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Incident Preclinical Mobility Disability Increases Future Risk of New Difficulty Walking and Reduction in Walking Activity

Carlos O. Weiss, M.D., M.H.S.^{a,1}, Jennifer L. Wolff, Ph.D.^{a,b}, Brian Egleston, Ph.D.^c, Christopher L. Seplaki, Ph.D.^d, and Linda P. Fried, M.D., M.P.H.^e

^aJohns Hopkins School of Medicine, 5200 Eastern Avenue, Baltimore MD, 21224-1734, U.S.A

^bJohns Hopkins Bloomberg School of Public Health, 624 N. Broadway, Baltimore MD, 21205-1996, U.S.A

^cFox Chase Cancer Center, 333 Cottman Avenue, Philadelphia PA, 19111-2497, U.S.A

^dUniversity of Rochester Medical Center, 601 Elmwood Ave., Box 644, Rochester NY, 14642, U.S.A

^eMailman School of Public Health, Columbia University, 722 W/168th St., New York NY, 10032, U.S.A

Abstract

Purpose—This study examines whether and how report of a change in walking behavior, incident preclinical mobility disability (PCMD), predicts subsequent reduction in walking activity.

Materials and Methods—Data are from a prospective study of 436 community-dwelling women age 70–79 years. Outcome measures include subjective and objective measures of walking ability at 3 years.

Principal Results—Incident PCMD is associated with loss of walking abilities at 3-years, regardless of baseline physical impairment. Compared to women without, women with incident PCMD at 1.5 years after baseline were 2.7 (95% CI 1.4–7.2) times more likely to report that they no longer walk outdoors at least 8 blocks and 4.9 (1.9–13.1) times more likely to report new difficulty walking. Incident PCMD was also associated with declines in objective outcomes. Incident PCMD is an independent marker of subsequent decreased walking activity.

Major conclusions—Incident PCMD appears to be a target for programs to prevent declines in walking activity in older adults.

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Corresponding Author: Carlos O. Weiss, M.D., M.H.S., Room 707, Mason F. Lord Center Tower, 5200 Eastern Avenue, Baltimore, MD 21224-2734, Phone: 410 550 8693; fax 410 550 8701, cweiss9@jhmi.edu.

¹(Present address) Department of Family Medicine, Michigan State University, 300 Lafayette Avenue SE Suite 3400, Grand Rapids, MI 49503, U.S.A.

Conflict of interest statement

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Keywords

disability; geriatrics; epidemiology; prevention; physical activity

1. INTRODUCTION

In the U.S. roughly one-half of older adults (age 65 years and older) report at least some difficulty walking, which includes difficulty walking, needing help from another person to walk, or avoiding walking (Shumway-Cook et al., 2005). Difficulty with this essential task is associated with an increased risk of more severe physical disability, institutionalization and death (Clark et al., 1998; Fried and Guralnik, 1997; Harris et al., 1989). The keys to improving the primary prevention of loss of walking activity in an aging society include understanding who is at risk of loss of walking ability and how that risk can be modified (Weiss et al., 2007; Whiteneck, 2006).

Early changes in physical task performance are sometimes a compensatory strategy: a way of doing a task in a way that is not “usual” and can take the forms of behavioral adaptations, the use of assistive devices, or the receipt of human assistance (Agree, 1999; Hoenig et al., 2003). Compensatory strategies are responses to task demand and can have opposing significance: on one hand they may signify taking wise precautions or striving for independence (Ward-Griffin et al., 2004); on the other they may indicate underlying risk of poor outcomes (Weiss et al., 2007). PCMD is a compensatory strategy in the form of behavioral adaptation.

Existing work shows that prevalent PCMD is a marker of vulnerability to the challenges of task performance. Specifically, prevalent PCMD can identify older adults who have worse task performance (Fried et al., 2001) and those who report walking fewer steps per day (Petrella and Cress, 2004), compared to those with no reported PCMD. In addition, longitudinal studies demonstrate that prevalent PCMD predicts self-reported incident mobility difficulty (Fried et al., 2000; Wolinsky et al., 2005). However, the use of prevalent PCMD as a risk factor is susceptible to reverse causation bias. It remains to be determined whether PCMD is in the causal pathway of loss of walking activity.

Our first study aim is to describe the types of incident PCMD strategies used by relatively high-functioning older women. A second aim is to estimate whether incident PCMD implemented after the onset of physical impairment is associated with increased or decreased self-reported mobility difficulty or objective changes in walking ability. We also posited that the effect associated with incident PCMD may vary according to the presence of physical impairment. We achieve our aims by employing methods specifically designed to address the effects of a risk factor in observational data. Our study extends prior work by a) focusing on incident PCMD among people with and without physical impairments; b) examining both subject self-reports of difficulty and objective, performance-based outcome measures; and, c) extending the length of follow-up to 3 years.

2. MATERIALS AND METHODS**2.1 Data Source**

The Women’s Health and Aging Study II (WHAS II) is a longitudinal cohort study designed to ascertain the causes and course of disability in old age. The recruitment of 436 women has been described previously (Fried et al., 2000). Eligibility was defined on the basis of self-reported difficulty (in ≤ 1 out of 4 physical domains), Mini-Mental State Examination (MMSE) (Folstein et al., 1975) score ≥ 24 and ability to participate in a baseline clinic

examination. Participants were recruited from a sample representing the higher functioning two-thirds of women age 70–79 in eastern Baltimore City and Baltimore County, Maryland and were enrolled in 1994 and 1995. Data from baseline, 1.5- and 3-year follow-ups were used for this study. The Johns Hopkins Medicine Institutional Review Board approved the study and informed consent was obtained from all participants.

2.2 Main Predictors

The main variable of interest, reported PCMD, was obtained as part of a series of task-specific questions about changing the frequency or method of performing daily activities: “Have you changed the way you walk 1/2 mile (about 5–6 city blocks), or how often you do this, due to a health or physical condition?” Response options were no, yes, no longer do the task due to difficulty, or, could do the task but don’t for non-health reasons. In addition responses of don’t know and refusals were recorded. People who responded affirmatively were then asked a series of more specific questions. In order to avoid reverse bias by PCMD that preceded impairment, people who reported PCMD at baseline (n=131) were excluded from longitudinal analyses. WHAS II collected both self-report data and measured performance on standardized objective tests of corresponding physical function, previously described in detail (Fried et al., 2001). Physical impairment was captured using measured knee extensor strength (using a handheld dynamometer) and a timed test of balance on one leg, taking the best attempt from either leg. We define participants as having a physical impairment who are in the lower half of performance in at least one of these measures, i.e. <0.31 kg knee strength or <8.0 s standing balance.

2.3 Outcomes

The main outcomes were two self-reported measures of mobility functioning. Distance walked was asked at each round using the question “Think about the walking you do outside your home. During the last week, about how many city blocks or their equivalent did you walk?” The number was recorded, with 0 in place of <1 block. The cutoff of 8 blocks per week was chosen because it has been shown previously to discriminate between those who do and do not maintain walking speed or walking activity (Simonsick et al., 2005). Difficulty walking was based on self-reported difficulty walking 1/2 mile “due to health or a physical condition,” a question which has been shown to precede and predict mobility dependence (Gill et al., 1998). Response options were no, yes, no longer do the task due to difficulty, or, could do the task but don’t for non-health reasons. In addition responses of don’t know and refusals were recorded. Two secondary (confirmatory) outcomes were objective performance measures that predict concurrent and future mobility difficulty, institutionalization and death in older adults (Guralnik et al., 2000): self-selected walking speed (SSWS) was measured over a 4-meter course from a standing start, corrected for height by dividing by knee height; and a Summary Performance Score (SPS) (Onder et al., 2002) of combined timed performance on three standardized tests of lower extremity function (balance, chair stands and SSWS), which ranges between 0–12. Both were studied as continuous outcomes. SSWS has been found to have a test-repeat reliability ICC (within-subject) of 0.96 (Weiss et al., 2008) and SPS an ICC of 0.81 (Mangione et al., 2010) or Cronbach’s alpha of 0.76 (Guralnik et al., 1994). Because we are interested in the risks associated with onset of PCMD, people with PCMD or outcome at baseline were excluded. For this reason and missing data, the numbers of people analyzed in each outcome model were 236 for blocks walked, 255 for walking difficulty, and 262 for SSWS and SPS.

2.4 Covariates

Covariates considered due to *a priori* knowledge of their association with physical difficulty included personal factors: race (African American, White), age (75+ versus 70–74 years), education (years), living alone, financial strain (having not enough or just enough to make

ends meet at the end of each month); health conditions: Geriatric Depression Scale (Yesavage et al., 1982) score (GDS, 0–30), body mass index (BMI, kilogram/meter²), comorbidity (count among 14 chronic diseases), and MMSE score; and environment: having 2 or more steps to get into the home.

2.5 Statistical Analysis

To describe the population, baseline proportions and mean values were calculated for personal, health and environmental characteristics. PCMD strategies were examined across study waves and, because they did not differ substantially, frequencies at baseline are reported. T-tests assuming unequal variances and χ^2 tests were used to test differences for continuous and categorical variables. We examined binary and continuous outcomes using a marginal structural models approach (Robins et al., 2000), where adjusted probability risk ratios (RRs) for binary outcomes and adjusted changes in mean for continuous outcomes are estimated using logistic regression and generalized linear models, respectively. Robust variance estimates were used throughout. Marginal structural models were designed to estimate associations from observational data in cases where the exposure may be simultaneously a confounder and intermediate variable. The RR or adjusted change in mean was estimated with those without PCMD, not the overall population, as the reference group. A standardized mortality ratio weight (Kurth et al., 2006; Sato and Matsuyama, 2003) based on propensity score methods (Brookhart et al., 2006; Rosenbaum and Rubin, 1984) was employed. An advantage of these weights was an improved ability to identify and minimize residual selection bias in measured variables. Appropriateness of propensity scores was confirmed by examining the density function of propensity scores across PCMD strata for sufficient overlap and by confirming graphically that there was a balance of confounders between PCMD strata within propensity score quartiles. To examine the RR for the subgroup with no impairment, an adaptation of Rubin's model (Eggleston et al., 2007) was employed and bootstrapping with 1,000 replications was used to create robust standard errors.

The association between PCMD, baseline gait speed and outcomes was examined by graphing the adjusted probability of reporting PCMD for impairment strata across a continuous range of SSWS. Potential non-linearity was tested with quadratic and spline terms, and collinearity was assessed by examining variance inflation factors. Hosmer-Lemeshow χ^2 goodness-of-fit statistics tested the fit of final models with data.

Two analyses were carried out to explore the possibility of biases. First, to assess whether the competing outcome of death might bias the findings, multinomial logistic regression sensitivity models including death as an alternative outcome were employed. Second, the findings were cross-validated against "external" data by selecting $n-1$ random people to be removed one at a time, then predicting each removed person from a model fit from remaining data, before calculating goodness-of-fit. Stata statistical software (Statacorp, College Station, TX) was used for all analyses.

3. RESULTS

At baseline, the average age of the study sample was 74 years, 71.6% of participants had 12 or more years of education, 18.6% were African-American, 51.1% lived alone and 45.4% had two or more chronic diseases (Table 1). The 30.5% of participants who reported walking PCMD at baseline tended to be older, more educated, to have a greater number of chronic health conditions, have more depressive symptoms and to have a higher average body mass index. At baseline, the percentage of participants reporting PCMD with 0, 1 or 2 impairments was 20.6%, 35.9% and 43.5%, respectively.

Among women who reported PCMD, walking more slowly was the most common compensatory strategy (Figure 1). Among people with normal SSWS (≥ 1.0 m/s), 23.7% reported PCMD, compared to 36.2% among those who walked < 1.0 m/s. Results were similar for other mobility tasks such as climbing steps and transferring from a chair. Pain was the most common symptom cited as a cause of PCMD (41.1% of women reporting PCMD).

To examine whether PCMD is associated with mobility disability, Table 2 displays actual and adjusted primary and secondary mobility outcomes at 3 years according to interim PCMD. Women with PCMD at 1.5 years, but not at baseline, were estimated to be 3.12 (95% CI: 1.35–7.23) times more likely to no longer walk at least 8 blocks outdoors and 4.93 (1.85–13.14) times more likely to report incident walking difficulty at 3 years, adjusted for covariates, than if they had not had PCMD. Objective measures of performance were similarly affected at 3 years. In women with interim PCMD, adjusted SSWS was 0.08 m/s slower overall, and 0.09 m/s slower among the subset of unimpaired people, compared to those with no PCMD. Correspondingly, their SPS was 1.14 and 1.20 points lower at follow-up, respectively. The results were not substantially altered by the sensitivity analyses that incorporated the 14 deaths that occurred by year 3 as a competing outcome. Cross-validation of results (see Methods) failed to identify dependence on baseline covariate structure in the longitudinal models.

Impairments, singly or jointly, were associated with the study outcomes at 3 years. The percentage reporting an outcome ranged from 11.4% among those with no impairment to 45.7% in those with both weak knee strength and balance impairment. To assess how the incident risk of poor outcomes changed according to PCMD, impairment in knee strength or balance, and baseline SSWS, Figure 2 displays the adjusted probabilities of decreasing outdoor walking activity (i.e., going from walking 8 or more blocks to less than 8 blocks per week outdoors), or, new walking difficulty, by these strata. Reported interim PCMD was associated with an increased risk of poor outcomes at 3 years, overall and in people without physical impairment. Across a range of SSWS, the probability of poor outcomes increased linearly. There was no suggestion of an interaction according to SSWS or the presence of physical impairment such that the probability of a poor outcome was approximately 6–8% at 3 years for women with a fast SSWS who did not report PCMD compared to approximately 30–65% for those with a slow SSWS who did report PCMD. PCMD was associated with an increased risk of mobility decline compared to physical impairment (as evident by comparing PCMD to no PCMD, and, those with impairment to those without).

4. DISCUSSION

In this study of generally high-functioning older women incident preclinical mobility disability, PCMD, was employed often and was associated with an increased risk of reduction in walking activity. PCMD was consistently associated with incident decreases in walking activity and incident walking difficulty at 3 years, both for the sample overall and for the group thought to be most likely to possibly benefit from compensatory strategies, namely, people with no physical impairment at baseline. These associations with worse self-reported outcomes were confirmed using objective tests of lower extremity performance. This study adds to previous work examining prevalent PCMD by providing observational evidence that compensatory strategies, and PCMD in particular, have the potential to alter the course of walking ability, even in people with high function at the outset.

An additional implication of this study is to reinforce the complexity of compensation and the challenge of identifying beneficial responses to aging-associated declines. Many responses to aging-associated conditions occur in the setting of increased risk, and the

alternative to using a compensatory strategy (is the alternative to avoid activity altogether, or, to continue activity at the same level?) is difficult or impossible to ascertain. Some have referred to compensatory strategies as “buffers” when they enable people to remain more active in the face of functional impairment (Verbrugge and Jette, 1994). Currently little is known about the reasons why people begin to adopt compensatory strategies like PCMD. It may be that the compensatory strategies studied here were not a response to physical impairment as measured, rather a response to factors such as pain, and attenuated further decline in physical function. Our findings draw attention to common modifiable causes of PCMD, especially pain, as potential targets for intervention. We also note that the most commonly reported strategy, slowing down, may be associated with uncomfortable fatigue that in turn creates forward feedback and decreases activity. A compensatory strategy that is helpful for one person given a specific level of function, or an acute illness, could be problematic for different person or if used for a prolonged period of time.

We used a longitudinal dataset designed to understand the causes and course of mobility functioning in older adults. The decrements in performance we show here appear clinically relevant because prior research suggests that 0.05 m/s changes in gait speed represent meaningful change and 0.1 m/s substantial change, and for the SPS these cutoffs are 0.5 and 1 point (Perera et al., 2006), based on the Standard Error of Measurement approach. As with all observational analyses, an important assumption for this study was that there was no substantial unobserved confounding. By using a marginal structural models approach with propensity-based weights, and confirming that this created groups that were balanced on important risk factors and overlapped in terms of risk, the possibility of confounding due to observed variables has been greatly reduced. In addition, the consistency of self-report and objective measures adds to the strength of the findings.

Even though people were allowed to report increasing the frequency of walking or “other” changes, it may be that some strategies were under-reported. Questions framed in the context of self-efficacy or confidence could possibly obtain results that vary with the findings presented here. In addition to information bias, some possibility of selection remains even after verification that exposed and unexposed groups were comparable in measured confounders. These findings draw from spontaneously adopted and self-reported compensations, and would not be expected to extend to strategies prescribed by physical therapists or physiatrists who provide theory- and evidence-based education in the setting of overt difficulty.

In summary, incident preclinical mobility disability is common in older women and appears to be a potent, possibly causal, and likely modifiable, risk factor for reductions in walking activity in later life. Attention to reported early changes in mobility function, and treatment of pain and other causes of slowing down appear warranted as part of programs to maximize the likelihood of preventing physical mobility disability, pending confirmation in randomized trials.

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Figure 1.
Frequency Distribution of Compensatory Strategies for Walking 1/2 mile, at Baseline.

Figure 2. Adjusted Probabilities of New Walking Difficulty (top) or No Longer Walking ≥ 8 Blocks/Week Outdoors at 3 years (bottom), stratified by Preclinical Mobility Disability (PCMD) and Physical Impairment, Across Baseline Self-Selected Walking Speed (SSWS).

Table 1

Baseline Characteristics, Overall and by Preclinical Mobility Disability (PCMD)

Proportion or mean values presented. MMSE is Mini-Mental State Exam and the lower range limit here is due to exclusion criteria. GDS is Geriatric Depression Screen.

	<u>PCMD</u>			<i>P-value^a</i>
	<u>Overall</u>	<u>Yes</u>	<u>No</u>	
n=	429	131	298	
<u>Characteristics</u>				
<i>Personal Factors:</i>				
Age, mean y	74.1	74.6	73.8	0.01
Education, mean y	12.5	12.7	11.9	0.02
Live alone, %	51.1	47.3	52.3	NS
Financial strain, %	18.3	22.7	16.8	NS
African-American, %	18.6	23.7	15.8	NS
<i>Health Factors:</i>				
Comorbid disease, mean number	1.6	1.8	1.4	0.001
MMSE, mean score (range 24–30)	28.1	28.2	28.0	NS
GDS, mean score (range 0–15)	4.0	5.2	3.6	<0.001
BMI, mean kg/m ²	26.7	28.7	25.9	<0.001
<i>Environment:</i>				
>1 Step into Home, %	81.8	81.2	82.8	NS
<i>Impairment:</i>				
Knee Strength, mean kg	21.3	21.4	21.4	NS
Balance, mean s	12.1	9.2	13.5	<0.001

BMI is body mass index. NS is not significant.

^a Chi-square statistic or t-test with unequal variances, comparing PCMD+ to PCMD–.

Table 2

Reported and Measured Walking Disability at 3-years according to Walking Preclinical Mobility Disability (PCMD): the Women's Health and Aging Study II.

In the models for the overall sample, results are also adjusted for physical impairment. Ratio or change calculated using n for adjusted models are 223 for overall/no longer walk 8 blocks; 241 for overall/new difficulty.

Overall	Among Unimpaired Only	
<u>Self-Reported</u>	<u>Modeled Risk Ratios (PCMD+/PCMD-) *</u>	
<u>Primary Outcome</u>		
New difficulty walking	4.9 (1.9–13.1)	6.0 (1.6–27.7)
No longer walk		
≥8 blocks/week outdoors	3.1 (1.4–7.2)	2.8 (1.3–5.8)
<u>Objective</u>	<u>Modeled Changes in Mean (PCMD+ minus PCMD-) ^a</u>	
<u>Secondary Outcome</u>		
Self-Selected		
Walking Speed, m/s	–0.08 (–0.15, 0.00)	–0.09 (–0.17, 0.02)
Summary		
Performance Score	–1.1 (–1.9, –0.35)	–1.2 (–2.3, –0.26)

All values in parentheses are 95% confidence intervals.

^aRR and change in mean are from propensity-adjusted marginal structural models estimating causal association with PCMD– as the reference group, as described in Methods. Covariates used in adjustment are listed in Methods.