to memory decline over a 9-year follow-up period, and executive function decline occurred more often than any other cognitive impairment.[58] Sedentary older adults with aMCI may be particularly vulnerable to executive function and mobility impairment and, therefore, at higher risk for subsequent functional decline and falls.

Slowed physical performance may be a compensatory strategy to maintain accuracy in older adults with aMCI.[59] People with MCI performed daily activities at slower speeds, but maintained accuracy on a series of daily activities.[60] Older adults with probable AD who were asked to perform a cognitive task (repeating random digits) while walking demonstrated slower walking and greater variability in their walking pattern, possibly due to reduced ability to divide or prioritize attention.[55] A similar phenomenon may be occurring in older adults with aMCI, with a slowing of task speed in an effort to maintain accuracy even under conditions of relatively low cognitive or environmental challenge, as implemented in our study. Therefore, older adults with aMCI may be particularly vulnerable to physical performance decline and fall risk on tasks that require attention and learning, such as attending to a new walking route or other nonroutine activities. Although age and age-related comorbid conditions may contribute to declining physical performance and executive dysfunction in older adults with memory impairment, the statistically significant associations that remain after adjusting for these factors in our study suggest that other mechanisms, such as brain pathology, may be contributing to this relationship.

Medial temporal lobe structures, which are responsible for memory and learning, are the first brain regions affected by AD pathology, followed by other cortical and subcortical regions with disease progression.[61,62] Pathology consistent with AD has been reported in the brains of older adults with aMCI[63] and may contribute to physical performance impairment through alterations in memory, attention, and executive function networks.[26,27] Alternatively, in older adults with aMCI, pathological mechanisms associated with declining physical performance may result from pathology not typically associated with AD, but instead with other dementia syndromes (eg, Parkinson disease, vascular disease) that interfere with frontal-subcortical circuits.[27,64] Therefore, further research is needed to identify neuropathological mechanisms involved in the association between physical performance speed and executive dysfunction in older adults with aMCI.

This study had a defined sample of sedentary older adults with aMCI and valid and reliable measures of physical performance and executive function. There were, however, several limitations. A ceiling effect on the TMT-B occurred with 8.0% of participants (final analysis) reaching the 300-second maximum, so we lack an estimate of the slowest performance possible on the TMT-B. The cross-sectional nature of this study does not allow for inferences of causation. Nevertheless, consistent associations were demonstrated, suggesting that combining physical performance and executive function assessments may be clinically useful in detecting early functional decline in older adults with MCI. Although efforts were made to minimize bias through the selection of valid tests, consideration of potential confounders, and recruitment practices,[65] a potential source of bias remains because this sample of older adults was recruited from independent retirement living centers. Future longitudinal studies to assess the predictive value of executive function measures on physical performance in people with aMCI are needed.

Conclusions

Slower physical performance was associated with lower executive function in our sample of sedentary older adults with aMCI, and associations remained statistically significant after adjusting for age, sex, depressive symptoms, medical comorbidity, and BMI. Slower gait and mobility associated with reduced executive function in sedentary older adults with aMCI have implications for accelerated functional decline, disability, and institutionalization. Further research is needed to determine mechanisms for this association and whether early intervention strategies are effective in slowing functional decline and disability in sedentary older adults with aMCI. Early intervention strategies that focus on enhancing executive function as well as physical performance (eg, exercise) should be studied in sedentary older adults with aMCI.

Dr McGough, Dr Kelly, Dr Logsdon, Dr McCurry, and Dr Teri provided concept/idea/research design. All authors provided writing. Dr McGough, Dr Logsdon, Dr McCurry, and Dr Teri provided data collection. Dr McGough, Dr McCurry, and Dr Teri provided data analysis. Dr Logsdon, Dr McCurry, and Dr Teri provided project management, fund procurement, participants, and facilities/equipment. Dr Teri provided institutional liaisons. Dr Kelly, Dr Logsdon, Dr McCurry, Dr Cochrane, Dr Engel, and Dr Teri provided consultation (including review of manuscript before submission). The authors thank the Northwest Research Group on Aging, Ken Pike, PhD, for statistical support, and June van Leynseele, MA, for study coordination.

The University of Washington Institutional Review Board approved the study procedures.

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Please read the news report " Rachel Morris: Racing against her own body", and answer the following questions in English or Chinese.

8. What is the possible diagnosis for Morris? (5%)
9. What are two major sorts of pain Morris encounters now? (10%) What are the characteristics of each type of pain? (20%)
10. Why does Rachel Morris push herself so hard? (5%)
11. What do you learn from this report? (10%)

(背面仍有題目,請繼續作答)

Rachel Morris: Racing against her own body
By Ollie Williams, from BBC Sport

Rachel Morris doesn't cycle for fun. She does it to make the pain bearable. The 32-year-old has already lost both of her legs to a rare and aggressive condition which causes her body to reject its own injured limbs. Now, after a training accident last month in which she dislocated her shoulder, she is worried she may lose her arm, too. In her position, you would be forgiven for wanting to shut the door behind you and never come out again. But Morris, who operates her bike with her hands, needs cycling. It is her life, consuming and sustaining her.

"Handcycling is more than a sport to me," said the Paralympic time trial gold medalist as she prepared for the sport's World Championships in Roskilde, Denmark.

"It's a way of managing the pain. Without it, my life becomes unmanageable. And it's what I do - it's what I get up to do in the morning, it's what I go to bed at night thinking about. It is me."

Her mother, Hilary, added: "She's driven by it. People say how wonderful it is when they see her out training at five in the morning. 'Yes,' I say, 'it is wonderful - but it's for pain control.' And then they think, 'Ooh. Gosh.' "But she has to do what she has to do. Part of her pain management is to push her body hard, distract herself and release endorphins into her brain which help control the pain. "She's driven by the pain to a great extent so you can't hold her back, because you can't let her have any more pain. She suffers every day, all day, anyway."

Morris's troubles began in the most terrifyingly innocuous of circumstances as a teenager.

"All I did in the beginning was twist my ankle on a dry ski slope," she says, apologetically. "It's quite embarrassing, it wasn't even on a snow-covered mountain." "From that I had an awful lot of problems which weren't picked up at the beginning - my condition is a strange thing, especially the way mine ended up going - and unfortunately it's ended up with me having multiple amputations."
The condition goes by several names, two of the most common being Reflex Sympathetic Distrophy (RSD) and Complex Regional Pain Syndrome.
Since it began destroying Morris's legs she has had to move from sport to sport, each time

accommodating a new level of disability. Her childhood love of athletics became a passion for sailing but, once she lost her second leg, road cycling was identified as the way forward.
She lives life, and competes, in near-constant pain.

"There are two sorts of pain," she explained. "One is from phantom limbs, and one is a pain inside you that has the same intensity as catching your arm on the oven or an iron.

"The first one gives you strange feedback where your limbs were, as though your foot is facing the wrong way or twisted around, and I feel that a lot with my left foot. Obviously, I've got no legs but it's incredible what your brain will do: in the night I'll wake up with cramp in my foot and reach down. It's so real, you reach down thinking that your leg is there. "The other pain is far more a burning pain which combines with what I call 'white pain'. That's when the pain is so powerful that there's nothing you can do about it, it'll make you drop anything and stop."

In the month leading up to the Worlds, things became even worse. Morris slid off a wet road on a training ride in Bath and dislocated her shoulder.

As she told us how the crash happened, it only slowly dawned on me that while dislocated shoulders are unpleasant for anyone, for Morris they must be particularly significant. I had to ask: if Rachel's body has in the past rejected injured limbs, and she has just injured a limb, is she not worried?
"Causing this injury to my body could, potentially, trigger the same reaction that's happened in my legs, and cause the RSD to become active in my arm. Obviously I have no legs, so the worst-case scenario is that it could do the same thing to my arm," she replied.

"I've become almost paranoid about the colour of it or watching the temperature, which are two of the things that change early on. So I have become very, very worried."

A week later, Morris crossed the finish line fourth in her first race at the World Championships, her body shaking and writhing with the exertion for a good 10 minutes afterwards.

Though disappointed not to win a medal, back in the British team's pit area she seemed happy to

have made it through the race.

"The best bit is my shoulder made it round the course. I came out and completed something I didn't think I could have done two weeks ago. I didn't do it as I would have wanted to, but I couldn't have done any more as I am at the moment."

A bronze medal in her second and final event, the road race, is something although - for last year's world champion - settling for one third-place finish was clearly immensely frustrating.

For more reasons than most, Morris is compelled to give everything she has to her sport. Next year, she would hate to settle for a bronze medal. But first she must get herself to the Paralympic start line safely, and that means almost 12 months of waking up and tentatively inspecting the suspect shoulder.

"I've got to think of next year," she says. "That is the ultimate goal for everyone and the pinnacle of my career, so I do have to be careful and protect myself for that.

"If that was taken away from me, I think that possibly is the point at which I would give up. Which is quite a terrifying thought, because the Games have so much power and so much emotion that does drive me on. Next year is massive in lots of ways."