Disability and Depression: Investigating a Complex Relation Using Physical Performance Measures

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Objective: *The objective of this study was to examine the relation of physical performance measures with depressive symptoms in older men.* **Method:** *A cross-sectional, multivariate comparison of several measures of upper- and lower-extremity performance and their relation with depressive symptoms was performed in 2,856 older Japanese American men, aged 71–93 years, who participated in the fourth examination of the Honolulu Heart Program. Depressive symptoms were measured using an 11-item version of Center for Epidemiologic Studies Depression (CES-D) Scale. A score of at least 9 (from a maximum score of 33) is considered clinically significant. Timed functional performance tests, including walking and repeated chair stands, were used to assess lower-extremity performance; handgrip strength was used as an indicator of upper-extremity performance.* **Results:** *Two hundred eighty-three participants (9.9%) had a score of 9 or greater on the 11-question CES-D Scale and were considered to be at high risk for depression. Time to walk 10 feet and time to complete five chair stands were significantly longer in those with depressive symptoms, whereas handgrip strength was significantly lower. Only the association of gait speed (time to walk 10 feet) and depressive symptoms remained significant when all physical performance measures were simultaneously included in a multivariate analysis.* **Conclusion:** *These results demonstrate physical performance measures, particularly gait speed, may be important potential correlates of depression in community-dwelling older men.* (Am J Geriatr Psychiatry 2006; 14:1060–1068)

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The NIH Consensus Development Panel on Depression in Late Life[1] and the World Health Organization[2] both identified depression as a leading cause of disability at older ages. Depression may amplify the morbidity of disability, pain, fatigue, drug side effects, and malnutrition as well as increase the utilization of health services.[3–6] Depression also increases risk for mortality in community-dwelling elderly persons,[7,8] particularly in depressed elderly persons with coronary heart disease.[9] The antecedents of depression in the elderly are multifactorial, but physical disability appears to be an important correlate. Physical disability may induce depression because of loss of independence and social function. On the other hand, depression may induce physical disability by reducing motivation for physical activity and subsequent deconditioning in older persons.

Using time-series analysis, Koenig[10] found that depression and disability tended to track together in older hospitalized persons. Which is more important in driving the other in this complex relation is not known. Time-series analysis failed to demonstrate a predominant causal effect for either depression or disability in older persons who were depressed after hospitalization, suggesting that neither depression nor physical disability exerts a primary role in fostering this relationship. In an attempt to determine which particular demographic, psychosocial, psychiatric, and physical health characteristics of patients at baseline predicted this relation, Koenig found that only three baseline characteristics significantly predicted depression–disability outcomes: race, history of depression, and stressful life events.

More work needs to be done on which particular factors are the strongest predictors of the depression–disability relation as well as the organic basis for this relation. This is likely to be complicated and multifactorial. For example, the association of chronic vessel disease in small penetrating arteries that supply cerebral white matter in the frontal lobe with both depression and lower-extremity dysfunction suggests a potential cardiovascular link. Consistent with this hypothesis, positive associations with inflammatory markers such as platelet-activating factor and homocysteine, in contrast to negative associations with cardioprotective omega-3 fatty acids, have been reported with both depression and disability.[11,12] Serotonin-mediated platelet reactivity has also been proposed as a link between vascular disease as a cause of both disability and depression through damage to frontal cerebral tissue.[13]

The aforementioned multifactorial aspects of depression and disability illustrate the complexity of the relation and the potential for studying this relation with multiple tools and on multiple levels. New measures and analytic strategies that help capture this complexity are needed. Bruce[14] identified several potential strategies, including studying potentially related physical components of disability and depression. Therefore, to better understand the physical components of disability and their relation to depression, we used timed physical performance measures of upper and lower body function.

Physical performance measures that test either upper or lower body function are generally conceptualized as indicative of underlying physical capacity. For example, grip strength is indicative of upper body strength. The correlation between self-report and performance measures tends to be less than ideal, and physical performance measures are a more objective and accurate means of capturing functional capacity. Performance tests are rarely pure indicators of underlying physical capacity, however, and are affected by cognitive, psychologic, and social factors, including depression.

Although there have been several studies that have investigated the association of physical performance measures with depression, this area is not well understood. Rantanen et al.,[15] in a three-year follow-up study of 2,275 men with average age of 77.1 years at baseline, demonstrated that depression at baseline was associated with a steep decline in handgrip strength, particularly in those with low body weight. Depressed mood, in combination with low body weight, may be an indicator of frailty or disease status that leads to accelerated strength loss and disability. Penninx et al.[16] performed a four-year prospective cohort study of 1,286 community-dwelling older persons and demonstrated that increasing levels of depressive symptoms were predictive of decline in lower-extremity performance as assessed by standing balance, timed 8-foot walk, and timed chair stands. Thus, although some studies have used measures of upper or lower body function, there is little information on the relative contribution of the different measures of upper-extremity performance and lower-extremity performance to depression, particularly with large studies using multivariate models. Although performance measures can be tedious and time-consuming for researchers, healthcare professionals and patients, or study subjects, understanding more about the components of disability that affect depression is vital for designing new interventions to help identify, prevent, and treat depression in the elderly.[14]

The present cross-sectional investigation was performed among older Japanese-American men in the Honolulu Heart Program and compared the relative associations of upper-extremity performance, as indicated by handgrip strength, and lower-extremity performance, indicated by time to walk 10 feet (gait speed) and time to complete five chair stands, as well as general physical activity level, with depressive symptoms. These are measures of physical performance with promising potential for understanding the physical components of disability and its link to depression.

METHODS

Sample

The Honolulu Heart Program is a longitudinal study of coronary heart disease and stroke in Japanese-American men.[17] Participants in the study are men of Japanese ancestry living on the island of Oahu, HI, in 1965 and who were between the ages of 45 and 68 years at baseline (i.e., born between 1900 and 1919). A total of 8,006 men participated in the baseline examination, which took place from 1965 to 1968, and three subsequent complete examinations occurred in 1968–1970, 1971–1975, and 1991–1993. For the purposes of this study, the fourth examination is used. Briefly, from 1991–1993, the surviving men, ranging in age from 71–93 years (mean age: 77.8 ± 4.7 years), were invited to participate in a fourth physical and psychosocial examination. Letters of invitation requesting that they schedule an appointment were sent to participants. Response rate to the request was 80% (including clinic, home, and nursing home visits; $N = 3{,}741$). Information on chronic health conditions, medications, lifestyle, functional status, diet, and numerous other conditions was obtained from questionnaires and physical examination.

Depressive Symptoms

Participants were screened for depressive symptoms by using an 11-question version of the Centers for Epidemiologic Studies Depression (CES-D) Scale questionnaire with scores ranging from 0–33.[8,15] The standard CES-D Scale uses a cutoff score of 16 points for depressive symptoms.[18] In this 11-question version, however, a score of 9 or greater was used. This shortened version has shown to be a valid measure of risk for depression in the older population.[19] For convenience, we refer to presence of depressive symptoms as "depression" or "depressed." Although the CES-D scale indicates risk for depression, it does not diagnose depression and our use of these terms is not synonymous with clinical depression. Participants who did not answer three or more of the 11 depression questions, those who had impaired cognitive function, or those who used antidepressant medications were excluded from this analysis, leaving 2,856 participants to be studied. Cognitive function was measured with the Cognitive Abilities Screening Instrument (CASI),[20] which was developed for crosscultural studies of dementia. A score on the CASI of less than 74 defined cognitive impairment.

Lower-Extremity Performance

Lower-extremity performance was assessed by the participant's ability to perform two timed 10-foot walks at his usual pace and the time required for the participant to rise from a chair five times. Both timed walk and chair stands were measured in whole seconds, and the participant was assigned to the group corresponding to the closest second. The average of the two timed walks was used for purposes of analysis and walking speed was calculated in meters per second. For the chair-rise task, the participant was asked to quickly perform five chair stands without using his arms for support. If the participant could perform five chair stands successfully, then the number of seconds necessary to perform the task was recorded.

Upper-Extremity Performance

A handgrip dynamometer was used to assess upper-extremity performance. If the participant had a recent worsening of pain or arthritis in his wrist, reported having tendonitis, or had surgery on his hand or arms during the last three months, the task was not performed. The participant first executed three maximal squeezes with the dynamometer using his dominant hand followed by three maximal squeezes using his nondominant hand. The best performance overall using the dominant hand, recorded as strength in kilograms, was used for analysis.

Physical Activity Measures

Physical activity was measured using the physical activity index (PAI). This index is based on self-reported time spent in performing various activities with intensities ranging from completely sedentary to heavy, similar to the method used in the Framingham[21] and Puerto Rico[22] studies. The score is a sum of hours spent per day for these activities using a weight of 5 for heavy activities (e.g., lifting or shoveling), 2.4 for moderate activities (e.g., carpentry or gardening), 1.5 for slight activities (e.g., casual walking), 1.1 for sedentary activities (e.g., sitting or standing), and 1.0 for basal condition (e.g., sleeping or reclining). This index is a reliable and valid indicator of overall energy expenditure in middle-aged and older people.[23]

Also, the participants were asked how many blocks they walked each day. We converted blocks walked each day into distance (miles) as 12 blocks were equal to one mile.

Other Variables

The presence of multiple chronic conditions was determined by surveillance, self-reported history, medication status, and physiological measurements. Stroke or cancer diagnosis was based on hospital record surveillance and questionnaire data. Coronary heart disease was verified on the basis of hospital record surveillance, electrocardiographic findings, and questionnaire data.[24] Diabetes was ascertained by asking subjects if they had a diagnosis of diabetes or if they used insulin or pills for diabetes and by a two-hour glucose tolerance test using the World Health Organization classification.[25]

Body mass index was defined as weight in kilograms divided by height in meters squared. Alcohol intake (ounces per month) was estimated based on the usual frequency of consumption of beer, wine, sake, and hard liquor. For both current and former smokers, values for cigarette pack-years were calculated by multiplying the average number of cigarettes smoked per day and the number of years smoked. Marital status was described using a dichotomous variable (1: married; 2: widowed, divorced, or unmarried).

Statistical Analysis

Participants were divided into two groups on the basis of presence or absence of depressive symptoms as previously defined. Means of various characteristics were compared in these two groups by using two-sample t tests for continuous variables and chi-squared tests for categorical variables.

Means of depression score according to categorized groups of lower- and upper-extremity performance were compared by using a one-way analysis of variance. Odds ratios and 95% confidence intervals, according to categorized groups of lower- and upper-extremity performance for depressive symptoms, were computed using multiple logistic regression models.

RESULTS

A comparison of various characteristics between elderly participants with and without depressive symptoms is shown in Table 1. A total of 283 participants (9.9%) had a score of 9 or greater on the 11-question CES-D Scale and were considered depressed.

Those considered depressed were significantly less likely to be married and had a lower body mass index. Time to walk 10 feet (gait speed) and time to complete five chair stands were longer, whereas handgrip strength was significantly lower in the depressed than nondepressed group. Those considered depressed had significantly lower physical activity index and distance of walking each day. The associations with age, education, cigarette consumption, alcohol consumption, and the prevalence of coronary heart disease, stroke, cancer, and diabetes were not significant.

To analyze the effects of lower- and upper-extremity performance on depression score, all variables

TABLE 1. Comparison of Characteristics Between Elderly Participants With and Without Depression

Characteristics	Depressed (N = 283)	Not Depressed (N = 2,573)	$t_{[df]}$[a]	p
Age (years)	76.99 ± 3.97	76.83 ± 3.95	$0.66_{[2854]}$	0.510
Education (years)	11.1 ± 3.09	10.92 ± 3.1	$0.90_{[2854]}$	0.369
Cigarette consumption (pack-years)	27.4 ± 35.47	26.34 ± 34.59	$0.48_{[2810]}$	0.629
Alcohol consumption (ounces/month)	21 ± 44.1	18.32 ± 38.73	$1.08_{[2812]}$	0.278
Body mass index (kg/m^2)	23.15 ± 2.96	23.69 ± 3.07	$-2.82_{[2850]}$	0.005
Time to walk 10 feet (seconds)	4.4 ± 3.36	3.77 ± 1.28	$6.25_{[2852]}$	0.000
Gait speed (meters/second)	1.44 ± 1.10	1.24 ± 0.42	$6.25_{[2852]}$	0.000
Time to complete five chair stands (seconds)	11.79 ± 3.62	11.33 ± 3.49	$2.01_{[2794]}$	0.044
Handgrip strength (kg)	30.48 ± 6.4	31.54 ± 5.94	$-2.82_{[2850]}$	0.005
Physical activity index (hours/day)	30.54 ± 4.33	31.27 ± 4.68	$-2.52_{[2848]}$	0.012
Distance of walking each day (miles)	1.04 ± 1.27	1.25 ± 1.38	$-2.37_{[2778]}$	0.018
Married (%)	0.77 ± 0.42	0.85 ± 0.36	$-3.37_{[2852]}$	0.001
Prevalent coronary heart disease (%)	0.22 ± 0.42	0.19 ± 0.39	$1.52_{[2854]}$	0.129
Prevalent stroke (%)	0.04 ± 0.2	0.02 ± 0.15	$1.79_{[2854]}$	0.074
Prevalent cancer (%)	0.17 ± 0.38	0.13 ± 0.33	$1.95_{[2854]}$	0.051
Prevalent diabetes mellitus (%)	0.28 ± 0.45	0.29 ± 0.45	$-0.54_{[2854]}$	0.586

[a]$t_{[df]}$ is the t value of a two-sided Student's t test and df is the degrees of freedom of the t test.

were analyzed in their continuous form. For presentation purposes, participants were divided into three groups for time to walk 10 feet (measured in whole seconds), four groups for time to complete five chair stands (measured in whole seconds), and four groups for handgrip strength (measured in kilograms) based on the distribution of each performance variable. The range and the proportion of participants in each performance classification are as follows: *time to walk 10 feet (gait speed):* 2 or 3 seconds (1.52 or 1.01 m/sec), 47.6%; 4 seconds (0.76 m/sec), 33.8%; and ≥5 seconds (≤0.61 m/sec), 18.6%. *Time to complete five chair stands:* 4–9 seconds, 30.0%; 10 or 11 seconds, 26.7%; 12–14 seconds, 27.9%; and ≥15 seconds, 15.4%. *Handgrip strength*: 0–27.9 kg, 25.1%; 28.0–31.9 kg, 26.1%; 32.0–35.9 kg, 24.4%; and 36.0–55.9 kg, 24.4%.

The strata cut points appear somewhat asymmetric because the subject scores were highly skewed when divided into quartiles or quintiles. For example, gait speed was measured in 1-second intervals with the majority of subjects falling into the 2- or 3-second category (for 10-foot walk).

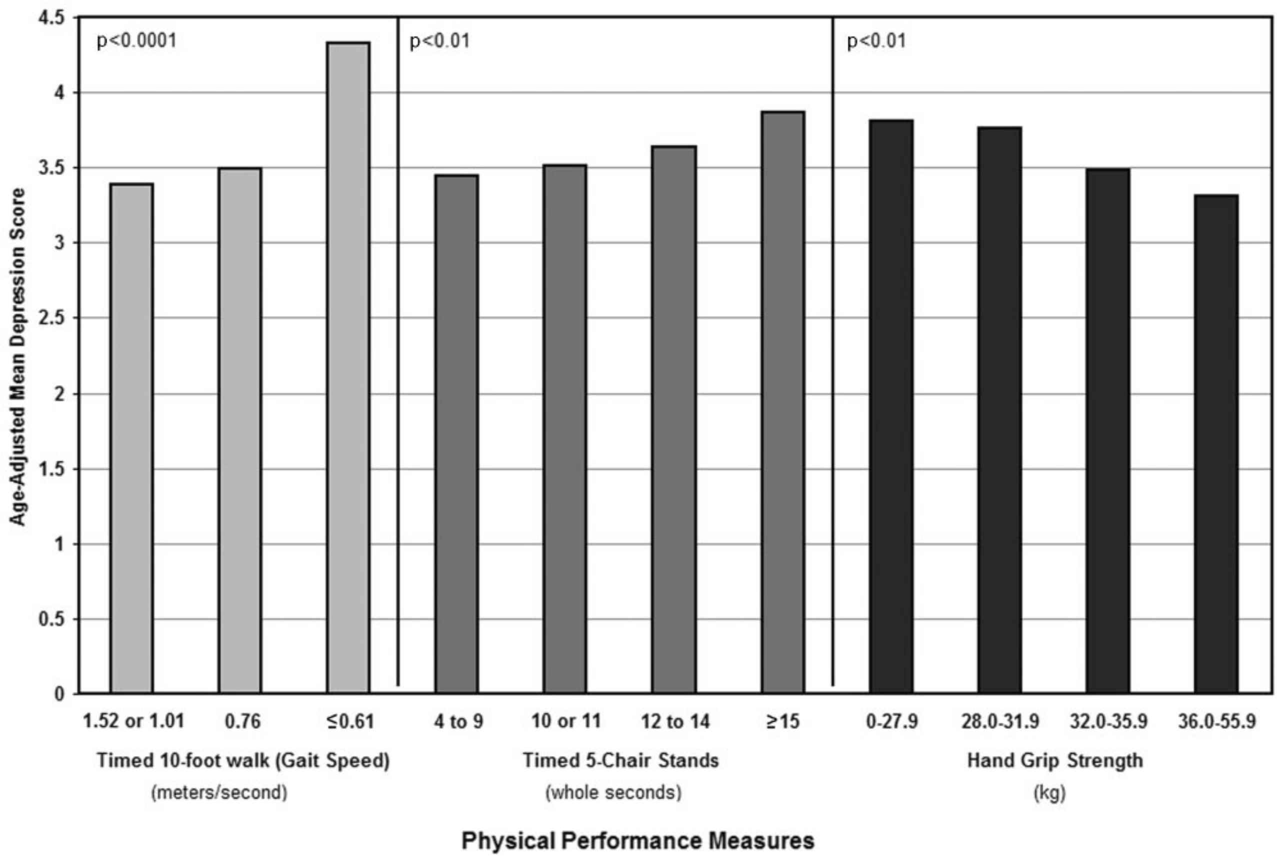
Means of depression score among the categorized groups, according to the type of physical performance, are shown in Figure 1. Participants with poorer performance showed higher depression scores in all types of physical performance. There was a clear and significant gradient between means of depression score and levels of each physical performance.

Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) according to categorized groups of lower- and upper-extremity performance for depressive symptoms are shown in Table 2. In model 1, in which we adjusted for age, OR was significantly lower in groups with higher performance compared with the lowest performance group (reference group) in all types of physical performance. In model 2, in which we adjusted for age, body mass index, marital status, physical activity index, and presence of chronic diseases (coronary heart disease, stroke, cancer, and diabetes), the groups with higher performance still exhibited significantly lower OR compared with the lowest performance group in all types of physical performance.

However, in model 3, in which we adjusted physical performance variables simultaneously (time to walk 10 feet, time to complete five chair stands, and handgrip strength) in addition to adjustment made in model 2, only the association of time to walk 10 feet with depressive symptoms remained significant. The fastest group, who walked 1.52 or 1.01 m/second, had an OR of 0.66 with 95% CI of 0.47–0.95, and the second group, who walked 0.76 m/second, had an OR of 0.68 and 95% CI of 0.48–0.98, respectively, compared with the slowest group, who walked slower than or equal to 0.61 m/second.

When we further excluded participants with arthritis in model 3, the association of gait speed with depression still remained significant (data not shown).

FIGURE 1. Physical Performance Measures and their Relation with Depressive Symptoms in Elderly Men



Participants with poorer physical performance had higher depression scores in all measures of physical function. Gait speed was the only independent correlate of depression when all physical performance measures were modeled simultaneously in multivariate models ($p < 0.05$).

DISCUSSION

This study showed that tests of both upper-extremity performance (handgrip strength) and lower-extremity performance (timed walk or gait speed and time to complete five chair stands) had significant inverse relations to depression in community-dwelling older men. These relations remained significant when examined after adjustment for multiple potential confounders such as body mass index, general level of physical activity (PAI), and chronic diseases. However, only the association of gait speed remained significant when all physical performance measures were included in a multivariate analysis. This suggests that gait speed, which is closely related to habitual walking,[26] may be an important correlate of depressive symptoms independent of general physical activity and upper extremity performance. Understanding more about this particular performance measure may help us better understand how lower-extremity performance is related to depression.

Strengths of this study include a large number of well-characterized subjects, a wide range of physical ability, repeated measures of gait speed, and experienced study personnel. A limitation of this study is its cross-sectional design, which did not allow us to differentiate whether depressive symptoms preceded slower gait speed or whether slower gait speed preceded depressive symptoms. On the other hand, the large number of subjects who participated in examination 4 of the Honolulu Heart Program

TABLE 2. Odds Ratios (ORs) and 95% Confidence Intervals (CIs) of Physical Performance Measures for Depressive Symptoms

Physical Performance Measures	Model 1[a] OR (95% CI)	Wald $\chi^2_{[1]}$	p	Model 2[a] OR (95% CI)	Wald $\chi^2_{[1]}$	p	Model 3[a] OR (95% CI)	Wald $\chi^2_{[1]}$	p
Walk 1[b] (2 or 3 seconds)	0.51 (0.37–0.70)	17.78	<0.0001	0.54 (0.39–0.75)	13.53	0.0002	0.66 (0.47–0.95)	5.09	0.0241
Walk 2 (4 seconds)	0.56 (0.40–0.78)	12.14	0.0005	0.61 (0.44–0.86)	8.15	0.0043	0.68 (0.48–0.98)	4.31	0.0379
Reference (≥5 seconds)	1.00			1.00			1.00		
Chair 1[c] (4–9 seconds)	0.63 (0.43–0.92)	5.78	0.0162	0.63 (0.43–0.93)	5.52	0.0188	0.72 (0.48–1.07)	2.61	0.1061
Chair 2 (10 or 11 seconds)	0.68 (0.46–1.00)	3.87	0.0492	0.69 (0.47–1.02)	3.52	0.0606	0.78 (0.52–1.16)	1.53	0.2159
Chair 3 (12–14 seconds)	0.73 (0.50–1.06)	2.79	0.0948	0.74 (0.51–1.09)	2.32	0.1278	0.81 (0.55–1.19)	1.13	0.2882
Reference (≥15 seconds)	1.00			1.00			1.00		
Grip 1[d]	0.62 (0.44–0.87)	7.67	0.0056	0.69 (0.49–0.98)	4.27	0.0389	0.80 (0.55–1.15)	1.45	0.2285
Grip 2	0.77 (0.55–1.08)	2.22	0.1359	0.89 (0.63–1.27)	0.39	0.531	1.03 (0.71–1.49)	0.02	0.8900
Grip 3	0.55 (0.38–0.80)	9.71	0.0018	0.63 (0.43–0.93)	5.30	0.0214	0.75 (0.50–1.14)	1.84	0.1751
Reference	1.00			1.00			1.00		

[a]Odds ratio (95% confidence interval), Wald chi-square ($\chi^2_{[df]}$), and p values are from the logistic regression models.

[b]Walk groups 1, 2, and reference are the time in whole seconds to walk 10 feet. These values correspond to 1.52 or 1.01, 0.76, and ≤0.61 meters/second, respectively.

[c]Chair groups 1, 2, 3, and reference are the time spent for five chair stands: 4–9, 10 or 11, 12–14, and ≥15 seconds, respectively.

[d]Grip groups 1, 2, 3, and reference are the kilograms of handgrip strength: 0–27.9, 28.0–31.9, 32.0–35.9, and 36.0–55.9 kg, respectively.

provided substantial statistical power to detect significant differences between study participants using a cross-sectional design and allowed for building several multivariate models in which we could evaluate the relative contribution of different performance measures to depression score.

Physical performance measures of upper-extremity function have been correlated with subsequent risk for disability, including disability resulting from depression.[15] Rantanen et al.[15] have shown that depressed mood is associated with declining handgrip strength, particularly in older men with low body weight. Handgrip strength is also positively correlated with lower-extremity strength in older persons with reported correlation coefficients between 0.47 and 0.51.[27,28] Handgrip strength also correlates with strength of other muscle groups and is thus a good indicator of overall strength.[29] Although a correlation between handgrip strength and depression was also found in our study, gait speed had a stronger relation to depressive symptoms and predicted this relation independent of handgrip strength. Handgrip strength was not an independent predictor of depression in a multivariate analysis that included lower-extremity performance measures.

Physical performance measures of lower-extremity function predict the onset of disability in those initially reported as disability-free.[30–32] In this study, gait speed appears to correlate better with depression than the other physical performance measures. Slower gait speed could indicate poorer overall mobility, which could increase risk for depression. In support of this, we found that participants with depressive symptoms had significantly shorter distance of daily walking than those without depression. Limitations in mobility affect almost one in four individuals aged 65 years or older and three-fourths of those living in nursing homes.[33,34] Mobility limitations are predictive of disability, institutionalization, and mortality.[30,31]

On the other hand, gait speed is closely linked with overall mobility and so may provide information that is more directly related to the potential benefits of mobility on depression. Penninx et al.[35] compared the effect of aerobic and resistance exercises on emotional and physical function among older persons with initially high or low depressive symptomatology. This study, involving 438 older participants with knee osteoarthritis, showed that aerobic exercise (a three-month facility-based walking program and a 15-month home-based walking program), but not resistance exercise, significantly lowered depression scores during an 18-month follow up. The antidepressive effect of aerobic exercise was found both for persons with initially high symptomatology and persons with low depressive symptomatology and was strongest for those who were the most compliant.

In support of this, McDermott[36] showed that greater numbers of depressive symptoms are associated with greater impairment in lower-extremity functioning in men and women with peripheral artery disease. Lamb[37] found a link between depression and reduced walking speed in the Women's Health and Aging Study and, according to a recent study by Abbott Laboratories,[26] timed walk also appears to predict subsequent risk for incident dementia, although walking distance was more predictive. A recent study by Hausdorff[38] suggests that walking is associated with higher-level cognitive resources, particularly executive function, rather than memory or general cognitive function. Rosano[39] found that gait speed was significantly associated with two measures of higher cognitive function, Mini-Mental Status Examination and the Digit Symbol Substitution Test, independent of demographic, weight, physical activity, and comorbid health conditions.

The value of walking tests as indicators of overall health, including psychologic health, appears to be increasingly apparent.[32,40] Lord et al. found that distance on the 6-minute walk test was related to several physiological, psychologic, and health measures. Of these, strength, balance, medication use, and age explained the largest proportion of variance in test performance. The authors concluded that rather than being merely a specific measure of cardiovascular exercise capacity, performance on this test may reflect a range of factors linked to overall mobility and physical functioning. Work by Guralnik[31,32] supports the value of timed walking as an indicator of overall physical function in which gait speed alone had important predictive ability for future physical disability. In this work, gait speed was as almost as predictive of subsequent disability as the EPESE short physical performance battery.

Our study suggests that gait speed, which appears to be a good indicator of overall mobility and physical function, has an important relation to depressive symptoms. This study found an independent and highly significant inverse relation between gait speed and depression. In addition, gait speed had the strongest relation to depression (in terms of odds ratio) in all statistical models and was the only performance-based measure of physical function to remain independent when all three physical performance measures were modeled together in multivariate analyses.

In conclusion, our findings suggest that clinicians should be alert to the potential of depression in patients with mobility limitations, because depression appears to be common in patients with functional impairment. Further prospective study is needed to determine the temporal relationship between lower-extremity performance and incident depressive symptoms in the elderly population. This study also highlights the need for a multidisciplinary approach to understanding the complex relation between disability and depression.[41] Better defining this relation may enhance the diagnosis and treatment of related syndromes such as frailty in older adults. This, in turn, may help contribute to more evidence-based practices in geriatric mental health care[42] and more effective use of community support services in older adults.[4]

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