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Physical Impairment and Disability: Relationship to Performance of Activities of Daily Living in Community-Dwelling Older Men

Background and Purpose. The decline of physical function of older adults, associated with loss of independent living status, is a major public health concern. The purpose of this study was to examine the relationship of physical impairment and disability to performance of activities of daily living (ADL) among community-dwelling older adults. **Subjects and Methods.** Eighty-three community-dwelling older men who were referred to a comprehensive outpatient geriatric evaluation program (mean age=75.5 years, SD=7.0, range=64–97) were examined. Measurements of physical impairment (muscle force production, flexibility, and fitness) and physical disability (gait speed, stride length, risk for recurrent falls, and physical function) were recorded. **Results.** A stepwise linear regression was used to determine the relationship of physical impairments and disability measures with ADL. The results indicated that walking speed, fall risk, and muscle force contributed independently to the characterization of the activities of daily living of the community-dwelling older men studied (adjusted R^2=.68; F=56.81; df=3,80; $P<.001$). Using a principal components factor analysis, 4 domains were identified that explained 68.2% of the variance in performance of ADL: (1) mobility/fall risk=26.5%, (2) coordination=15%, (3) fitness=14.7%, and (4) flexibility=12.0%. **Discussion and Conclusion.** The identification of domains of physical function may be useful to physical therapists in the development of interventions targeted for physical impairments and disabilities that contribute to deficits in performance of ADL. Targeting interventions for physical impairments and disabilities related to function may improve the effectiveness of physical therapist interventions and reduce the loss of independence among community-dwelling older people. [Brach JS, VanSwearingen JM. Physical impairment and disability: relationship to performance of activities of daily living in community-dwelling older men. *Phys Ther*. 2002;82:752–761.]

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Function and disability are essential parts of the examination of older people.[1] Unrecognized physical impairments and disabilities can often lead to a loss of independence in community dwelling,[2] an increased use of support services,[3] institutionalization,[4] and mortality.[5,6] The process of increasing impairment and disability may be altered by interventions[7]; thus, the potential exists to delay dependency and increase active life expectancy among older people.[8]

Based on the definitions in the World Health Organization's (WHO's) *International Classification of Impairments, Disabilities, and Handicaps* (ICIDH),[9,10] a number of impairments (eg, limited range of motion, reduced muscle force) and disabilities (eg, falling, difficulty walking) in older people have been described. Either individually or in combination, the impairments and disabilities have been assumed to be contributing factors to a decline in health (even death) and function and to the loss of independence. For some impairments and disabilities, a relationship has been demonstrated.*,[12–15]

Function has been the focus of investigators[1,16,17] who have attempted to identify community-dwelling older people who are at risk for losing independence. Establishing guidelines and identifying interventions to alter the risk or to provide public health services to manage increasing dependence has also been a focus of researchers.[16,17] *Physical function* relates to the ability to perform activities of daily living (ADL), instrumental activities of daily living, and mobility tasks important for independent living without substantial risk of injury.[18]

Understanding the relationship of physical impairments and disabilities to physical function of community-dwelling older adults may increase the ability to identify older adults who are at risk for loss of independence and may help streamline the process of functional assessment. Identifying physical impairments and disability associated with physical capabilities may be useful in

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* The terms "impairment" and "disability" are used in this report as described in the WHO's 1980 ICIDH process of disablement scheme.[9] *Impairment* refers to any physiologic or anatomic abnormalities at the organ or tissue system level (eg, muscle weakness). *Disabilities* are person-level problems or the inability to perform any of the activities considered usual for a human being (eg, limitations in walking, limited ability to communicate). In the 2001 version of the scheme, *ICF: International Classification of Functioning, Disability, and Health,*[11] impairments would be considered problems in "body functions and structure," and disabilities would be considered "activity limitations and participation restrictions."

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developing interventions that can be tailored to specific impairments and disabilities. The purpose of our study was to examine the relationship of physical impairment and disability to physical function in community-dwelling older adults (≥60 years of age). We expected 4 domains (eg, a practical or meaningful set of related physiological functions, actions, or tasks[11]) in physical impairment and disability to contribute to function in a manner consistent with independent community-dwelling living status: (1) mobility/fall risk, (2) muscle force, (3) coordination, and (4) general fitness.

Method

Subjects

Participants in our study were male veterans referred to the Geriatric Evaluation and Management (GEM) program of the Pittsburgh University Drive Veterans Affairs Medical Center (UDVAMC), Pittsburgh, Pa, for examination. The GEM program is an interdisciplinary team approach to the examination and management of community-dwelling older veterans (≥60 years of age). The target population of veterans for the GEM program has been community-dwelling older veterans who are having difficulty in managing the daily activities and responsibilities of living in the community. Nonambulatory older veterans and older veterans with severe dementia or acute terminal illness are generally not seen by the GEM team, because the benefits of the GEM appear to be minimal for these groups.[19] Veterans were referred primarily by health care professionals (eg, primary care physician, nurse, pharmacist, social worker) who were participating in the veterans' care. Referrals were based on the clinical opinion of the health care worker.

The geriatric nurse practitioner on the GEM team screened all referrals using telephone interviews before scheduling. This action excluded veterans with acute or terminal illness or severe dementia.

The study participants were 83 community-dwelling older veterans who were referred to the GEM team for an initial examination from December 1991 through May 1995. To be included in the study, they had to: (1) demonstrate the ability to follow verbal requests for movements or tasks (eg, write a sentence, place a foot on a 15.2-cm [6-in] step in front of a chair while sitting), (2) demonstrate antigravity strength of the ankle dorsiflexor and plantar-flexor muscle groups (eg, show active range of motion [AROM] for dorsiflexion and plantar flexion in the sitting position with the knee partially extended), and (3) ambulate without assistive devices other than a straight cane. All of the veterans included in this study walked a minimum of 6 m. Because of the predominance of men among older veterans, we decided to only include men to create a homogeneous sample. Over the course of the study, 157 veterans were referred to the GEM team for examination; however, 3 veterans were excluded from the study because they were women, and 71 veterans were excluded because they did not meet the inclusion criteria or they were not community-dwelling at the time of the examination. The mean age, height, and weight of the study group were 75.5 years (SD=7.0, range=64–97), 157.1 cm (SD=15.2, range=115.5–191.8), and 81.0 kg (SD=15.4, range=50–125.9), respectively.

Measurements

The physical therapy examination consisted of performance-based measures of physical impairment and disability administered by a physical therapist who was familiar with the measures and the methods. A cross-sectional design was used to study the relationship of physical impairment and disability to physical function. All of the measurements were obtained during the initial physical therapy examination of the subject. The examination occurred during a single session and required approximately 20 minutes to complete. No consistent order was used to obtain the measurements, although the most common order was: Physical Performance Test (PPT)[6]; 15.2-m (50-ft) walk from the PPT, which was simultaneously videotaped for use with the Modified Gait Abnormality Rating Scale (GARS-M)[20]; walking speed; grip force; ankle AROM (measured in sitting position); and the Modified Sitting Step Test (MSST).[21] Participants were provided with rest periods, if requested; otherwise, rest time could occur when the examiner got ready for the next test procedure.

Impairment Measures

Muscle force production (maximal voluntary isometric force of grip). Maximum voluntary grip force was measured using a handheld dynamometer (Jamar grip dynamometer[†]) set on the middle ring setting. Grip force was tested in the dominant hand with the elbow adducted to the side and the forearm flexed to 90 degrees, the position recommended by the American Society of Hand Therapists.[22] The grip force measure was used because of its level of reliability (r=.84 and .81 for left and right grip force, respectively, in women aged 60–90 years [n=50]).[23] Kallman et al,[24] in a study of adults 20 to 90 years of age (n=842; subset of those 60–90 years of age, n=355), found a 6% coefficient of variation for repeated grip force measurements. The grip force measure also was used because it has been shown to have a relationship with the muscle force production of other muscle groups in older adults, with correlation coefficients (r) for grip force and force of .57 to .65 for the elbow flexors, .47 to .51 for the knee extensors, .33 to .56 for the trunk extensors, and .37 to .58 for the trunk

flexors.[25,26] Grip force measured in midlife (men who were in good health and 45–68 years of age) has also been shown to predict walking disability and self-care disability 25 years later.[14]

Flexibility (ankle active range of motion). Bilateral ankle AROM was measured using a biplane goniometer.[†] Participants were seated with the plantar surface of their feet resting on the footplate of the goniometer. The stationary arm of the goniometer was aligned with the longitudinal axis of the lower leg along a line bisecting the lateral malleolus and the fibular head proximally. The stationary arm was held still while the patient plantar flexed or dorsiflexed, moving the footplate. A pilot study of 4 adults aged 64 to 96 years determined the test-retest reliability of the biplanar goniometric measurements of ankle AROM, which were obtained by the physical therapist who was responsible for all of the ankle motion measurements (intraclass correlation coefficients [ICC (2,1)] of .94 for dorsiflexion and .99 for plantar flexion).[27] The value recorded and used in all analyses was the total ankle AROM, defined as the average of the sum of the AROM for plantar flexion and dorsiflexion in both lower extremities. In a previous unpublished study, walking speed and stride length were correlated with isolated ankle dorsiflexion and ankle plantar-flexion AROM and with total ankle AROM among older community-dwelling adults who were frail.[28] We decided to study the total ankle AROM because we believe it provided a broad representation of AROM and reduced the problem of several highly related measures of impairment of flexibility. If variables that are highly correlated are used in regression analyses, the variables can inflate the standard errors and can contribute to inaccuracy and inconsistency if the estimates of the variance explained.

We studied flexibility of the ankle because ankle AROM is used in walking, which avoids the need for the subjects to learn a novel task for testing. In our opinion, ankle flexibility was important in maintaining function in older people because of the relationship of ankle AROM to mobility and to the maintenance of the upright posture and because of the potential for decreases in ankle AROM to place older people at risk for a fall.[29,30]

Fitness (Modified Sitting Step Test). Fitness was determined using an MSST that was adapted from Smith and Gilligan.[21] The MSST is a 5-minute submaximal exercise test that is conducted with the participant seated. The test consists of alternating placement of the feet on the edge of a 15.2-cm (6-in) step at a stepping rate of one step per second for 5 minutes. The test has a reported exercise workload of 8.05 mL $O_2 \cdot kg^{-1} \cdot min^{-1}$ (2.3 meta-

bolic equivalents).[21] We measured heart rate (HR) and blood pressure at the start of exercise, after 5 minutes of exercise, and 2 minutes after exercise. Subjects were excluded from performing the MSST for the following reasons: (1) a resting HR greater than 100 bpm, (2) a resting systolic blood pressure (SBP) greater than 180 mm Hg, or (3) a diastolic blood pressure greater than 95 mm Hg. The test was symptom limited and was terminated if the participant demonstrated any of the following: (1) shortness of breath, (2) fatigue that prevented continuance, (3) an HR greater than 120 bpm, (4) a drop in SBP greater than 10 mm Hg, (5) an SBP greater than 220 mm Hg, or (6) an increase in diastolic blood pressure greater than 10 mm Hg.

Based on their ability to initiate and complete the 5-minute (300-s) MSST and the response to the exercise stimulus, the participants were classified as belonging to 1 of 3 fitness categories: unhealthy, deconditioned, or conditioned.[31,32] Subjects were classified as unhealthy if they were unable to initiate or complete the 5-minute MSST. Based on the rate-pressure product (RPP=HR × SBP) after 5 minutes of exercise and at 2 minutes into recovery, subjects were classified as deconditioned if they completed the 5-minute MSST, but demonstrated an inadequate response to exercise or an inadequate recovery from the short (5-minute) bout of exercise.

An *inadequate response* was defined as failure to achieve an adequate exercise RPP value after 5 minutes; an *adequate exercise RPP* was greater than or equal to 30% of the heart rate reserve (heart rate reserve as determined by the Karvonen equation) multiplied by the sum of the resting SBP plus 20 mm Hg (an estimate of expected rise in SBP with exercise). *Inadequate recovery* was defined as failure to exhibit an RPP at recovery, 2 minutes after exercise, that was less than or equal to the resting RPP plus 50% of the difference between the adequate exercise RPP and the resting RPP (ie, RPP recovery of 50% of the change with exercise). Older people classified in the conditioned category demonstrated the ability to achieve an adequate exercising RPP and the ability to recover to less than or equal to 50% of the change in RPP from rest to exercise at 2 minutes after exercise.

We used the RPP to classify the response to the MSST because the RPP is believed to represent the work of the heart[33] and can be used to quantify the work of the heart even for people taking beta-blockers.[34,35] Heart rate increases are limited by an age-restricted maximum, and the increase is not linear in older people.[36] Systolic blood pressure is only moderately responsive to exercise, but Williams et al[37] suggested that increases in maximum RPP values in older people with cardiac disease after exercise training indicate a greater ability of the heart to function at higher workloads. Because of the restricted

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HR response and modest SBP response of older people, we used the exercise duration (0–300 seconds) and fitness categories based on the RPP values for response to and recovery from exercise during the MSST to describe fitness of the participants.

Reliability of the MSST category classification (for test-retest within 1–6 months: ICC [2,1]=.67, n=20) and construct validity of categories by comparison to physical function status as indicated by the PPT percentile rank has been demonstrated for community-dwelling older men (64–97 years of age, n=73).[38] For statistical analyses, the categories were given numerical codes: 1=unhealthy, 2=deconditioned, 3=conditioned.

Disability Measures

Mobility (gait speed and stride length). Gait characteristics were recorded as described by Cerny[39] in 1983 and previously measured by Wolfson et al.[40] The participants wore permanent markers taped to the back of the heel of the shoe, with the tip of the marker just touching the floor. The floor was covered by a brown paper walkway. Subjects were timed as they completed a 6-m walk at a self-selected pace. To avoid any acceleration or deceleration effects of initiating or stopping the walk, gait speed and stride length were determined from the measurement of the central 3 strides of the walk.

Test-retest reliability (ICC [2,1]=.78, Pearson r=.93, n=199) has been demonstrated in a sample of community-dwelling older people who were over 55 years of age (60% of sample was ≥70 years of age [n=116])[41] and in a different sample of older people with disability (ICC=.79, n=105).[42] Concurrent validity of the use of gait speed as a generalizable measure of the ability to walk in community-dwelling older people is indicated by comparison with stride length, cadence, and double support time (Pearson r=.93 [n=51], .74 [n=51], and .86 [n=49], respectively).[43] The use of gait speed for distinguishing community-dwelling older people who are at risk or not at risk for recurrent falls has been demonstrated with a sensitivity of 72% and a specificity of 74% and with a cutoff score for recognizing fall risk of 0.56 m/s.[44]

Fall risk (Modified Gait Abnormality Rating Scale [GARS-M]). The GARS-M is a 7-item qualitative measure designed to identify abnormalities of gait characteristics of older adults who are at risk for falling.[20] The 7 items of the GARS-M scored are: variability (consistency of stepping and arm movements), guardedness (reduced momentum, as indicated by the relationship of the head, arms, and trunk with the vertical axis of the body during stepping), staggering (stumbling, sudden lateral partial loss of balance), foot contact (position of the heel compared with the forefoot at heel-strike), hip AROM

(angle of the thigh to the vertical axis from the ground during double support), shoulder extension (AROM of the upper arm during arm swing), and arm–heel-strike synchrony (degree to which contralateral arm and leg movements are coordinated).

The GARS-M was scored by a rater (physical therapist) who viewed a videotaped recording of the participant walking at a self-selected speed on a smooth tile surface. The videotape of gait usually consisted of the participant walking 7.6 m (25 ft) in one direction, turning, and walking 7.6 m to return to the starting point. Scoring the GARS-M from videotape allowed for repeated playback and slow- or stop-action viewing of the walk. The 7 items of the GARS-M are scored on a 4-point scale (0–3), with higher scores representing poorer performance. The total score of the GARS-M ranges from 0 to 21, with higher scores indicating greater gait abnormality and risk for falling.[44]

The GARS-M has been tested on community-dwelling older adults who are frail, with a demonstrated interrater reliability (K) of .968 and intrarater reliability (K) of .967, concurrent validity by comparison with temporal and spatial gait characteristics (ie, walking speed and stride length), and construct validity for distinguishing older adults who do not have a history of recurrent falls. Sensitivity (62.3%) and specificity (87.1%) for recurrent fall risk have been determined for community-dwelling older men (64–96 years of age), including a cutoff score of 9 for recurrent fall risk.[44]

Measure of Physical Function

Physical Performance Test (PPT). Physical function was measured using the 7-item PPT, a test of usual daily activities, including both basic and instrumental activities of daily living.[6] The 7 items are: writing a sentence, simulating eating, lifting a book, donning and doffing a jacket, picking up a penny, turning 360 degrees, and walking 15.2 m (50 ft). The PPT is an objective, quantified assessment of function involving little or no judgments by the rater.

Each of the 7 items of the PPT has levels of performance scored from 0 to 4 based on completion of the task and the time for completion. The older people were asked to perform the tasks at their usual pace and were not encouraged to hurry during testing. For example, "pick up a penny from the floor" is scored based on the time it takes to bend over from a standing position, pick up a penny off the floor, return to a standing position, and place the penny on a table. The scoring is as follows: 0=unable, 1=greater than 6 seconds, 2=4.5–6 seconds, 3=2.5–4 seconds, 4=less than or equal to 2 seconds. The individual item scores are added for a total score

(range=0–28), with higher scores representing better performance.[6]

Interrater reliability, validity by comparison with accepted functional status assessments (self-report and performance-based measures of ADL and instrumental activities of daily living and measures of mobility and balance),[6] and predictive validity for institutionalization or mortality have been demonstrated.[45] The PPT was designed and tested for community-dwelling older people. Percentile scores for the PPT (indicating the distribution of PPT scores for community-dwelling older adults) have been defined and can be used for comparison with scores of a sample of the population of community-dwelling older adults.[6]

Data Analysis

Descriptive statistics were calculated to determine the mean and distribution of values for each of the measures. Recorded measurements were converted to standardized scores (z scores) for use in the regression and factor analyses to accommodate the different scales used by the measures (eg, ordinal, categorical). The converted scores allow for direct comparisons between groups of measures because the converted z scores all have the same mean (0) and standard deviation (1).[46]

Stepwise linear regression, controlling for age, was used to determine the relationship of physical impairment and disability measures with physical function (ie, as measured using the PPT). To reduce the problem of multicollinearity of the variables, bivariate correlations were used to identify impairment and disability variables that were highly correlated with other measures in the set. The fitness category (ie, unhealthy, deconditioned, or conditioned) derived from the MSST was highly correlated ($r=.78$) with exercise duration, and stride length was highly correlated with gait speed ($r=.90$); therefore, only the exercise duration and gait speed variables were used in the regression to represent fitness and gait respectively. To control for the effects of age on physical function, as measured using the PPT, age was entered into the model before the other variables. The impairment and disability measures were entered into the regression equation as follows:

$$PPT = age + grip\ force + ankle\ AROM$$
$$+ exercise\ duration + gait\ speed + GARS\text{-}M$$

The criteria for entry into and removal from the regression equation were: $\alpha=.05$ to enter and $\alpha=.10$ to remove. To control for multicollinearity, all variables were submitted to a tolerance criterion of 0.0001 to be entered in the equation, and no variable was entered if its entry into the model would reduce another variable's

Table 1.
Summary of Impairment and Disability Measures[a]

	X̄	SD	Range
Impairment[b]			
Ankle AROM (°)[c]	39.8	9.6	14.2–61.7
Left	38.8	11.3	11.3–59.3
Right	40.6	9.2	15.3–65.0
Grip force (kg)	47.9	23.5	11–109
Exercise duration (s)[d]	209.7	121.2	0–300
Disability			
Gait speed (m/s)	0.60	0.27	0.07–1.41
Stride length (m)	0.89	0.26	0.34–1.50
GARS-M	7.3	5.2	0–18
Measure of physical function			
7-item PPT	14.3	5.1	3–25

[a] AROM=active range of motion, GARS-M=Modified Gait Abnormality Rating Scale, PPT=Physical Performance Test, MSST=Modified Sitting Step Test.
[b] Includes fitness category based on performance on the MSST: 1=unhealthy (n=34 [41% of the sample]), 2=deconditioned (n=31 [37%]), and 3=conditioned (n=18 [22%]).
[c] Ankle AROM=sum of AROM for dorsiflexion and plantar flexion bilaterally/2.
[d] Exercise duration=time (in seconds) of the 5-minute MSST completed, 0–300 s possible.

tolerance below the tolerance criterion of 0.0001.[47] The residuals of the regression analysis were also checked to test linear model assumptions of normal distribution and homoscedasticity.[46]

To confirm the 4 primary domains in physical function (mobility/fall-risk, force, coordination, and fitness), the impairment measures (grip force, ankle AROM, fitness, and exercise duration), measures that could reflect on disability (gait speed, stride length, and GARS-M scores), and individual PPT items reflecting performance of ADL tasks were submitted to a principal components factor analysis (PCFA). We expected that the individual PPT items and the impairments and disabilities would load on 4 factors representing the major domains of physical function we proposed that are consistent with independent community-dwelling living: mobility/fall risk, force, coordination, and fitness. We defined *coordination* (not obviously represented by the impairment and disability measures unlike the other domains) as a motor skill or the ability to perform goal-directed, well-learned movements with optimal speed, range, and accuracy.[48] Among community-dwelling older people, we considered the multistep individual item tasks of the PPT (writing a sentence, simulating eating, lifting a book to a shelf) to be skilled motor acts that would load on the factor representing coordination. The PCFA was calculated with an eigenvalue of 1 and a varimax rotation of the component loadings.[47]

Results

Descriptive statistics for the impairment and disability measures are displayed in Table 1. Given a usual adult

Table 2.
Stepwise Linear Regression of Physical Impairment and Disability Variables on Physical Function

Variable	R	Change in R^2	P (of Change)	Adjusted R^2	P
Age[a]	.21	.05	<.06	.03	<.06
Gait speed	.77	.55	<.01	.58	<.01
GARS-M[b]	.82	.07	<.01	.65	<.01
Grip force	.83	.03	<.02	.68	<.02

[a] Age was not an independent predictor of physical function, but is shown because age was entered first to control for the effect of age in the regression equation.
[b] GARS-M=Modified Gait Abnormality Rating Scale.

Table 3.
Percentage of Total Variance Explained by Rotated Factor Loadings of the Principal Components Factor Analysis

| | Factor | | | |
	Mobility/ Fall Risk	Coordination	Fitness	Flexibility
% total variance	26.5	15.0	14.7	12.0
Latent roots	3.71	2.10	2.06	1.69

Table 4.
Principal Component Factor Analysis: Rotated Factor Loadings[a]

Variable	Mobility/ Fall Risk	Coordination	Fitness	Flexibility
Gait speed	**.81**	−.11	.10	.34
Stride length	**.78**	−.16	.11	.43
Walking 15.2 m (50 ft)[b]	**−.81**	.17	−.26	−.18
GARS-M	**−.61**	.18	−.37	−.42
Picking up a penny[b]	**−.76**	.19	.00	.23
Turn 360°[b]	**.72**	−.01	.14	.00
Exercise duration	.27	−.13	**.87**	.01
Fitness	.19	−.11	**.90**	.00
Donning and doffing a jacket[b]	−.13	.32	−.23	**−.56**
Ankle AROM	.20	.01	−.01	**.78**
Writing a sentence[b]	−.18	**.67**	.00	−.19
Simulating eating[b]	−.26	**.73**	−.27	−.11
Lifting book to a shelf[b]	.01	**.80**	−.11	.01
Grip force	.25	**−.46**	−.31	−.38

[a] GARS-M=Modified Gait Abnormality Rating Scale, AROM=active range of motion. Boldfaced numbers indicate the variables that "loaded" (contributed) predominantly to the domain identified in the column heading.
[b] Item of the 7-item Physical Performance Test (PPT).

walking speed of 1.2 to 1.3 m/s,[49,50] the participants in this study walked slowly (mean gait speed=0.60 m/s). The GARS-M mean score of 7.3 was close to the cutoff score of 9 for risk for recurrent falls.[44] Based on the average score on the 7-item PPT, the participants would rank in the 25th percentile of physical performance.[6] That is, 75% of community-dwelling older adults would be better at performing the ADL tasks than the community-dwelling older adults we studied.

Relationship of Physical Impairment and Disability to Physical Function
Stepwise linear regression analysis—with age, grip force, ankle AROM, exercise duration, gait speed, and fall risk entered into the equation for physical function as measured using the PPT—indicated that only gait speed, fall risk, and grip force were independently related to physical function (Tab. 2). The impairment and disability variables described 68% of the phenomena of physical function (adjusted R^2=.68; df=3,80; P<.001). Indicators of multicollinearity—such as a fairly large R^2 with insignificant coefficients, marked changes in regression coefficient with addition or deletion of variables from the equation, and unexpected signs (+ or −) of the coefficients—were not observed. Analysis of the residuals indicated that the linear model assumptions were met: (1) the distribution of the standardized residuals was nearly normal, and (2) the plot of the standardized residuals against the predicted values demonstrated that most scores were located close to the predicted regression line.[46]

Describing Domains of Physical Function
Four domains that explained 68.2% of the total variance in physical function were identified using PCFA. The 4 domains identified represent mobility/fall risk (26.5%), coordination (15%), fitness (14.7%), and flexibility (12%) (Tabs. 3 and 4), which confirmed 3 of the expected domains of physical impairment and disability associated with physical function and the inclusion of flexibility instead of the expected domain of force as 1 of the 4 domains.

The 6 variables representing the mobility/fall risk domain were: gait speed, stride length, GARS-M score, and 3 items from the PPT (picking up a penny, turning around, and the time to walk 15.2 m). The first 3 variables are related to gait and fall risk. The 3 items from the PPT include components of balance and mobility in performing the tasks.

Coordination, the second domain, was represented by the expected 3 multistep items from the PPT (writing a

sentence, simulating eating, and placing a book on a shelf) and also by the grip force measure. The grip force measure loaded on this domain but with a lower score (.46) than the loadings for the other variables contributing to this domain (.67, .73, .80).

The third domain, fitness, similar to the coordination domain, explained nearly 15% of the variance in physical function. The fitness domain was represented by the 2 variables (exercise duration and fitness category) measured during the MSST, which is a measure of a person's fitness level.

The fourth domain, flexibility, was represented by the impairment variable ankle AROM and 1 item from the PPT (donning and doffing a jacket). The donning and doffing a jacket task of the PPT was most associated with the flexibility domain (factor loading=.56); however, the variable also was associated with the coordination domain (factor loading=.32).

Discussion and Conclusion

The results of the regression analysis indicate that measures of gait speed, fall risk, and grip force identified a large component of physical function as measured using the PPT among community-dwelling, older adults. The contribution of mobility to physical function is similar to the findings of Guralnik and colleagues,[17,51] who studied the prediction of future disability among community-dwelling older adults without disability. It may be important to develop interventions for mobility to reduce future disability among older adults; however, the benefits of such interventions would need to be determined in randomized clinical trials.

Grip force was found to independently contribute to the physical function of the older adults. Similarly, previous investigators[14] who were interested in the association of muscle force and physical function found grip force at midlife in men without impairments predicted physical disability 25 years later. Grip force has been considered to represent overall muscle force because of a positive correlation with muscle force production of many other muscle groups.[25] Other investigators[14] contend, as we also do, that the existence of an association between muscle force and physical function in older adults can be supported by research findings. Low grip force may indicate a need to strengthen specific weak muscle groups; however, other authors argue that grip force is an indicator of physical activity[52] and vitality, both of which may relate to good physical function.[14]

We identified 4 domains of physical function—mobility/fall risk, coordination, fitness, and flexibility—representing the overlapping and unique contribution of measures of impairment, disability, and ADL tasks. The flexibility domain was an addition to the physical function domains that we expected. Although we assumed flexibility to be an inherent component of mobility, fitness, and coordination, the findings demonstrate the importance of flexibility as an independent contributor to the description of physical function.

The flexibility domain was represented by ankle AROM and the ADL task of donning and doffing a jacket. People with limited shoulder AROM often have difficulty donning and doffing a jacket in the amount of time people without impairments would use to complete the activity; therefore, it is not surprising to have this variable load on the flexibility domain. Unlike the impairment variables for ankle AROM, the disability-level variable of donning and doffing a jacket contributed to the flexibility domain, but to a lesser degree to the coordination domain as well. The complexity of ADL tasks in everyday life, such as donning and doffing a jacket, can be captured by the factor analysis method, which accounts for contributions of a variable to more than one factor[53] associated with a single construct such as physical function. The pattern of factor loadings for donning and doffing a jacket suggests that, for this sample of older men, flexibility was a predominant factor in performing the task, whereas the motor skills necessary for multistep tasks were also important components for success.

Muscle force, represented by the grip force measure, was not identified as a domain contributing to physical function as we expected; instead, grip force contributed as a component of coordination. Perhaps grip force co-loaded with the items representing the coordination domain because grip force shared the common theme of upper-extremity function with the 3 PPT items. Grip force may also have co-loaded with the coordination domain because the participants may have perceived the task to be more complex than the one-step task of gripping the handheld dynamometer. Participants were asked (and shown how) to position their arm at their side, grasp the dynamometer, and squeeze the dynamometer in their hand while maintaining the arm position. The grip force task most likely represented a novel task for the older veterans, further adding to the complexity of task performance. Thus, grip force as performed in this study may not solely represent muscle force performance.

Although the measures we studied contributed to a majority of the variance in physical function as measured using the PPT, 32% of the variance in physical function was not accounted for by our factors. Cognitive function is one component of all performance that was not captured directly by the variables in this study. Carlson et al[54] demonstrated that cognitive processing speed is an independent predictor of physical function. After

controlling for age and number of medications, which together explained 33% of the variance in physical function, they found that cognitive processing speed explained an additional 5% of the variance in physical function.[54] Adding age and measures of health and cognitive function to our list of variables for the PCFA might have accounted for an even greater portion of the variance in physical function.

The 4 domains representing 68.2% of the variance in physical function indicate important physical impairments and disabilities of community-dwelling older people that need to be assessed during the examination. The domains could be used as a guide to selecting measures for the assessment of the physical function of older people. The description of deficits gains from the assessment could be used to develop interventions especially targeted for deficits in the domains in which performance is deemed inadequate for independence in community dwelling. For example, if an older person demonstrated deficits in the domain of fitness and little or no deficit in the mobility/fall-risk domain, then the indicated intervention might be a progressive conditioning program of aerobic exercise that would target the reduced tolerance for physical activity. Relevant outcome measures would be similarly identified based on the domain in which the deficit occurs (fitness) and the general goal of intervention (the improvement of physical function). The benefits of such an approach, targeting interventions for deficits in specific domains to improve physical function and to reduce or prevent decline is only an assumption and will require randomized clinical trials to demonstrate the usefulness of this approach.

Physical function in ADL tasks has been shown to be a strong predictor of mortality, long-term institutionalization, or dependence.[55–59] The identification of domains of physical function and the criteria for recognizing deficits in specific domains may be useful for physical therapists in the development of interventions to improve the physical function status of older adults.

We identified the domains of physical function in a sample of community-dwelling, older men who demonstrated mobility and physical function deficits (slow mean gait speed and a mean PPT score below the 25th percentile for community-dwelling older people). Physical impairments and disabilities contributed to 4 domains of physical function that described a large proportion of the physical function in the community-dwelling older men we studied. The domains may provide therapists with information to develop interventions or prevention strategies for specific physical impairments and disabilities. This could improve clinical outcomes and cost-effectiveness of health services, including improved physical function and reduced loss of independence for community-dwelling older people. Because our study was correlational in nature, however, future research would be need to determine whether these benefits could be achieved.

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