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What Physical Attributes Underlie Self-Reported *vs.* Observed Ability to Walk 400 m in Later Life?:

An Analysis from the InCHIANTI Study

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Abstract

Objective—The aims of this study were to evaluate and contrast the physical attributes that are associated with self-reported *vs.* observed ability to walk 400 m among older adults.

Design—Analysis of baseline and 3-yr data from 1026 participants 65 yrs or older in the InCHIANTI (Invecchiare in Chianti) study was conducted. Observed and self-reported ability to walk 400 m at baseline and at 3 yrs were primary outcomes. Predictors included leg speed, leg strength, leg strength symmetry, range of motion, balance, and kyphosis.

Results—Balance, leg speed, leg strength, kyphosis, leg strength symmetry, and knee range of motion were associated with self-reported ability to walk 400 m at baseline ($P < 0.001$, $c = 0.85$). Balance, leg speed, and knee range of motion were associated with observed 400-m walk ($P < 0.001$, $c = 0.85$) at baseline. Prospectively, baseline leg speed and leg strength were predictive of both self-reported ($P < 0.001$, $c = 0.79$) and observed ($P < 0.001$, $c = 0.72$) ability to walk 400 m at 3 yrs.

Conclusions—The profiles of attributes that are associated with self-reported *vs.* observed walking ability differ. The factor most consistently associated with current and future walking ability is leg speed. These results draw attention to important foci for rehabilitation.

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Keywords

Physical Performance; Rehabilitation; Successful Aging; Mobility Limitation

Mobility limitations affect approximately 20%– 25% of adults 70 yrs or older.[1] In this age group, difficulty with mobility tasks such as walking, climbing stairs, or rising from a chair are more prevalent than common chronic diseases including stroke and cancer.[2] Mobility problems increase the risk for further disability and are often the earliest indicator of functional decline.[3–5] Difficulty walking, in particular, can lead to loss of independence and social isolation, which have a significant negative impact on the quality-of-life of older adults.[6–8]

Walking limitations can be identified by physical performance measures or self-report. Although both types of assessment often address the same construct, recent work has shown that these likely reflect different aspects of a patient's functioning.[9] The 400-m walk test is a common performance-based measure and indicates the risk for mortality and subsequent disability in older adults.[10,11] Consequently, the inability to walk 400 m is often used as a benchmark for identifying mobility-related disability. Self-reported walking difficulty has also been shown to predict future disability and mortality[5,12,13] and may provide complementary information to performance-based measures.

Given the association between walking limitations and adverse health outcomes, much attention has been paid to identifying determinants of walking limitations in older adults. Previous investigations have focused on factors such as disease status, mood, cognition, age, sex, and education.[14–19] However, there is a shortage of evidence on the determinants of walking ability and, in particular, on the specific physical attributes that underlie walking, which are both feasible to measure in geriatric rehabilitative settings and potentially amenable to rehabilitation. This information is essential for informing the development of evidence-based strategies to help maintain walking ability in older adults.

The primary aim of this study was to evaluate the physical attributes at baseline that were associated with current and prospective self-reported and observed ability to walk 400 m among community-dwelling older adults in the InCHIANTI (Invecchiare in Chianti) study. As a secondary aim, potential differences in the physical attributes associated with self-reported vs. observed walking ability were explored. This is important because walking ability is often measured using both self-report assessments and performance testing, sometimes interchangeably to evaluate the same outcome.

Methods

Study Population

The InCHIANTI study is a longitudinal population-based study of factors that contribute to mobility decline among older adults residing in the Tuscany region of Italy. A sample of 1155 participants 65 yrs or older were randomly selected from Greve and Bagno a Ripoli, two towns in Chianti, using a multistage stratified sampling method. Details of data collection procedures and methodology have been previously published.[20]

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Baseline data from the InCHIANTI study were collected from three assessment sessions: a home interview, a medical examination, and a functional performance evaluation. Physicians and physical therapists performed the medical examinations and the functional evaluations, respectively. At the 3-yr follow-up, the same tests were repeated using standardized protocols. At baseline, 1026 participants 65 yrs or older completed medical and functional evaluations. At 3 yrs, self-report data from 864 participants were available for analysis, and performance data were available from 645 participants.

Conceptual Framework

The InCHIANTI study was designed within a conceptual model that characterized walking as being dependent on attributes within six subsystems: (1) central nervous system, (2) peripheral nervous system, (3) perceptual system, (4) muscles, (5) bone and joints, and (6) energy production and delivery.[20] For the purpose of this analysis, which is designed to inform rehabilitative care, the authors chose to refine their focus to physical attributes measured within the InCHIANTI study that have the potential for rehabilitation.

Measures

The primary outcomes of interest in this study were self-reported and observed ability to walk 400 m. For the 400-m walk test, the participant was instructed to complete ten laps around a 20-m course, walking as fast as possible at a steady pace. Standardized verbal encouragement was provided on completion of each lap, and time to complete the test was measured using an optoelectronic system with two photocells connected to a chronometer.[21]

At baseline, the participants were classified as unable to walk 400 m if they were unable to complete the test in less than 15 mins.[22] Self-reported ability to walk 400 m was assessed by an interviewer-administered question, “are you able to walk 400 meters?” with the following response options: (1) no difficulty, (2) with difficulty but without help, (3) with some help from another person, (4) unable, and (5) can do without help but does not. The participants with responses 2–4 were categorized as unable and those with responses 1 and 5 were categorized as able to walk 400 m. The participants unable to walk 400 m at baseline were excluded from the 3-yr analysis.

A change over time of 60 secs in completion has been shown to represent the minimal clinically important difference for the 400-m walk test.[23] Therefore, at 3 yrs, retained walking ability was considered if the participants did not experience a decline of 60 secs or greater on the 400-m walk test. In addition, those participants who were excluded from the 400-m walk because of safety criteria[24] were classified as unable. Self-reported walking ability was considered retained if the participants reported the ability to walk 400 m at the 3-yr follow-up assessment.

The physical attributes hypothesized to underlie walking ability and selected for their clinical feasibility in geriatric rehabilitation are described below. Where possible, categorization of attributes was based on clinically meaningful thresholds identified through previous research.

Leg Speed—Leg speed was measured using the heel-shin coordination test.[25] The participant, sitting in a chair with their feet resting on the ground, was asked to bring one heel to the external part of the inferior one-third of the tibia on the opposite side and to repeat the task ten times as quickly as possible. The total time to complete ten repetitions was recorded.

Leg Strength—Maximal voluntary isometric leg strength was measured using a handheld dynamometer under standardized testing conditions.[26] The participants were asked to push as strongly as possible against the device for 5 secs while lying in a lateral decubitis position with the hip and the knee flexed to 45 and 60 degrees, respectively. The test was repeated three times, and the highest result was recorded. Knee extensor strength, measured in kilograms, and the ratio of strength between the right and left legs (stronger/weaker) were selected for this analysis. Leg strength asymmetry was defined as a difference of 15% or greater between sides.

Lower Extremity Range of Motion—Passive range of motion of the lower extremity was measured with a plastic universal goniometer using a standardized protocol.[27] The smallest knee extension and hip external rotation measurement recorded on either side were used for this analysis. For knee extension, a loss of 5 degrees or greater was used as a cut point.[28]

Kyphosis—The distance between the prominence of the spinous process of the seventh cervical vertebra and the wall was measured with a rigid ruler. The subjects were instructed to stand with their heels and sacrum against the wall and with their head positioned in the "Frankfurt frontal plane" (represented by a horizontal line between the lowest point on the margin of the orbit and the highest point on the margin of the auditory meatus). A recorded distance of 5 cm or greater was used as a cut point for kyphosis.[20]

Unipedal Balance Score—Recorded as part of the FICSIT [Frailty and Injuries: Cooperative Studies of Intervention Techniques] Balance Scale,[29] the participants were asked to stand on one foot and attempt to maintain stability for up to 10 secs. For this analysis, the participants were classified on the basis of the ability to stand on one leg for more than 5 secs.[30]

Leg Power—Leg power was not evaluated as a primary attribute because it was felt to represent two distinct attributes that were already captured using other measurements (i.e., leg speed and leg strength). However, leg power was included as part of an additional analysis described below.

Statistical Analysis

All analyses were performed using the SAS statistical software version 9.2 (SAS Institute Inc, Cary, NC). Descriptive statistics were used to summarize baseline characteristics of the study sample.

Multivariable logistic regression models were used to evaluate the association of baseline physical attributes with self-reported and observed ability to walk 400 m at baseline and at 3 yrs. The bivariable relationships of all attributes were inspected for significant colinearity, which could influence their inclusion in the multivariate model. In choosing between correlated predictors, the measure with the highest association to the outcome was selected. Agreement between self-report and observed performance was evaluated with the kappa statistic. The authors did not adjust for disease status because it was felt that this would represent an over-adjustment for physical attributes that are impaired as a result of disease. All models were adjusted for age and sex. An α level of 0.05 was used to determine statistical significance.

Missing data within the physical attributes were largely a result of individuals who were excluded for health/safety reasons and were felt to represent the participants who were the most physiologically impaired. Therefore, to address missing data with respect to the independent variables (i.e., excluding those lost to follow-up), sensitivity analyses were performed on the basis of a three-step process: (1) first, models were evaluated excluding missing variables; (2) second, missing data were included as a separate dummy variable to confirm the hypothesis that the missing variables would represent a similar or lower likelihood for achieving the primary outcomes than the reference category; and (3) lastly, because this study's hypothesis regarding missing data was correct, the missing subject data were grouped with those in the reference category within the final model.

To confirm that this study's clinical measures of limb speed and leg strength were representative of leg power, the authors performed a post hoc analysis in which they substituted leg power for leg speed and/or leg strength if these were significant predictors in the final models.

Results

Among the participants 65 yrs or older at baseline (n = 1026), 81% reported being able to walk 400 m and 78% demonstrated the ability to walk 400 m in less than 15 minutes (Table 1). At 3 yrs, among those able to walk 400 m at baseline, 77% reported the ability to walk 400 m and 66% retained the observed ability to walk 400 m (Table 2). Agreement between the observed and self-reported measures of walking ability at baseline was moderate (κ = 0.58, $P < 0.001$) (Table 3). Agreement between the two outcomes at 3 yrs was poor (κ = 0.32, $P < 0.001$) (Table 4).

The final set of physical attributes that were selected for inclusion in all models was kyphosis, leg speed, leg strength, leg strength ratio, range of motion of the knee, and unipedal balance. The multi-variable logistic regression models are shown in Figures 1–2. The physical attributes that were significantly associated with self-reported 400-m walk at baseline were kyphosis, leg speed, leg strength, leg strength ratio, knee range of motion, and balance (model $P < 0.001$, $c = 0.85$) (Fig. 1A). Leg speed, knee range of motion, and balance were significantly associated with the observed ability to walk 400 m at baseline (model $P < 0.001$, $c = 0.85$) (Fig. 1B).

At 3 yrs, the baseline physical attributes that were significant predictors of self-reported ability to walk 400 m were leg speed and leg strength (model $P < 0.001$, $c = 0.79$) (Fig. 2A).

Leg speed and leg strength were also significant predictors of the observed 400-m walk performance at 3 yrs (model $P < 0.001$, $c = 0.72$) (Fig. 2B).

The sensitivity analyses including the missing data did not significantly alter the findings for any model. In the analyses in which the authors substituted leg power for leg strength and leg speed, the associations were very similar to the models above (data not shown).

Discussion

The novel findings of this study are the following: (1) a number of physical attributes underlie current and future walking ability, (2) there are differences in the profiles of attributes associated with self-report *vs.* objective performance-based measures of walking, and (3) leg speed is the most consistent predictor of both self-reported and observed walking ability among older adults and is an important target for rehabilitation.

Difficulty walking puts elders at increased risk for disability and death.[10,12] In rehabilitation, efforts to prevent new or worsening mobility problems should focus on the attributes that are directly associated with walking ability. In this study, balance, leg speed, leg strength, leg strength symmetry, kyphosis, and knee range of motion were identified as attributes that are amenable to rehabilitation and that seem to be most strongly associated with current self-reported walking ability. Balance, leg speed, and knee range of motion were associated with observed walking performance. This study's results are in line with previous observations evaluating the predictors of 400-m walk performance and mobility performance as measured by the Short Physical Performance Battery.[31,32] Marsh et al.[31] found an association between leg strength and leg power (the product of strength and speed) and 400-m walk performance. Similarly, an association between balance, leg strength and leg speed, and performance on the Short Physical Performance Battery was previously demonstrated. The current findings extend these observations by considering other physical attributes that are easily targeted in rehabilitative care and that are predictive of walking ability at 3 yrs. Interestingly, at the 3-yr follow-up, only leg speed and leg strength, as measured at baseline, were retained as predictors of walking ability (both self-reported and observed). Several reasons may account for this finding. The cohort was generally older at the 3-yr follow-up, and it may be that leg speed and leg strength are more important predictors of mobility performance in older patients. It is also possible that the other physical attributes that were not retained as predictors of walking ability were more influential among those that were lost to follow-up before the 3-yr assessment. Nonetheless, the results of this study add to the growing literature on muscle power as an important factor underlying mobility performance in older adults[31,33–35] and a potentially important target for future intervention-based research. Furthermore, as demonstrated by this study's post hoc analysis, inclusion of measurements of both leg speed and leg strength may serve as a proxy for more complex measures of leg power, which are often unavailable in typical rehabilitation settings.

Although self-report and performance-based measures of function are often used interchangeably, the results of this study support previous work suggesting that the two types of measures may not provide equivalent information.[36,37] Previous studies comparing self-report and performance-based measures of function have been limited by measures that

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often assessed different types of tasks or even different constructs.[38] A strength of the current study is that two measures evaluating an identical construct were compared. The results of this study showed that the profiles of baseline physical attributes that are associated with self-report *vs.* observed walking ability differ (see Figs. 1, 2). In general, more physiologic attributes were associated with self-reported walking ability compared with observed walking performance. These differences may reflect the fact that patient-reported function can be influenced by many physical, health, and psychosocial factors.[36] In addition, self-reported walking ability may capture more global aspects of everyday functioning that extend beyond a single performance test. For example, older adults who have moderate to severe kyphosis may experience difficulty with walking that may not be captured in the performance test but, if addressed through rehabilitation, might improve functioning. This study's findings support previous work that suggests that a comprehensive mobility assessment should consider both self-report and performance-based measures because both types of measures seem to convey distinct yet complementary information. However, the choice of outcome measure for research or practice should ultimately be guided by the construct being measured, evidence for its psychometric properties, and ease of use.

It is noteworthy that, in line with a previous study investigating the predictors of patient-reported *vs.* performance-based function,[36] the authors found that leg speed predicted both observed and self-reported walking ability at baseline and at 3 yrs. Leg speed has not traditionally been targeted as part of disability prevention strategies. To date, large clinical trials evaluating interventions to prevent mobility-related disability in older adults have primarily included aerobic exercise, balance training, and lower extremity strength training but have not considered limb speed of movement.[39,40] The findings of this study suggest that leg speed, although rarely prioritized in rehabilitation, may be a worthwhile target for optimizing mobility and mitigating disability. In addition, the results of this study support the heel-shin test, a measure of rapid coordination, as a simple and clinically feasible method for deriving information on limb speed in the context of walking.

This study has several limitations. The results of this study may not be generalizable to all older adults; the study sample was representative of a population living in Chianti, Italy, and may not be reflective of older adults living in other areas of Europe, North America, or Asia. Although this study's post hoc analysis supported the use of the heel-shin test as a surrogate for leg speed, it is important to note that performance on this test is also related to coordination. In addition, while a number of physical attributes hypothesized to be important for walking ability were evaluated, it is possible that other attributes that were not measured are also important. In particular, the authors were unable to assess aerobic capacity because this was not directly measured in the InCHIANTI study. At the 3-yr analysis, loss to follow-up was high, and thus, the results of this study are potentially biased. The high number of missing data for kyphosis measurements is also a limitation of the current analysis.

In summary, this study's findings improve the understanding of the set of physical attributes that underlies successful walking among older adults. By focusing on attributes that can be easily measured and targeted as part of rehabilitation, the results of this study are directly relevant to clinicians. Leg speed seems to be a particularly important predictor of current and future walking limitations and should be considered as part of exercise therapy programs. In addition, the results of this study showing the differences in attributes associated with self-report *vs.* objective performance-based measures of walking highlight the importance of considering both types of measures as part of a mobility evaluation among older adults.

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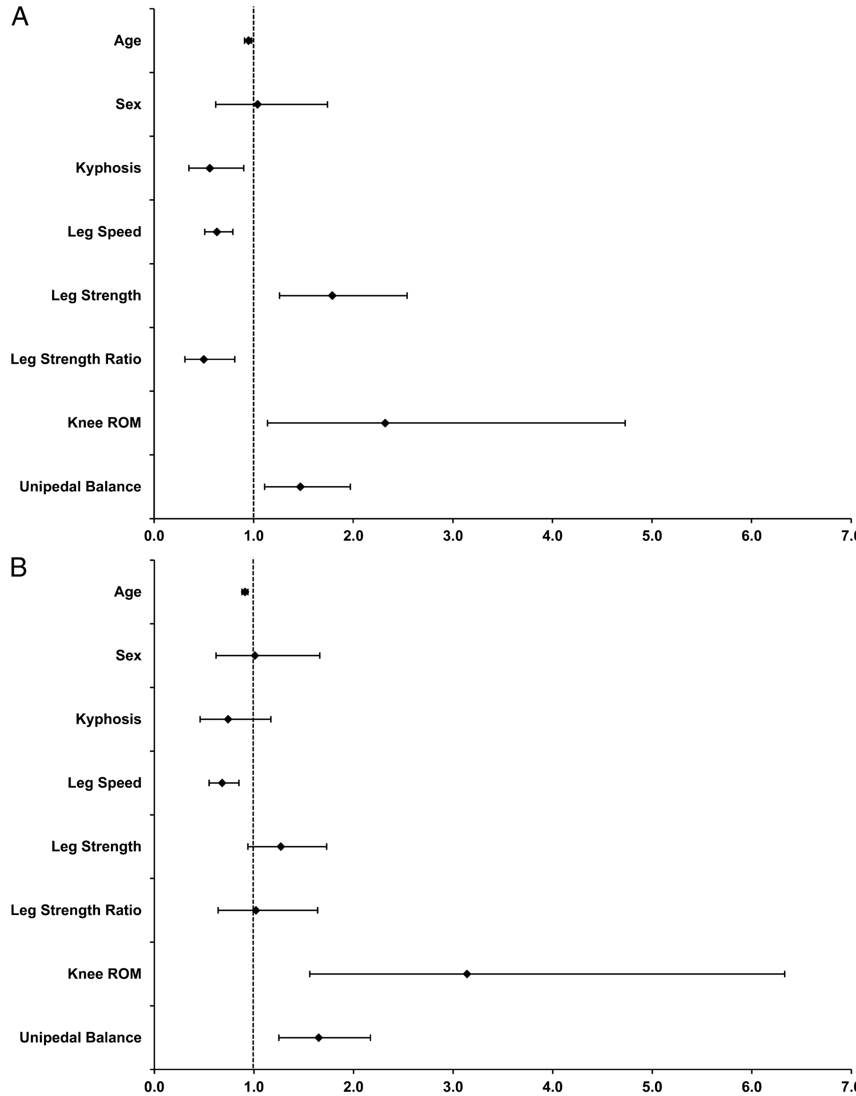

Figure 1. Odds ratios and 95% confidence intervals estimating the association between baseline physical attributes and self-reported ability to walk 400 m (A) and observed ability to walk 400 m (B) (n = 910). ROM, range of motion

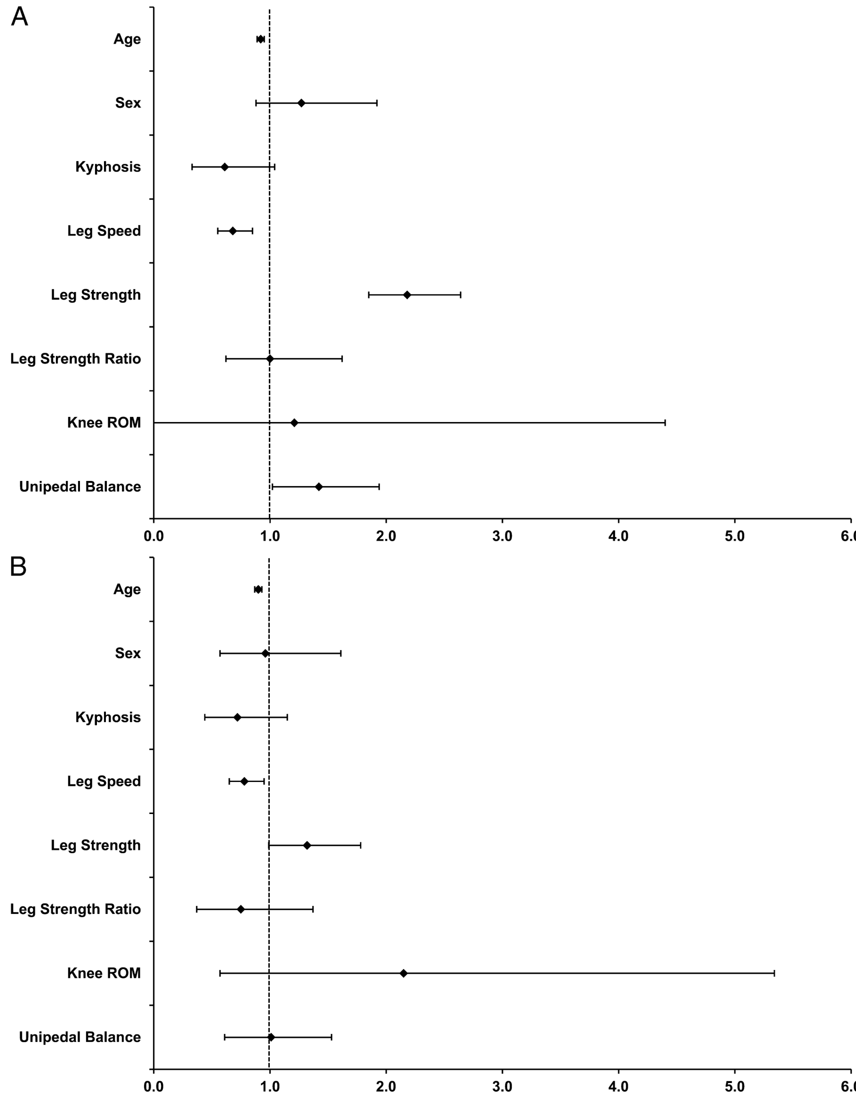

Figure 2. Odds ratios and 95% confidence intervals estimating the association between baseline physical attributes and self-reported ability to walk 400 m (A) and observed ability to walk 400 m (B) at 3 yrs (n = 628). ROM, range of motion

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Table 1
Baseline characteristics of InCHIANTI participants

Characteristic	*N*	Missing	Mean (SD) or *n* (%)	Range
Age, yrs	1026	0	74.9 (7.3)	65–102
Female sex	1026	0	572 (55.8)	
Weight, kg	984	42	68.9 (12.5)	41.0–120.0
Leg speed,[a] secs	951	75	12.6 (3.9)	6.4–41.0
Leg strength, kg	954	72	15.9 (6.1)	3.2–41.7
Leg strength ratio (right/left)	897	129		
Difference ≥15%			298 (33.2)	
Difference <15%			599 (66.8)	
Knee ROM	1019	7		
Loss of ≥5 degrees			80 (7.9)	
Loss of <5 degrees			939 (91.2)	
Hip ROM	1016	10	31.7 (8.3)	2.0–62.0
Kyphosis	858	168		
Distance ≥5 cm			281 (32.8)	
Distance <5 cm			577 (62.3)	
Unipedal balance	1026	0		
>5 secs			528 (51.5)	
≤5 secs			498 (48.5)	
Self-reported ability to walk 400 m	1026	0		
Yes			830 (80.9)	
No			196 (19.1)	
Observed ability to walk 400 m	1026	0		
Yes			801 (78.1)	
No			225 (21.9)	

[a]Time to complete ten repetitions of the heel to shin test.

ROM, range of motion.

Table 2
Walking outcomes of InCHIANTI participants (3-yr follow-up)

Characteristic	*n*	*n* (%)
Self-reported ability to walk 400 m	864	
Maintained		666 (77.1)
Worsened		198 (22.9)
Missing	33	
Observed ability to walk 400 m	645	
Maintained		426 (66.0)
Worsened		219 (34.0)
Missing	252	

Table 3

Self-report *vs.* observed ability to walk 400 m at baseline

	Self-report		
Observed	**No**	**Yes**	**Total**
No	140 (13.7%)	56 (5.5%)	196 (19.1%)
Yes	85 (8.3%)	745 (72.6%)	830 (80.9%)
Total	225 (21.9%)	801 (78.1)	1026 (100%)

$\kappa = 0.58$, $P < 0.001$.

Table 4

Self-report *vs.* observed ability to walk 400 m at 3 yrs

	Self-report		
Observed	**No**	**Yes**	**Total**
No	74 (11.5%)	144 (22.4%)	218 (33.9%)
Yes	27 (4.2%)	399 (62.0%)	426 (66.2%)
Total	101 (15.7%)	543 (84.3%)	644 (100%)

[a] $\kappa = 0.32$, $P < 0.001$.