ORIGINAL ARTICLE

# Sensorimotor and Psychosocial Correlates of Adaptive Locomotor Performance in Older Adults

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ABSTRACT. Deshpande N, Metter EJ, Ferrucci L. Sensorimotor and psychosocial correlates of adaptive locomotor performance in older adults. Arch Phys Med Rehabil 2011;92: 1074-9.

**Objective:** To identify sensorimotor and psychosocial factors independently associated with an inability to perform adaptive walking tasks in older adults.

**Design:** Cross-sectional cohort study.

**Setting:** Population-based older cohort.

**Participants:** Community-living elderly (N=720; age ≥65y) who could walk 7m at self-selected normal speed.

**Interventions:** Not applicable.

**Main Outcome Measures:** Walking performance was assessed in 4 walking tests: fast walking, obstacle crossing, narrow-based walking, and walking while talking. Possible correlates of the inability to perform the walking test included knee extensor strength, lower limb coordination, Cumulative Somatosensory Impairment Index (CSII), visual acuity and contrast sensitivity, cognition, depression, personal mastery, social support, and years of education.

**Results:** The results of binary logistic regression analyses, adjusted for demographics and self-selected normal speed, demonstrated that poor knee extensor strength was associated with an inability to perform tasks demanding an increase in walking speed (fast walking and obstacle crossing). Both poor lower limb coordination and higher CSII were significantly associated with failure in tests that demanded precise control over foot placement (obstacle crossing and narrow-based walking). Higher CSII was associated with failure in all tests except in the walking while talking. In contrast, poor cognition was associated with an inability to perform walking while talking. Poor personal mastery was the only variable that was associated with failure in all walking tests.

**Conclusions:** The results demonstrated a systematic and coherent pattern in these associations and indicated possible sensorimotor and psychological parameters that should be specifically investigated and should be intervened if a patient reports a difficulty/inability in walking in certain situations.

**Key Words:** Adaptive behavior; Gait; Locomotion; Rehabilitation; Walking.

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MOBILITY IS DEFINED AS the ability to walk safely and independently in one's natural environment[1] and thus, is a prerequisite for one's independence in activities and instrumental activities of daily living,[2] preserving social interactions, and for maintaining overall quality of life.[3] It is not surprising that improving mobility is a major goal in rehabilitation of older persons.

Although the ability to walk provides the basis of mobility, "the ability to walk" and "mobility" are not synonymous.[4] The natural environment commonly imposes varied challenges while walking; for example, increasing walking speed when necessary, avoiding or stepping over obstacles, walking longer distances, accommodating different kinds of surfaces (eg, slippery surfaces or slopes, narrow paths), performing simultaneous cognitive activities (eg, holding a conversation), postural transitions (eg, picking up something from the floor), and walking under suboptimal ambient conditions (eg, low light levels).[1] Therefore, adaptive locomotion is the mainstay of mobility.

Recently, it was demonstrated that the age-associated decline in the walking speed on adaptive locomotor tasks is much steeper than the decline in the speed in level walking at a self-selected pace.[5] A few studies have also described biomechanical differences between young and older adults during adaptive locomotion that may be important in safely facing challenges while walking.[6,7] Surprisingly, there is no solid knowledge of the factors that may contribute to the ability of older persons to accommodate various environmental challenges while walking. Understanding these factors is critical for 2 reasons: first, for matching the specific mobility impairment that an older individual with a particular sensorimotor and/or psychosocial deficit may encounter; and second, for designing targeted interventions to sustain and improve mobility.

The objective of the present study was to identify sensorymotor and psychosocial factors associated with the inability to perform adaptive walking tasks in older adults who can walk 7m at self-selected normal speed. We hypothesized that the sensorimotor and psychosocial attributes associated with the inability of older persons to successfully perform adaptive locomotion would be specific to the challenge imposed.

**List of Abbreviations**

| | |
|---|---|
| CES-D | Center for Epidemiological Studies Depression Scale |
| CSII | Cumulative Somatosensory Impairment Index |
| MMSE | Mini-Mental State Examination |
| PSMS | Pearlin and Schooler Mastery Scale |

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## METHODS

### Participants

The InCHIANTI study population is a representative sample of the population living in the Chianti countryside of Tuscany, Italy. The study design and data collection have been described previously elsewhere.[8] In 1998, 1453 adults were randomly recruited from the population registry of the 2 study sites. Follow-up data were collected after 3 and 6 years. The protocol was approved by the ethical committee of the Italian National Institute of Research and Care of Aging, and participants gave written informed consent. The present study uses the year 3 data of the study participants (2001–2002, n=1167) who were originally evaluated. Older participants (age ≥65y) who could walk 7m at a self-selected usual walking speed and had scores of 18 or greater on the MMSE were included in this analysis.

***Primary Outcome Measures.*** *Adaptive walking tests.* Walking tests were carried out in a clinical setting. Participants used their usual gait aids. Those who needed manual assistance for walking or used a walker were excluded. The starting location was marked with a colored tape. The end of the 7-m walking path was not marked, to prevent slowing in anticipation. The time to complete the walking test was measured using 2 photocells positioned at the start and end of the path. The time data were then converted into walking speed (m/s). Initially, participants were asked to walk at their self-selected usual speed (normal speed).

For increasing demands while walking, participants were asked to walk in the following 4 challenging walking tests:

1. *Fast walking:* participants were asked to walk as fast as possible. If the participant could not increase the speed by at least 0.1m/s,[9] a failure was recorded.
2. *Obstacle crossing:* participants were required to cross over 2 obstacles placed in the path while walking as fast as possible. The obstacles were 6-cm and 30-cm tall, positioned, respectively, after 2m and 4m from the starting line. Participants failed the test if they tripped on or touched the first obstacle, or needed manual assistance for any reason.
3. *Narrow path walking:* participants were instructed to walk at their usual pace, but to stay between lines of colored tape placed 25cm apart. Failure to complete this test was recorded if the participant stepped on or outside the tape lines 2 or more times.
4. *Walk and talk:* participants were required to walk while performing a cognitive verbal task in which they were asked to recite names of animals starting with a specific letter. They were instructed to focus equally on the verbal and the locomotor task. If the participant could not verbalize even 1 name, a failure was recorded.

Participants also failed the walking tests if they could not successfully complete the trial, if it was perceived unsafe by the tester for the participant to perform (eg, unsteady, heart surgery in last 3 months, or systolic blood pressure >180mmHg or diastolic blood pressure >100mmHg), or if the participant refused to perform the walking trial. A zero value was assigned for gait speed in case of failure.

***Sensorimotor domain.*** Lower limb strength was represented by the strength of the knee extensor muscle groups and measured using a handheld dynamometer (Nicholas Manual Muscle Tester; model BK-5474).[10,a] The location of the dynamometer was on the anterior surface of the right leg 10cm above the proximal margin of the lateral malleolus. The maximum value of 3 repeated measurements was noted.[10]

A standard heel-shin clinical test in the supine position was used to assess lower limb coordination. The participant was instructed to place the right heel on the left shin just below the knee and then slide it down to the foot, repeating this movement 10 times. The total time required to perform the test was measured in seconds.[11]

The lower limb somatosensory function was assessed using a CSII. In this test, a cumulative score is developed from standard clinical assessments of vibrotactile sensitivity, pressure sensitivity, ankle proprioception, and plantar graphesthesia.[12]

A standard Snellen eye chart placed at a distance of 3m was used to test visual acuity. Visual acuity scores of 0/0 to 11/10 were graded from 0 to 11.[13] Visual contrast sensitivity was measured using the standard Pelli-Robson chart test. The last correctly identified letter was noted, and the associated log contrast sensitivity was recorded.[14] The vision testing was completed using binocular vision with the participant's usual corrective lenses.

***Psychosocial domain.*** Cognitive function was evaluated by the MMSE.[15] The MMSE is a widely used tool for measuring global cognitive impairment across multiple domains (orientation, memory, concentration, language, and praxis), with scores ranging between 0 and 30, and higher scores indicating better cognition. The CES-D, a 20-item self-report questionnaire, was used to assess depressive symptoms. Scores can range from 0 to 60, with higher scores indicating more depressive symptoms.[16] To evaluate the sense of personal mastery, a short version of the PSMS was used (6 items; scores 6–30, higher scores indicate more mastery). Sense of mastery addresses the extent to which people feel in control of their own life circumstances and how they would react to stresses, difficulties, and adversities of life.[17] Social support from 12 categories of people was included to measure the degree of available social support. Participants were asked about the availability of these 12 categories of people (scores 1–4; 1, completely available; 4, not available) in a hypothetical scenario where help or assistance was required. The mean score was calculated, with higher scores indicating less support.[18] Education was recorded as years of formal education.

### Covariates and Descriptive Variables

Demographic variables of age (y), sex, height (cm), and weight (kg) were included as covariates. A history of multiple falls in the previous year and the total number of medications were recorded for descriptive purposes only.

### Statistical Analysis

Variables with a skewed distribution (CSII, visual acuity, MMSE, CES-D, PSMS) were $\log_{10}$ transformed for the analysis and back-transformed for data presentation. Missing values were less than 5% and were replaced by overall means. The differences between those who could and those who could not perform a specific adaptive locomotor task were determined using analysis of covariance or multinomial logistic regression analysis, as appropriate, adjusting for normal walking speed. The sensorimotor and psychosocial parameters that were significantly different between the groups were further included in the binomial logistic regression analysis to identify factors that were independently associated with the inability to perform that adaptive walking test. Statistical analyses were performed using SPSS version 18.0.[b] A $P$ value of less than .05 was considered for statistical significance.

## RESULTS

A total of 784 participants who walked 7m at a normal self-selected speed and had an MMSE score of 18 or higher

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