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Adding Challenge to Performance-Based Tests of Walking: The Walking InCHIANTI Toolkit (WIT)

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Abstract

Bandinelli S, Pozzi M, Lauretani F, Phillips C, Shumway-Cook A, Guralnik JM, Ferrucci L: Adding challenge to performance-based tests of walking: The Walking InCHIANTI Toolkit (WIT).

Objective—In this report, we provide a detailed description of and reproducibility data on the 14 performance-based tests of lower limb function included in the Walking InCHIANTI Toolkit, which were designed to mimic challenging situations that are encountered while walking in daily life.

Design—Five women and five men were randomly selected from each of the age strata, 65–74, 75–84, and ≥ 85 yrs, among those who received a functional evaluation in the Greve site at the second InCHIANTI study follow-up (total $n = 30$). Walking tests were administered twice at 2-wk intervals. Analyses were aimed at assessing reproducibility of the Walking InCHIANTI Toolkit components and the existence of a learning effect.

Results—Performance remained stable for eight walking tests and slightly but significantly improved for the 25-cm narrow-path walk, 7-m usual-pace, 7-m obstacle normal light, 7-m holding a package, and 7-m talking while walking tests. Test–retest reliability was in general very high, with 11 of 14 (79%) of the intraclass correlation coefficient values >0.80 and all except one (7-m holding a package) >0.75 .

Conclusion—The walking tests included in the Walking InCHIANTI Toolkit show very good medium-term reproducibility and modest learning effect. Administering components of the Walking InCHIANTI Toolkit may help in the understanding of the effect of challenges encountered in daily life on walking performance.

Keywords

InCHIANTI Study; Mobility; Performance Tests; Reproducibility; Aging

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Objective tests of lower limb function are extensively used as measures of physical function in older persons, as indicators of functional limitations, as proxy measures of global health status, and as outcomes of pharmacologic and nonpharmacologic interventions.^{1–7} Objective measures of walking in which subjects are asked to walk a certain distance either at a usual or fast pace are considered essential components of the assessment of lower limb function.^{8–12} The results of these tests have shown robust predictive validity for incident disability, mortality, nursing home admission, and healthcare utilization.^{9–11,13} However, the ecologic validity of these measures is limited. In fact, walking in real life is considerably more challenging than walking in a laboratory setting, which generally consists of walking on a wide, flat, smooth, and well-lit course, with no obstacles to overcome or circumvent.^{8,14,15} In addition, whereas in traditional tests of walking, the individual's attention is entirely focused on the walking activity, walking in real life is performed in combination with other cognitively and physically demanding tasks that require shared attention.^{8,14–17} The need for developing a battery of standardized tests of walking that would capture the typical challenging conditions encountered during daily life was considered a critical feature in the design of the InCHIANTI study, a cohort study performed in Tuscany, Italy, aimed at understanding the causal pathway leading to mobility disability in late life.¹² The Walking InCHIANTI Toolkit (WIT) was designed with two main objectives: 1) to gain a broad set of information on the participants' ability to walk autonomously in many situations encountered in daily life and 2) to quantify participants' functional reserve, operationalized as the ability to maintain stable performance despite increased complexity of the walking task. We hypothesized that by administering the WIT, we could detect meaningful changes in performance at an earlier stage than by using traditional objective tests of walking. Such an early screening may be important to clearly understand the critical impairments that trigger the disablement process and that should be targeted for intervention. In addition, studying the initial phase of the disablement process may help in discerning the effect of aging from individual pathologies.

In this report, using data collected in a subset of the InCHIANTI study population, we describe the components of the WIT and provide data on reproducibility of repeated measurements performed during a 2-wk period.

METHODS

Participants

InCHIANTI is an epidemiologic study of risk factors for mobility disability in old age. The InCHIANTI study population is a representative sample of the population living in Greve in Chianti and Bagno a Ripoli, two small towns located in the Chianti countryside of Tuscany, Italy. The study design and data collection have been previously described.¹² At the second InCHIANTI follow-up, performed 6 yrs after baseline, 459 participants received a functional evaluation at the Greve site. Of these, five women and five men randomly selected in each of the age strata, 65–74, 75–85, and ≥ 85 yrs, were enrolled in this reliability study (total $n = 30$).

Exclusion criteria for this study were: inability to walk without assistance or use of a walker, history of recent (during the last 3 mos) myocardial infarction, unstable angina, heart surgery, hip or knee surgery, uncontrolled hypertension (systolic blood pressure of >180 mm Hg or diastolic blood pressure of >110 mm Hg), bradycardia (<40 beats/min) or tachycardia (>135 beats/min), or severe dyspnea at rest or with minimal effort, loss of consciousness in the past 3 mos, and pathologies recorded on the electrocardiograph. In the InCHIANTI protocol, these same criteria establish the eligibility for the walking tests included in the WIT. Although criteria for the interruption of the test were also preestablished, they were never used in this protocol, and all participants completed all the proposed tests.

The study protocol was examined and approved by the Florence Health Care Agency Ethical Committee. All participants were informed of the study procedure, purposes, and known risks, and all gave their informed consent.

Procedure

The 30 selected subjects were tested twice, always by the same experienced physical therapist who had received specific training in the administration and scoring of the InCHIANTI functional assessment. The first administration of the WIT was performed in the context of the regular InCHIANTI functional assessment and the second 2 wks later (± 1 day). Both examinations used an identical standardized protocol and were conducted at the same time of the day with the participant wearing the same shoes.

Measures

The WIT includes a battery of tests evaluating walking performance under different conditions and distances (4, 7, 60, and 400 m). The participant was required to wear comfortable clothes and shoes and received an extensive description of the tests, including demonstrations. However, no preliminary trial test was allowed. Although the use of a cane was allowed for the simpler tests, none of the participants selected for this study used any assistive device. The starting, but not the finishing, line of the walking course was marked by a colored tape to help prevent the participant from slowing down in the final portion of the course. The time from the beginning to the completion of the test was recorded by a photocell-based recording system (Zingerle Sports Timing, Bolzano, Italy) mounted on the starting and finishing lines.

At the beginning of the tests, the participant was positioned behind the starting line and started walking after a “start” verbal clue. The different tests were always presented in the same order as reported below, and resting times of 2–3 mins were allowed between tests at the participants’ request. Resting time was mandatory before and after performing the 400-m walk. The following 14 walking tests were administered:

- 1) 4 m of walking at usual pace performed twice.
- 2) 4 m of walking as fast as possible without running.
- 3–4) 4 m of fast walking within the limits of a narrow path indicated by tape on the floor, 25 cm and then 15 cm wide. Path trespasses were recorded, but no penalty was assigned.
- 5–6) 7 m of usual- and fast-pace walking.
- 7) 7 m walking with steps as long as possible.
- 8–9) 7 m of fast walking overcoming two obstacles (the first 5 cm tall and the second 30 cm tall, positioned, respectively, 2 and 4 m from the starting line), first with normal illumination and then wearing standard sunglasses to mimic a semidark environment.
- 10) 7 m of usual-pace walking while carrying a large, light package that obstructs the view of the feet.
- 11) 7 m of usual-pace walking while naming animals with names starting with a specific letter given to the participant at the beginning of the test (S, T, M, depending on whether the participant’s birthday was in the first, second, or last 10 days of the month).
- 12) 7 m of usual-pace walking and picking up one (a spoon) of three objects from the floor during the course.
- 13) 400 m as fast as possible (walking 20 times around a 20-m corridor loop, with narrow turns).

14) 60 m of fast walking while wearing a jacket that increased the weight of the participant by 15%.

Cognitive status was assessed by the 30-point Mini-Mental State Examination.⁹ Weight and height were objectively measured using a standard protocol and used to calculate the body mass index (BMI) as kilograms per meter square.

Data Analysis

Mean values and standard error of the walking speed measured in the first set of tests are reported according to sex and age strata. Differences across sexes and age groups were formally tested by analysis of variance. A term for age $\times$ sex interaction was always introduced in the initial analysis of variance models, but because it was never statistically significant, it is not reported in the text and tables. Systematic differences in performance between the first and second tests were analyzed with paired Student's *t* test.

Test–retest reliability was estimated by analysis of variance– based intraclass correlation coefficients, calculated for measurements obtained from the same subject by the same therapist at two points in time.¹⁸

All analyses were performed using the SAS statistical package, version 8.2 (SAS Institute, Cary, NC).

RESULTS

The age of the 30 participants enrolled in this reliability study was 79.9 ± 6.7 yrs (range, 65–89 yrs). Study participants tended to be slightly overweight (body mass index, 26.2 ± 2.9 kg/m² in men and 27.1 ± 4.8 kg/m² in women) and to have normal cognitive function (Mini-Mental State Examination, 27.0 ± 2.6 in men and 25.1 ± 2.8 in women). All participants completed the whole battery of walking tests in <40 mins without reporting any symptoms or complaints. The average walking speeds obtained at the first assessment for the different tests are reported in Table 1, according to sex and age group. Despite the small number of participants, the effect of sex and age on performance was consistent with a priori expectations. In most tests, women were significantly slower than men and, independent of sex, older age was significantly associated with lower performance.

The results of the reproducibility analysis are reported on Table 2. From the first to the second assessment, performance either remained stable or slightly improved. The magnitude of improvement was statistically significant for the 25-cm corridor walk, 7-m usual-pace, 7-m obstacle normal light, 7-m holding a package, and 7-m talking while walking tests. Test–retest reliability was in general very high, with many of the intraclass correlation coefficient values (11 of 14, 79%) at >0.80 and all except one (7-m holding a package) at >0.75.

DISCUSSION

In this study, we tested the reproducibility of a battery of walking tests that were specifically designed to mimic the challenges that are usually encountered during walking in real life. Test–retest reliability was very good, with the only exception being the 7-m holding a package test, which had an intraclass correlation coefficient of 0.661. Confirming previous reports, the difference between the first and the second assessment was attributable, at least in part, to a learning effect,^{19,20} especially in the WIT subtests that are demanding of attention.

Because most of the performance tests designed for the WIT have never been previously used in epidemiologic studies, our findings cannot be compared with the literature. However, our

findings further support the notion that performance-based tests of walking are very reliable and provide information that is stable over short time periods.^{19–21}

The slight improvement demonstrated for some of the challenging tests is not completely unexpected. In fact, after experiencing the test a first time, participants may learn how to respond more efficiently to the challenge, and this is especially true for complex tasks that are primarily demanding of attention.

Although this study provides solid evidence of the reliability of the WIT, some limitations should be acknowledged. The tests were administered in 2-wk intervals, always by the same examiner. Therefore, the long-term reproducibility and the interrater reliability remain undetermined. The second limitation is offset, at least in part, by the automatic, photocell-based method used to assess walking time and by the strict adherence to a detailed administration protocol.

Future analysis performed on the rich InCHIANTI database will attempt to demonstrate that the WIT assessment provides novel information on older persons' functional status that supplements what we can learn from standard performance-based measures of lower limb function. In particular, we are planning to test the hypothesis that assessing the change in performances between reference and challenged walking tests may provide information on the functional reserve that older individuals can access to respond to challenges that occur in their day-by-day life. Using this information, we can start selecting the components that convey the essential information on physical function and trim down tasks that are relatively uninformative or redundant. For example, the finding of this reliability study suggests that the 7-m, usual-pace, holding a package test should be considered for elimination.

CONCLUSIONS

We believe that a refined, abbreviated version of the WIT can be used in clinical practice to identify older persons who are already in a trajectory of functional decline at an early stage, when it is likely that interventions are more effective. To translate the measurement approach proposed by the WIT from research to clinical practice, we need to demonstrate that introducing challenges in performance-based tests provide information on physical function and risk of disability over and beyond traditional performance tests of walking. The findings of this study set the stage for this developmental work.

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TABLE 1
Walking speeds measured at the first assessment in the different subtests of the Walking InCHIANTI Toolkit

Walking Subtest, m/sec	Men			Women			Age Effect <i>p</i> ^a	Sex Effect <i>p</i> ^a
	65–74 yrs (<i>n</i> = 5)	75–84 yrs (<i>n</i> = 5)	≥85 yrs (<i>n</i> = 5)	65–74 yrs (<i>n</i> = 5)	75–84 yrs (<i>n</i> = 5)	≥85 yrs (<i>n</i> = 5)		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
4 m, usual pace	1.24(0.15)	1.09(0.09)	0.90(0.21)	1.13(0.17)	1.01(0.21)	0.87(0.25)	<0.0001	0.07
4 m, fast pace	1.77(0.18)	1.52(0.13)	1.26(0.35)	1.42(0.18)	1.25(0.22)	1.22(0.43)	<0.001	30.005
Corridor walk, 25 cm	1.65(0.31)	1.57(0.19)	1.18(0.20)	1.39(0.13)	1.19(0.14)	1.19(0.17)	<0.0001	30.005
Corridor walk, 15 cm	1.57(0.33)	1.38(0.22)	0.99(0.12)	1.28(0.17)	1.10(0.28)	0.96(0.14)	<0.0001	30.01
7 m, usual pace	1.42(0.13)	1.29(0.11)	0.86(0.36)	1.31(0.15)	1.18(0.25)	0.97(0.27)	<0.0001	0.33
7 m, fast pace	1.80(0.14)	1.66(0.10)	1.12(0.28)	1.44(0.18)	1.33(0.26)	1.19(0.40)	<0.0001	30.01
7 m, long steps	1.79(0.16)	1.55(0.09)	1.20(0.23)	1.35(0.25)	1.12(0.12)	0.98(0.34)	<0.0001	30.0001
7 m, fast pace, obstacles, normal light	1.74(0.23)	1.54(0.12)	0.97(0.24)	1.27(0.20)	1.06(0.28)	0.87(0.28)	<0.0001	30.0001
7 m, fast pace, obstacles, sunglasses	1.70(0.35)	1.45(0.10)	1.01(0.28)	1.19(0.12)	1.14(0.15)	0.84(0.26)	<0.0001	30.001
7 m, usual pace, holding a package	1.34(0.14)	1.39(0.11)	1.19(0.06)	1.29(0.10)	1.28(0.16)	1.04(0.20)	<0.05	0.11
7 m, usual pace, talking while walking	1.30(0.18)	1.13(0.25)	0.56(0.33)	1.13(0.18)	1.01(0.25)	0.67(0.22)	<0.0001	0.07
7 m, usual pace, pick up object	1.19(0.18)	1.04(0.12)	0.75(0.22)	1.02(0.13)	0.93(0.18)	0.61(0.25)	<0.0001	30.05
400 m, fast pace	1.40(0.14)	1.36(0.09)	1.01(0.25)	1.21(0.17)	1.13(0.31)	0.91(0.20)	<0.001	30.05
60 m, fast pace, heavy jacket	1.27(0.41)	1.38(0.05)	1.15(0.19)	1.18(0.16)	1.21(0.20)	0.96(0.32)	0.12	0.08

^aThe effects of sex and age on performance are estimated from the same analysis of variance model.

TABLE 2

Walking speeds measured at the first and second evaluations

Walking speed, m/sec	Test 1		Test 2		<i>t</i> Value ^a	<i>P</i> ^a	ICC ^b
	Mean	SD	Mean	SD			
4 m, usual pace	1.04	0.21	1.07	0.22	-0.85	0.40	0.812
4 m, fast pace	1.41	0.31	1.41	0.31	-0.42	0.68	0.820
Corridor walk, 25 cm	1.38	0.27	1.45	0.30	-2.19	0.04	0.817
Corridor walk, 15 cm	1.23	0.33	1.30	0.25	-1.28	0.21	0.756
7 m, usual pace	1.17	0.29	1.24	0.25	-2.11	0.04	0.872
7 m, fast pace	1.42	0.35	1.47	0.32	-1.92	0.07	0.950
7 m, long steps	1.34	0.33	1.39	0.32	-1.36	0.18	0.874
7 m, fast pace, obstacles, normal light	1.27	0.29	1.32	0.41	-2.37	0.03	0.893
7 m, fast pace, obstacles, sunglasses	1.24	0.36	1.36	0.25	-1.16	0.26	0.797
7 m, usual pace, holding a package	1.27	0.16	1.33	0.17	-2.21	0.04	0.661
7 m, usual pace, talking while walking	0.96	0.25	1.10	0.32	-3.24	0.003	0.842
7 m, usual pace, pick up object	0.93	0.25	0.97	0.28	-1.33	0.20	0.907
400 m, fast pace	1.17	0.26	1.18	0.27	-0.93	0.36	0.968
60 m, fast pace, heavy jacket	1.20	0.26	1.26	0.19	-0.88	0.39	0.871

ICC, intraclass correlation coefficients.

^aFrom paired *t* tests for the H0 hypothesis that the first and the second value come from the same distribution.

^bICC (analysis of variance based) evaluating the degree of reproducibility.