Comparative Study of Four Physical Performance Measures as Predictors of Death, Incident Disability, and Falls in Unselected Older

(Article begins on next page)

01 July 2024

Once you have Acrobat Reader open on your computer, click on the Comment tab at the right of the toolbar:

| | | | 1 / 27 | | | 70.4% ▼ | | | ▼ | Tools | Comment | Share |
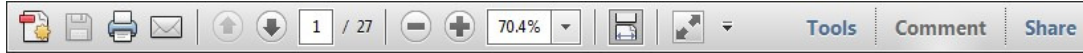
This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the Annotations section, pictured opposite. We've picked out some of these tools below:

▼ **Annotations**

---
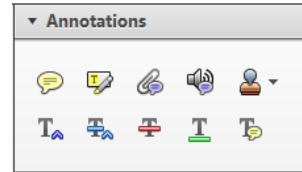
1. Replace (Ins) Tool – for replacing text.

Strikes a line through text and opens up a text box where replacement text can be entered.

How to use it

- Highlight a word or sentence.
- Click on the Replace (Ins) icon in the Annotations section.
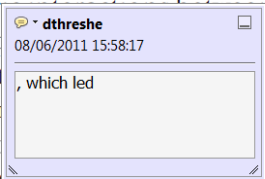- Type the replacement text into the blue box that appears.

ndard framework for the analysis of m
icy. Nevertheless, it also led to exoge
ole of strategi... interaction what u fi
nber of comp...   o
: is that the st...   of
nain compo...   be
level, are exc...   nc
important works on entry by Girc
:M henceforth)[1] we open the 'black h

> dthreshe
> 08/06/2011 15:58:17
> , which led

---

2. Strikethrough (Del) Tool – for deleting text.

Strikes a red line through text that is to be deleted.

How to use it

- Highlight a word or sentence.
- Click on the Strikethrough (Del) icon in the Annotations section.

there is no room for extra profits ar
k ups are zero and the number of
ket) values are not determined by
Blanchard and Kiyotaki (1987),
rfect competition in general equilil
ts of aggregate demand and supply
lassical framework assuming monof
een an exogenous number of firms

---

3. Add note to text Tool – for highlighting a section to be changed to bold or italic.

Highlights text in yellow and opens up a text box where comments can be entered.

How to use it

- Highlight the relevant section of text.
- Click on the Add note to text icon in the Annotations section.
- Type instruction on what should be changed regarding the text into the yellow box that appears.

namic responses of mark ups
:ent with the VAR evidence

:sation...   ith
y Ma...   :ell
. and...   led
on n...   ber
to a...   on
:tent also with the demand-

> dthreshe
> 08/06/2011 15:31:38

---

4. Add sticky note Tool – for making notes at specific points in the text.

Marks a point in the proof where a comment needs to be highlighted.

How to use it

- Click on the Add sticky note icon in the Annotations section.
- Click at the point in the proof where the comment should be inserted.
- Type the comment into the yellow box that appears.

land and supply shocks. Most of
a umi...   eti
numbe...   iff
dard fra...   sis
icy. Nev...   o
ole of st...   we
ber of competitors and the imp
is that the structure of the secte

> dthreshe
> 08/06/2011 15:18:08

5. Attach File Tool – for inserting large amounts of text or replacement figures.

Inserts an icon linking to the attached file in the appropriate place in the text.

How to use it

- Click on the Attach File icon in the Annotations section.
- Click on the proof to where you'd like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.

END
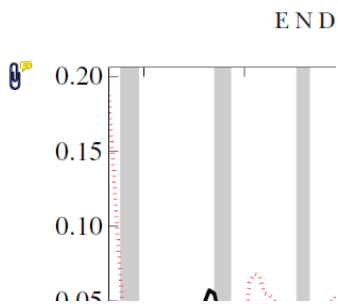
6. Drawing Markups Tools – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks. Allows shapes, lines and freeform annotations to be drawn on proofs and for comment to be made on these marks.
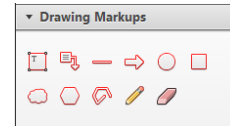
How to use it

- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.
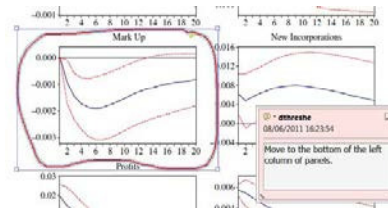
BRIEF METHODOLOGICAL REPORTS

Comparative Study of Four Physical Performance Measures As Predictors of Death, Incident Disability, and Falls in Unselected Older Persons: The Insufficienza Cardiaca negli Anziani Residenti a Dicomano Study

[2] *Cristina Minneci, PT,* $*^{\dagger}$ *Anna Maria Mello, MD,* $*^{\ddagger}$ *Enrico Mossello, MD, PhD,* $*^{\ddagger}$ *Samuele Baldasseroni, MD, PhD,* $*^{\ddagger}$ *Loredana Macchi, PT,* § *Stefano Cipolletti, PT,* † *Niccolò Marchionni, MD,* $*^{\ddagger}$ *and Mauro Di Bari, MD, PhD* $*^{\ddagger}$

OBJECTIVES: To compare the ability of the Short Physical Performance Battery (SPPB), 4-m walk test (4mWT), 6-minute walk test (6MWT), and handgrip strength to predict mortality, incident disability, worsening mobility, and falls in older community dwellers.

DESIGN: Cohort study.

SETTING: Population-based.

PARTICIPANTS: Individuals aged 65 and older (n = 561) without prevalent basic activity of daily living (ADL) disability participating in a population-based study.

MEASUREMENTS: Separate logistic regression models were developed to predict incident ADL disability, worsening mobility, and falls in 3 years, and Cox regression models were used to assess 7-year risk of death as a function of the four tests, adjusting for covariates.

RESULTS: Performance tests were reciprocally correlated at baseline. After 3 years, 33 (7.3%) of 453 participants reexamined were disabled in ADLs, 87 (20%) had worsening mobility, and 99 (22%) reported falls. Of the 561 baseline participants, 141 (25%) died over the 7 years. All measures predicted incident ADL disability, with adjusted odds ratios (ORs) per unit increase of 0.85 (95% confidence interval (CI) = 0.77–0.93) for handgrip strength, 0.08 (95% CI = 0.02–0.36) for 4mWT, 0.74 (95% CI = 0.61–0.89) for SPPB, and 0.993 (95% CI = 0.988–0.997) for 6MWT. Handgrip strength (OR = 0.88, 95%

CI = 0.83–0.93), 4mWT (OR = 0.33, 95% CI = 0.11–0.94), and SPPB (OR = 0.81, 95% CI = 0.71–0.93) predicted worsening mobility. No measure predicted falls; only SPPB (hazard ratio (HR) = 0.92, 95% CI = 0.85–0.997) and 6MWT (HR = 0.997, 95% CI = 0.995–0.999) predicted death.

CONCLUSION: Performance measures are independent predictors of relevant health outcomes, with the exception of falls. Because SPPB is easily applied and is the only measure predicting incident ADL disability, worsening mobility, and death, it is preferable to the other tests. J Am Geriatr Soc 2014.

Key words: performance tests; cohort studies; predictive value

Aging is characterized by a decline in physical performance, a complex phenomenon with multifactorial etiology. It represents a marker of frailty,[1] which stems from reduced homeostatic reserves, and increases the risk of adverse health outcomes.[1] Diminished physical performance, even without overt disability, predicts loss of independence, institutionalization, and death in older adults.[2–9] Therefore, several tests have been proposed as components of comprehensive geriatric assessment to obtain objective, quantitative, sensitive, specific, responsive-to-change measures of physical performance.[10–12]

Among others, handgrip strength,[13] the 4-m walk test (4mWT), the Short Physical Performance Battery (SPPB),[3] and the 6-minute walk test (6MWT)[14] are of particular interest. Their independent prognostic value toward relevant outcomes has been documented in population studies[2,3,9,13] and clinical settings,[6,11] but these four tests differ in their burden of administration, which is minimal for handgrip

From the *Research Unit of Medicine of Aging, Department of Experimental and Clinical Medicine, University of Florence, Florence, †Starbene SrL Rehabilitation Centre, Cerreto Guidi, ‡Division of Geriatric Cardiology and Medicine, Department of Heart and Vessels, Azienda Ospedaliero-Universitaria Careggi; and §Functional Rehabilitation Service, Azienda Ospedaliero-Universitaria Careggi, Florence, Italy. [1]

Address correspondence to Mauro Di Bari, Research Unit of Medicine of Aging, Department of Experimental and Clinical Medicine, University of Florence, Viale Pieraccini, 18, 50139 Firenze, Italy. E-mail: mauro.dibari@unifi.it

DOI: 10.1111/jgs.13195

strength, intermediate for 4mWT and SPPB, and definitively greater for 6MWT. Thus, it was decided to verify whether the longer time and greater resources required for performance of some of these tests are better able to predict important outcomes, such as worsening functional status, falls, and mortality.

METHODS

Study Population and Protocol

Data were obtained from the Insufficienza Cardiaca negli Anziani Residenti a Dicomano (ICARe Dicomano) Study, a cohort study of heart failure in older persons conducted in Dicomano, a small rural town near Florence, Italy, whose methods have been published previously[15] and are consistent with the principles of the Declaration of Helsinki. Briefly, in 1996, the entire unselected community-dwelling elderly (≥65) population recorded in the city registry office was enrolled in the parent study, with the only exclusion criterion being living in a nursing home. This cohort was reexamined in 1999, and the city registry office was consulted again in 2003 to define vital status. Individuals with prevalent activity of daily living (ADL) disability were excluded from the present study.

Data Collection

After obtaining informed consent, study physicians collected multidimensional geriatric assessment data at baseline, including complete clinical examination, laboratory studies, 12-lead electrocardiogram, echocardiography, carotid ultrasound, and bell spirometry. This information, assembled in prespecified diagnostic algorithms, enabled the diagnosis of 14 comorbidities and quantification of the burden of comorbidity as disease count.[16]

Cognitive impairment and depressive symptoms, frequent nonsomatic comorbidities of late life, were evaluated using the Mini-Mental State Examination (MMSE)[17] and the 30-item Geriatric Depression Scale (GDS).[18]

Subjective assessment of functional status was obtained at baseline and in the follow-up from the number of tasks in which the participant reported complete inability or need for help, separately for the two domains of activities of daily living (ADLs) (washing hands and face, dressing and undressing self, toileting, transferring from bed to chair, maintaining continence, eating) and mobility (walking in the house, walking outdoors, walking for 400 m, climbing stairs, bathing or showering, cutting toe nails). Individuals with prevalent disability in one or more ADLs were excluded, so those reporting disability in one or more ADLs in 1999 represent incident cases. Worsening mobility disability was defined as an increase from baseline to follow-up in the number of mobility items in which the participant reported complete inability or need for help.

Handgrip strength, 4mWT, SPPB, and 6MWT were performed at baseline. Handgrip strength was evaluated as the best of three measures taken 1 minute apart using the dominant hand using a handheld dynamometer. The 4mWT, performed as part of the SPPB, was assessed as the fastest speed (m/s) in two attempts. The SPPB assesses balance, time needed to complete a short-distance (4 m)

walk, and ability to stand up from a chair without using the arms five times consecutively as quickly as possible. The results are transformed into a score based on test results in a reference older population, and a summary score (ranging from 0 (worst performance) to 12 (best performance)) is calculated as the sum of individual test scores.[2] Sustainable walking capacity was assessed using the 6MWT, which measures the distance an individual is able to walk in 6 minutes at their preferred speed. In individuals with lung disease or heart failure, the 6MWT reflects cardiovascular and respiratory fitness,[19] whereas in older persons, the test is a measure of overall mobility and physical functioning.[20]

The 1999 follow-up visit was conducted to identify cases of incident ADL disability and worsening mobility disability, as previously defined, and falls in the 12 months preceding the assessment. These three conditions and death by 2003 were separate final endpoints of the study.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows 18 (SPSS, Inc., Chicago, IL). Continuous variables are reported as mean and standard errors of the mean. Relative frequencies were compared using the chi-square test. Correlation between continuous variables was analyzed using Pearson correlation coefficients.

The risk of incident ADL disability, worsening mobility disability, and falling as a function of the individual performance measures was expressed as odds ratios (ORs) and 95% confidence intervals (CIs) from separate logistic regression models, adjusting for age, sex, height, weight, disease count, and MMSE and GDS scores, with backward deletion of redundant variables (P out >.10). The Hosmer-Lemeshow test was used to check for goodness of fit of the models. The risk of death associated with the individual performance measures was predicted as hazard ratios (HRs) with 95% CIs from Cox proportional hazards models, with the same covariates reported above added in a second step and backward deleted when redundant (P out >.10). The method proposed by May and Lemeshow was used to verify the goodness of fit of the models. Areas under the receiver operating characteristic (ROC) curves (AUCs) and their 95% CIs were calculated to test the predictive accuracy of the individual performance measures for each outcome.

$P < .05$ was considered statistically significant.

RESULTS

Baseline Assessment

Of 697 participants assessed in the parent ICARe Dicomano Study, 56 were excluded from this report because of prevalent ADL disability and 80 because of missing data, leaving 561 available for the present study. Included participants were younger (72.9 ± 0.3 vs 79.3 ± 0.6, $P < .001$), had a similar proportion of men (42.4% vs 36.8%, $P = .23$), and less frequently reported mobility disability (13.7% vs 71.3%, $P < .001$) than the 136 excluded. One hundred forty-nine participants (26.6%) were aged 75 to 84, and 28 (5.0%) were aged 85 and older.

As shown in Table 1, participants were on average slightly overweight and had a mild burden of comorbidity; their cognitive status was preserved, whereas physical performance, albeit in the absence of ADL disability according to the inclusion criteria, was suboptimal, as low SPPB scores and slow 4mWT speed indicated. All performance tests were reciprocally highly correlated, with Pearson r values between 0.292 (handgrip strength vs 4mWT) and 0.639 (SPPBV vs 4mWT) (all $P < .001$).

Follow-up Assessment

In 1999, 453 participants (81% of those seen at baseline) were reexamined; 33 (7.3%) had developed ADL disability, 87 (19.7%) had worsening mobility disability, and 99 (21.9%) reported at least one fall in the prior 12 months. All 561 participants assessed at baseline could be traced for vital status; 141 (25.1%) had died by 2003.

Participants who developed ADL disability, had increasing severity of mobility disability, or reported falling in the previous year had worse baseline performance than those who did not reach these endpoints, as indicated by lower handgrip strength, 4mWT, SPPB, and 6MWT scores. Similar findings were found when comparing 4mWT, SPPB, and 6MWT of long-term survivors and nonsurvivors, whereas the difference was nonsignificant for handgrip strength (Table 2).

The results of multivariable logistic regression models predicting functional outcomes and falls in 3 years and of Cox proportional hazards models predicting death in 7 years are shown in Table 3. All models were based on a single performance measure and included sex, age, height, weight, disease count, and MMSE and GDS scores in a subsequent step, with backward deletion of redundant variables to obtain a parsimonious model. Handgrip strength was an excellent independent predictor of incident ADL disability and worsening mobility but not of falls or death. Similar results were obtained using the 4mWT, which predicted incident ADL disability and worsening mobility but not falls or mortality. The SPPB predicted incident ADL disability, worsening mobility, and death but not falls. Finally, the 6MWT predicted incident ADL disability and was the strongest predictor of death. Age always contributed significantly to the prediction of all outcomes, whereas the contribution of the other covariates to the various outcomes was inconstant (Table 3). GDS score always predicted falls. The fitting of the models tested was always at least satisfactory.

ROC curve analysis was conducted for the performance measures that, in the models reported in Table 3, were significant predictors of the individual outcomes considered. Handgrip strength and the 4mWT obtained AUCs of 0.68 and 0.73 for incident ADL disability and 0.70 and 0.68 for worsening mobility, respectively. With the SPPB, AUCs were 0.71 for incident ADL disability, 0.68 for worsening mobility, and 0.63 for death, whereas the

Table 1. General Characteristics of Baseline Participants (N = 561)

Characteristic	Value
Age, mean (SEM)	72.9 (0.3)
Male, n (%)	238 (42.4)
Weight, kg, mean (SEM)	67.4 (0.5)
Height, cm, mean (SEM)	157.8 (0.4)
Body mass index, kg/m^2, mean (SEM)	27.0 (0.2)
Mobility disability, number of items lost, mean (SEM)	0.24 (0.03)
Disease count, mean (SEM)	3.8 (0.7)
Mini-Mental State Examination score, mean (SEM)	26.0 (0.1)
Geriatric Depression Scale score, mean (SEM)	8.2 (0.3)
Handgrip strength, kg, mean (SEM)	25.4 (0.4)
4-m walk speed, m/s, mean (SEM)	0.82 (0.01)
Short Physical Performance Battery score, mean (SEM)	9.3 (0.1)
6-minute walk test, m, mean (SEM)	315 (4.1)

SEM = Standard error of the mean.

Table 2. Bivariate Comparisons of Performance Tests Between Participants Who Did and Did Not Experience Clinical Outcomes

Outcome	Handgrip Strength, kg Mean (SEM)	P-Value	4-m Walk Speed, m/s Mean (SEM)	P-Value	Short Physical Performance Battery Mean (SEM)	P-Value	6-Minute Walk Test, m Mean (SEM)	P-Value
Incident activity of daily living disability[a]								
No (n = 420)	25.8 (0.41)	.002	0.84 (0.01)	<.001	9.6 (0.09)	<.001	325 (4.4)	<.001
Yes (n = 33)	21.0 (1.47)		0.62 (0.04)		7.6 (0.49)		242 (16.5)	
Worsening mobility[a]								
No (n = 341)	26.8 (0.46)	<.001	0.87 (0.02)	<.001	9.9 (0.09)	<.001	336 (4.7)	<.001
Yes (n = 112)	21.3 (0.73)		0.70 (0.03)		8.2 (0.23)		268 (9.1)	
Fall in previous year[a]								
No (n = 354)	26.2 (0.46)	<.001	0.84 (0.02)	.02	9.6 (0.10)	<.001	325 (4.8)	.02
Yes (n = 99)	22.8 (0.80)		0.76 (0.02)		8.7 (0.22)		299 (10.3)	
Death[b]								
No (n = 420)	25.7 (0.42)	.12	0.84 (0.01)	.003	9.6 (0.09)	<.001	327 (4.4)	<.001
Yes (n = 141)	24.4 (0.73)		0.76 (0.02)		8.5 (0.21)		276 (9.1)	

[a] Based on 1999 in-person examination.
[b] Based on 2003 city registry office consultation.
SEM = Standard error of the mean.

Table 3.   Multivariable Prediction of Incident Activity of Daily Living (ADL) Disability, Worsening Mobility, Falls in Previous Year, and Death

Model	Incident ADL Disability (n = 453) OR (95% CI)	P-Value	Worsening Mobility (n = 453) OR (95% CI)	P-Value	Falls (n = 453) OR (95% CI)	P-Value	Death (n = 561) Hazard Ratio (95% CI)	P-Value
Handgrip-based models								
Handgrip, kg	0.85 (0.77–0.93)	<.001	0.88 (0.83–0.93)	<.001	0.99 (0.96–1.02)	.446	0.99 (0.96–1.02)	.41
Sex (1 = M, 2 = F)	0.14 (0.04–0.48)	.002	0.38 (0.16–0.93)	.03	–	–	0.42 (0.27–0.67)	<.001
Age	1.09 (1.02–1.17)	.01	1.11 (1.06–1.17)	<.001	1.08 (1.04–1.13)	<.001	1.11 (1.08–1.15)	<.001
Height, cm	–	–	–	–	–	–	–	–
Weight, kg	1.04 (1.01–1.07)	.02	1.04 (1.01–1.07)	<.001	–	–	–	–
Disease count	1.62 (1.27–2.06)	<.001	1.19 (1.01–1.40)	.04	–	–	1.17 (1.06–1.28)	.001
MMSE score	–	–	1.03 (0.99–1.08)	.10	–	–	0.96 (0.92–0.996)	.03
GDS score	–	–	–	–	1.08 (1.04–1.12)	<.001	–	–
4mWT-based models								
4mWT speed, m/s	0.08 (0.02–0.36)	.001	0.33 (0.11–0.94)	.04	0.94 (0.38–2.35)	.90	0.83 (0.43–1.63)	.59
Sex (1 = M, 2 = F)	0.45 (0.19–1.04)	.06	–	–	–	–	0.47 (0.34–0.67)	<.001
Age	1.09 (1.02–1.17)	.008	1.13 (1.07–1.19)	<.001	1.09 (1.04–1.13)	<.001	1.12 (1.09–1.15)	<.001
Height, cm	–	–	0.95 (0.92–0.99)	.01	–	–	–	–
Weight, kg	1.03 (1.002–1.06)	.04	1.04 (1.02–1.07)	.001	–	–	–	–
Disease count	1.55 (1.23–1.94)	<.001	1.20 (1.03–1.40)	.02	–	–	1.17 (1.07–1.29)	.001
MMSE score	–	–	–	–	–	–	0.96 (0.92–0.998)	.04
GDS score	–	–	–	–	1.08 (1.05–1.12)	<.001	–	–
SPPB-based models								
SPPB	0.74 (0.61–0.89)	.001	0.81 (0.71–0.93)	.003	0.95 (0.84–1.08)	.44	0.92 (0.85–0.997)	.041
Sex (1 = M, 2 = F)	0.45 (0.19–1.04)	.06	–	–	–	–	0.44 (0.31–0.62)	<.001
Age	1.09 (1.02–1.17)	.008	1.12 (1.07–1.18)	<.001	1.06 (1.01–1.11)	.01	1.11 (1.08–1.15)	<.001
Height, cm	–	–	0.96 (0.93–0.998)	.04	0.96 (0.92–0.997)	.03	–	–
Weight, kg	–	–	1.04 (1.01–1.06)	.004	–	–	–	–
Disease count	1.54 (1.23–1.93)	<.001	1.19 (1.01–1.39)	.03	–	–	1.16 (1.06–1.27)	.001
MMSE score	–	–	–	–	–	–	0.96 (0.92–1.00)	.06
GDS score	–	–	–	–	1.08 (1.04–1.12)	.001	–	–
6MWT-based models								
6MWT	0.993 (0.988–0.997)	.001	0.997 (0.994–1.00)	.09	1.00 (0.998–1.004)	.55	0.997 (0.995–0.999)	.002
Sex (1 = M, 2 = F)	0.39 (0.17–0.92)	.03	–	–	–	–	0.39 (0.27–0.56)	<.001
Age	1.10 (1.03–1.17)	.003	1.13 (1.08–1.18)	<.001	1.08 (1.03–1.13)	.001	1.11 (1.07–1.14)	<.001
Height, cm	–	–	0.97 (0.93–1.00)	.06	0.98 (0.95–1.01)	.10	–	–
Weight, kg	–	–	1.04 (1.01–1.06)	.005	–	–	–	–
Disease count	1.49 (1.19–1.87)	<.001	1.17 (0.996–1.37)	.05	–	–	1.15 (1.05–1.26)	.003
MMSE score	–	–	–	–	–	–	0.96 (0.92–0.996)	.03
GDS score	–	–	1.03 (0.996–1.08)	.08	1.08 (1.04–1.12)	<.001	–	–

Parsimonious logistic regression models, each based on a separate performance measure and on covariates, which were backward deleted when redundant (dash), with P out >.1.

CI = confidence interval; OR = odds ratio; 4mWT = 4-m walk test; MMSE = Mini-Mental State Examination; GDS = Geriatric Depression Scale; SPPB = Short Physical Performance Battery; 6MWT = 6-minute walk test.

6MWT obtained AUCs of 0.74 for incident ADL disability and 0.63 for death. When different performance measures were compared against the same endpoint, the 95% CI of the AUCs always overlapped.

DISCUSSION

Four simple performance measures (handgrip strength, 4mWT, SPPB, and 6MWT), applied in older persons living in the community free from ADL disability, although well correlated cross-sectionally, differed in their ability to predict a variety of clinically relevant long-term outcomes. None of the measures predicted falls, whereas handgrip strength was an excellent predictor and 4mW speed a moderate to good predictor of incident ADL disability and worsening mobility. SPPB was the only measure able to predict independently three of four outcomes, although it was less able than the 6WMT to predict mortality.

Observational studies have reported that performance-based measures are good predictors of functional decline,[2,3,16,21] mortality,[3,8,16,22] and hospital-related outcomes;[3,23] they have also been recently applied as outcome measures in randomized clinical trials,[24] but only a few studies compared these measures in the same population and on an array of outcomes.

In a clinic-based sample of 110 subjects (70% women) aged 67 to 98,[7] the predictive value of the SPPB, 4mWT, Berg Balance Scale, Timed Up-and-Go Test, and handgrip strength was compared against onset of difficulty in ADLs at 6, 12, and 18 months, adjusting for comorbidity. The Berg Balance Scale was the most-consistent predictor at all three times, although the SPPB was slightly superior at 12 months. Using data collected in two large population-based epidemiological studies, the ability of a performance battery similar to the SPPB to predict incident disability in the domain of mobility only or also in the domain of ADLs was compared with that of 8-foot (2.44 m) distance gait speed alone.[21] The risk of disability, adjusted for demographic characteristics and comorbidity, was lower with better performance, more for mobility than for ADL disability. In agreement with the findings of the current study, gait speed alone had the same predictive ability as the complete battery for onset of ADL disability in 4 years. Isometric muscle strength is easy, rapid, and inexpensive to assess and has been shown to be a good predictor of future decline in physical performance, loss of independence,[13] and clinical outcomes,[23] possibly because it is a marker of age-related sarcopenia,[25] but the findings of the current study show that its predictive value for these outcomes is lower than that of the SPPB and 6MWT, which were able to predict mortality. Finally, despite its widespread use in respiratory and cardiovascular medicine, no previous study has ever assessed the ability of the 6MWT to predict incident ADL disability and death in unselected older persons living in the community, although its application in very old subjects is difficult.[26]

In contrast with previous findings that lower handgrip strength was longitudinally associated with falls,[27] none of the performance measures was a multivariable predictor of falls in the previous year. This is somewhat surprising, because the risk of falling in elderly adults depends, in addition to environmental conditions, on a variety of intrinsic risk factors that might affect physical performance measures; in particular, the SPPB, which includes a test for balance, would be expected to be a predictor of falling risk. It is possible that the approach of the current study to detecting falls, based upon self-report over a long period, underestimated the true occurrence of this event, but depressive symptoms, expressed in the GDS score, predicted falls, an association consistent with previous studies,[28] thus suggesting that data collection on falls for the current study was adequate.

Study limitations cannot be ignored. In particular, in a secondary analysis of an epidemiological study whose original purpose was different,[15] the quality of the data collected might be suboptimal for the intended purposes. This relates also to the fairly large proportion of participants with missing data. Nevertheless, most previous studies have been conducted with a similar approach and had even larger proportions of missing data.[21]

In conclusion, these findings offer a valid contribution to the ongoing debate on strengths and weaknesses of physical performance measures as prognostic tools in older persons. When the global predictive ability of the four tests considered in this study is weighted against their ease of application, the SPPB appears to offer the best compromise between these two different, potentially conflicting characteristics and should therefore be preferred in most clinical and epidemiological applications.

ACKNOWLEDGMENTS

REFERENCES

1. Fried LP, Tangen CM, Walston J et al. Frailty in older adults: Evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56A:M146–M156.
2. Guralnik JM, Ferrucci L, Simonsick EM et al. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. N Engl J Med 1995;332:556–561.
3. Guralnik JM, Simonsick EM, Ferrucci L et al. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol A Biol Sci Med Sci 1994;49A:M85–M94.
4. Williams ME, Gaylord SA, Gerrity MS. The Timed Manual Performance test as a predictor of hospitalization and death in a community-based elderly population. J Am Geriatr Soc 1994;42:21–27.

5. Reuben DB, Siu AL, Kimpau S. The predictive validity of self-report and performance-based measures of function and health. J Gerontol 1992;47:M106–M110.

6. Chiarantini D, Volpato S, Sioulis F et al. Lower extremity performance measures predict long-term prognosis in older patients hospitalized for heart failure. J Card Fail 2010;16:390–395.

7. Wennie Huang WN, Perera S, Van Swearingen J et al. Performance measures predict onset of activity of daily living difficulty in community-dwelling older adults. J Am Geriatr Soc 2010;58:844–852.

8. Rolland Y, Lauwers-Cances V, Cesari M et al. Physical performance measures as predictors of mortality in a cohort of community-dwelling older French women. Eur J Epidemiol 2006;21:113–122.

9. Studenski S, Perera S, Patel K et al. Gait speed and survival in older adults. JAMA 2011;305:50–58.

10. Applegate WB, Blass JP, Williams TF. Instruments for the functional assessment of older patients. N Engl J Med 1990;322:1207–1214.

11. Volpato S, Cavalieri M, Guerra G et al. Performance-based functional assessment in older hospitalized patients: Feasibility and clinical correlates. J Gerontol A Biol Sci Med Sci 2008;63A:1393–1398.

12. Thomas DR, Marren K, Banks W et al. Do objective measurements of physical function in ambulatory nursing home women improve assessment of functional status? J Am Med Dir Assoc 2007;8:469–476.

13. Rantanen T, Guralnik JM, Foley D et al. Midlife hand grip strength as a predictor of old age disability. JAMA 1999;281:558–560.

14. ATS Committee on Proficiency Standards for Clinical Pulmonary. Function Laboratories. ATS statement: Guidelines for the six-minute walk test. Am J Respir Crit Care Med 2002;166:111–117.

15. Di Bari M, Marchionni N, Ferrucci L et al. Heart failure in community-dwelling older persons: Aims, design and adherence rate of the ICARe Dicomano project: An epidemiologic study. J Am Geriatr Soc 1999;47:664–671.

16. Di Bari M, Virgillo A, Matteuzzi D et al. Predictive validity of measures of comorbidity in older community-dwellers. The ICARe Dicomano Study. J Am Geriatr Soc 2006;54:210–216.

17. Folstein MF, Folstein SE, McHugh PR. 'Mini-mental state'. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–198.

18. Yesavage JA, Brink TL, Rose TL et al. Development and validation of a geriatric depression screening scale: A preliminary report. J Psychiatr Res 1982;17:37–49.

19. Salzman SH. The 6-min walk test: Clinical and research role, technique, coding, and reimbursement. Chest 2009;135:1345–1352.

20. Lord SR, Menz HB. Physiologic, psychologic, and health predictors of 6-minute walk performance in older people. Arch Phys Med Rehabil 2002;83:907–911.

21. Guralnik JM, Ferrucci L, Pieper CF et al. Lower extremity function and subsequent disability: Consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci 2000;55A:M221–M231.

22. Al Snih S, Markides KS, Ray L et al. Handgrip strength and mortality in older Mexican Americans. J Am Geriatr Soc 2002;50:1250–1256.

23. Kerr A, Syddall HE, Cooper C et al. Does admission grip strength predict length of stay in hospitalised older patients? Age Ageing 2006;35:82–84.

24. Pahor M, Guralnik JM, Ambrosius WT et al. Effect of structured physical activity on prevention of major mobility disability in older adults: The LIFE study randomized clinical trial. JAMA 2014;311:2387–2396.

25. Cruz-Jentoft AJ, Baeyens JP, Bauer JM et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European working group on sarcopenia in older people. Age Ageing 2010;39:412–423.

26. Cesari M, Onder G, Zamboni V et al. Physical function and self-rated health status as predictors of mortality. BMC Geriatr 2008;8:34.

27. Sayer AA, Syddall HE, Martin HJ et al. Falls, sarcopenia, and growth in early life: Findings from the Hertfordshire cohort study. Am J Epidemiol 2006;164:665–671.

28. Kvelde T, McVeigh C, Toson B et al. Depressive symptomatology as a risk factor for falls in older people: Systematic review and meta-analysis. J Am Geriatr Soc 2013;61:694–706.

Author Query Form

Dear Author,
During the copy-editing of your paper, the following queries arose. Please respond to these by marking up your proofs with the necessary changes/additions. Please write your answers on the query sheet if there is insufficient space on the page proofs. Please write clearly and follow the conventions shown on the attached corrections sheet. If returning the proof by fax do not write too close to the paper's edge. Please remember that illegible mark-ups may delay publication.
Many thanks for your assistance.

Query reference	Query	Remarks
1	**AUTHOR: Please check that authors and their affiliations are correct.**	
2	**AUTHOR: Please confirm that given names (red) and surnames/family names (green) have been identified correctly.**	