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Incremental Value of Gait Speed in Predicting Prognosis of Older Adults With Heart Failure

Insights From the IMAGE-HF Study

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ABSTRACT

OBJECTIVES The aim of this study was to assess the relationship between gait speed and the risk for death and/or hospital admission in older patients with heart failure (HF).

BACKGROUND Gait speed is a reliable single marker of frailty in older people and can predict falls, disability, hospital admissions, and mortality.

METHODS In total, 331 community-living patients ≥70 years of age (mean age 78 ± 6 years, 43% women, mean ejection fraction 35 ± 11%, mean New York Heart Association functional class 2.7 ± 0.6) in stable condition and receiving optimized therapy for chronic HF were prospectively enrolled and followed for 1 year. Gait speed was measured at the usual pace over 4 m, and cutoffs were defined by tertiles: ≤0.65, 0.66 to 0.99, and ≥1.0 m/s.

RESULTS There was a significant association between gait speed tertiles and 1-year mortality: 38.3%, 21.9%, and 9.1% ($p < 0.001$), respectively. On multivariate analysis, gait speed was associated with a lower risk for all-cause death (hazard ratio: 0.62; 95% confidence interval: 0.43 to 0.88) independently of age, ejection fraction <20%, systolic blood pressure, anemia, and absence of beta-blocker therapy. Gait speed was also associated with a lower risk for hospitalization for HF and all-cause hospitalization. When gait speed was added to the multiparametric Cardiac and Comorbid Conditions Heart Failure risk score, it improved the accuracy of risk stratification for all-cause death (net reclassification improvement 0.49; 95% confidence interval: 0.26 to 0.73, $p < 0.001$) and HF admissions (net reclassification improvement 0.37; 95% confidence interval: 0.15 to 0.58; $p < 0.001$).

CONCLUSIONS Gait speed is independently associated with death, hospitalization for HF, and all-cause hospitalization and improves risk stratification in older patients with HF evaluated using the Cardiac and Comorbid Conditions Heart Failure score. Assessment of frailty using gait speed is simple and should be part of the clinical evaluation process. (J Am Coll Cardiol HF 2016;4:289–98) © 2016 by the American College of Cardiology Foundation.

Heart failure (HF) is a common condition in older patients. However, despite remarkable advances in diagnosis and therapy over the past decades, the prognosis of these patients remains poor, with high rates of hospitalization, readmission, and mortality (1,2). Thus, accurate prognostic stratification is essential for optimizing clinical management and treatment decision making (3).

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ABBREVIATIONS AND ACRONYMS

AUC = area under the curve

HF = heart failure

LVEF = left ventricular ejection fraction

MMSE = Mini-Mental State Examination

NRI = net reclassification improvement

3C-HF = Cardiac and Comorbid Conditions Heart Failure

The prognosis of older patients depends not only on cardiac diseases or comorbidities but also on geriatric conditions, such as disability, cognitive impairment, and frailty, as a consequence of their biological heterogeneity (4). Despite their strong associations with clinically remarkable outcomes, geriatric conditions have been rarely assessed in previous studies of HF (5,6); hence, they are not typically included in cardiovascular risk models (3).

Frailty is common in older people and is clinically recognized as a syndrome of loss of reserves that enhances vulnerability to stressors (e.g., concomitant acute illnesses, hospitalizations, medical procedures), thus increasing the risk for major events and disability in patients with or without HF. Because it reflects biological rather than chronological age, frailty may explain substantial heterogeneity in clinical outcomes within older patients (7). Gait speed testing has proved to be a reliable single marker of frailty. Decreased gait speed can predict adverse health-related events such as falls, disability, hospital admissions, and mortality in older people (8,9).

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We studied the prognostic value of gait speed by investigating its relationship with mortality and HF hospital admissions, as well as its incremental prognostic value when added to a multiparametric clinical score. In this study, we used the Cardiac and Comorbid Conditions Heart Failure (3C-HF) score (10) to predict all-cause mortality in patients with chronic HF. The variables included in the score are New York Heart Association functional class III or IV, left ventricular ejection fraction (LVEF) <20%, absence of beta-blocker therapy, absence of renin-angiotensin system inhibitor therapy, severe valve heart disease, atrial fibrillation, diabetes with micro- or macroangiopathy, renal dysfunction, anemia, hypertension, and older age. The choice of the 3C-HF score is justified by its high predictive performance and the presence of comorbidities in the variables included in the score; the latter are typically prevalent in older populations.

METHODS

STUDY DESIGN. The aim of the IMAGE-HF (Italian Multidimensional Assessment Group for Elderly With Heart Failure) registry was to define: 1) the clinical profile of older patients with HF; 2) the utility of a geriatric minimum dataset to improve clinical management of these patients with severe chronic cardiac syndromes; and 3) whether parameters of disability and/or frailty provide additional prognostic information to the traditional risk factors for death and/or hospitalization in these patients. The study was conducted at 7 hospital cardiology HF clinics across the country. We evaluated consecutive, clinically stable, community-living patients with HF 70 years of age or older with reduced or normal LVEFs and histories of at least 1 hospitalization for HF requiring intravenous diuretic, inotropic, and/or vasodilator therapy within 1 year of enrollment. The diagnosis was determined according to European Society of Cardiology guidelines (11). Patients were excluded if they had valvular heart disease requiring planned surgery, were active substance abusers, had conditions that were strongly associated with severely decreased walking speed (i.e., Parkinson's disease, dementia, severe osteoarthrosis or recent hip fracture, disabling stroke, and unstable angina), had severe psychiatric disease, required long-term intravenous inotropic therapy, were unwilling to provide informed consent, or were living in nursing homes or outside the areas served by the clinical sites. The enrollment period was January through December 2007. The study patients were followed from 2008 through 2009. The protocol was consistent with the principles of the Declaration of Helsinki, and all participants gave their informed consent to the anonymous use of data for their care and research purposes. Databases for clinical use were authorized at each center.

ASSESSMENT AND FOLLOW-UP. All patients underwent thorough histories and complete physical and echocardiographic examinations, routine blood tests, and standard electrocardiography. Renal function was estimated using the Chronic Kidney Disease Epidemiology Collaboration (12) equation. LVEF was defined preserved if ≥45% and reduced if <45%. A comprehensive geriatric assessment was performed using previously validated instruments that explored 6 areas: socioeconomic factors (including years of education and living arrangement); ability to perform basic activities of daily living and instrumental activities of daily living (13,14); global cognitive function, measured with the Mini-Mental State Examination (MMSE) (15); and depressive symptoms, measured with the 15-item Geriatric Depression Scale (16). Patients were asked to walk along a 4-m corridor at their usual speed without running. Each patient started in standing position 1 m before the start line, so that gait speed did not include any acceleration time. Patients first executed dry runs to check whether they understood the instructions before we measured the actual speed. They were permitted to use walking aids such as canes or walkers. A standard digital stopwatch was used to time the travel between the first footstep after the 0-m line and the first footstep after the 4-m line (17). Gait speed was defined as the ratio between distance and time measured with a chronometer, and cutoffs were defined by tertiles. Cognitive impairment was defined by an MMSE score ≤24. Anemia was defined as hemoglobin <12 g/dl. One-year mortality risk was evaluated according to the classification deriving by the 3C-HF prognostic score (10).

All patients were followed for 1 year. Primary endpoints were all-cause mortality and HF and all-cause hospitalization. Events were collected using phone calls, discharge reports, hospital and administrative databases, and death certificates, and they were evaluated by a central endpoint committee composed of 3 cardiologists blinded to geriatric assessment results.

STATISTICAL ANALYSIS. Normally distributed continuous variables were compared using analysis of variance, with Bonferroni correction as appropriate, and are expressed as mean ± SD. Categorical variables were compared using chi-square or Fisher exact tests and are expressed as counts and percentages. Patients were classified in 3 groups according to tertiles of gait speed: "slow walkers" (gait speed ≤0.65 m/s), "intermediate walkers" (gait speed 0.66 to 0.99 m/s), and "fast walkers" (gait speed ≥1.0 m/s).

Logistic regression analysis was performed to identify factors potentially related to gait speed, comparing the lowest tertiles (slow and intermediate walkers) with the highest tertile (fast walkers). Models included all covariates strongly associated with gait speed (sex, education level, MMSE score, body mass index, height). The event-free survival of patients was evaluated using the Kaplan-Meier method and compared by means of the log-rank test.

The additive effect of different variables on event-free survival was investigated using the Cox proportional hazards regression model. Variables that showed statistically significant effects in univariate analyses were entered in a multivariate Cox proportional hazards model using stepwise selection to obtain the final model. To evaluate the incremental value of gait speed when added to 3C-HF score, the score was considered either grouped in 8 increasing risk ranks according to Senni et al. (10) or as a continuous variable.

The increase in predictive accuracy for all-cause death and HF readmission within 12 months was measured with the area under the curve (AUC) (18), and receiver-operating characteristic curves were compared by means of the De Long test. For these analyses, gait speed and 3C-HF score were treated as continuous variables. The increase in predictive accuracy obtained by adding gait speed to 3C-HF score was assessed with the net reclassification improvement (NRI), in its continuous version, that is, evaluating increases in the predicted probabilities of events in the group that experienced the events (NRI for events) and decreases in the group that did not (NRI for nonevents) and summing these 2 components (19).

A p value <0.05 was considered to indicate statistical significance. Analyses were performed using SPSS version 19.0 (SPSS, Inc., Chicago, Illinois) and R version 3.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The study sample consisted of 331 consecutive patients 70 years of age or older. The mean age was 78 ± 6 years, 43% were women, and 33.5% were octogenarians or older. The mean New York Heart Association functional class was 2.7 ± 0.6, and the mean LVEF was 35 ± 11%. Preserved LVEFs were observed in 66 patients (19.9%). Anemia was found in 131 (39.5%), estimated glomerular filtration rates <60 ml/min/1.73 m^2 in 282 (85.2%), and chronic obstructive pulmonary disease in 115 (34.7%). All patients were on optimized HF therapy according to the high prevalence of comorbidities such as chronic obstructive pulmonary disease and renal failure (beta-blockers in 55%, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers in 87%) and were in stable clinical condition. The mean additive 3C-HF score was 19.7 ± 12.5 points.

CLINICAL CORRELATES OF GAIT SPEED. The mean gait speed was 0.74 ± 0.23 m/s. Severely reduced gait speeds (≤0.65 m/s) were measured in 115 patients (34.7%). **Tables 1 and 2** show the baseline clinical characteristics and comprehensive assessment of the study population according to gait speed tertiles, respectively. **Figure 1** shows the correlation plot of gait speed and 3C-HF score. There was no significant correlation between gait speed and the clinical risk score, suggesting that gait speed represents a distinct domain that has not been considered in the risk score. On multivariate logistic regression analysis, variables independently associated to low gait speed were age, atrial fibrillation, MMSE score ≤24, anemia, Geriatric Depression Scale score >6, and LVEF (**Table 3**). Preserved LVEF was more prevalent among very slow walkers (**Table 2**).

OUTCOMES. No patients were lost to follow-up. During 1-year follow-up, 80 patients died (24.2%), 125 (37.8%) had at least 1 hospitalization for HF, and

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TABLE 1 Clinical and Instrumental Variables at Entry According to Gait Speed Tertiles

	All (n = 331)	Tertile 1 (≤0.65 m/s) (n = 115 [34.7%])	Tertile 2 (0.66–0.99 m/s) (n = 128 [38.4%])	Tertile 3 (≥1.0 m/s) (n = 88 [26.6%])	p Value
Age (yrs)	78 ± 5.2	80.2 ± 5.6	77.1 ± 4.7	76.4 ± 48	<0.001
Male	191 (57.7)	56 (48.7)	78 (60.9)	57 (64.8)	0.04
BMI (kg/m^2)	24.4 ± 4	24 ± 4	24.6 ± 4	24.6 ± 3.7	NS
Height (m)	1.65 ± 0.1	1.63 ± 0.1	1.65 ± 0.1	1.67 ± 0.1	0.003
Heart rate (beats/min)	73.3 ± 14	73.6 ± 13	74.9 ± 15	70.6 ± 11.9	0.09
SBP (mm Hg)	128 ± 20	129 ± 20	125 ± 20	132 ± 17	0.06
NYHA functional class III/IV	170 (51.4)	59 (51.3)	74 (57.8)	37 (42)	NS
HF etiology					NS
Ischemic	235 (71)	82 (71.3)	92 (71.9)	61 (69.3)	
Nonischemic	96 (29)	33 (28.7)	36 (28.1)	27 (30.7)	
Permanent atrial fibrillation	98 (29.6)	38 (33)	49 (38.3)	11 (12.5)	<0.001
History of diabetes	87 (26.3)	30 (26.1)	37 (28.9)	20 (22.7)	NS
Hypertension	213 (64.4)	74 (64.3)	81 (63.3)	58 (65.9)	NS
COPD	115 (34.7)	34 (29.6)	54 (42.2)	27 (30.7)	NS
Moderate to severe valvular disease	57 (17.2)	21 (18.3)	21 (16.4)	15 (17)	NS
HBG (g/dl)	12.4 ± 1.7	11.9 ± 1.8	12.4 ± 1.6	13 ± 1.5	<0.001
Anemia (HBG <12 g/dl)	81 (24.5)	38 (33)	36 (28)	7 (8.5)	<0.001
History of cancer	19 (5.7)	11 (9.6)	5 (3.9)	3 (3.4)	NS
Serum creatinine (mg/dl)	1.57 ± 0.83	1.67 ± 0.86	1.59 ± 0.94	1.45 ± 0.58	NS
eGFR (ml/min/1.73 m^2)	44.7 ± 18	41.4 ± 36	45.2 ± 17	48.3 ± 1.76	0.022
eGFR <30 ml/min/1.73 m^2	77 (23.3)	34 (29.6)	30 (23.4)	13 (16.9)	0.047
LVEF (%)	34.6 ± 11.6	36.4 ± 12.7	32.6 ± 11	35.3 ± 9.8	0.03
LVEF >45%	66 (19.9)	32 (27.8)	21 (16.4)	13 (14.8)	0.031
Prognostic additive 3C-HF score	19.7 ± 12.5	21.1 ± 12.1	21.9 ± 12.2	14.7 ± 12.6	<0.001
Oral treatments					
Beta-blockers	181 (54.7)	57 (49.6)	66 (51.6)	58 (65.9)	0.04
ACE inhibitors/ARBs	292 (88.2)	102 (88.7)	111 (86.7)	79 (89.8)	NS
ICD	16 (4.8)	4 (3.5)	8 (6.3)	4 (4.5)	NS
CRT	15 (4.5)	5 (4.3)	7 (5.5)	3 (3.4)	NS

Values are mean ± SD or n (%).

ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker; BMI = body mass index; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; CRT = cardiac resynchronization therapy; eGFR = estimated glomerular filtration rate; HBG = hemoglobin; HF = heart failure; ICD = implantable cardioverter-defibrillator; LVEF = left ventricular ejection fraction; NS = not significant; NYHA = New York Heart Association; SBP = systolic blood pressure; 3C-HF = Cardiac and Comorbid Conditions Heart Failure.

TABLE 2 Comprehensive Geriatric Assessment Variables According to Gait Speed

	All (n = 331)	Tertile 1 (≤0.65 m/s) (n = 115 [34.7%])	Tertile 2 (0.66–0.99 m/s) (n = 128 [38.4%])	Tertile 3 (≥1.0 m/s) (n = 88 [26.6%])	p Value
Education <5 yrs	204 (61.6)	77 (67)	82 (64.1)	45 (51.1)	0.06
Living alone	80 (24.2)	29 (25.2)	33 (25.8)	18 (20.5)	NS
Gait speed (m/s)	0.74 ± 0.23	0.51 ± 0.48	0.73 ± 0.6	1.06 ± 0.13	<0.001
IADL mean score	4.9 ± 2	4.2 ± 2	4.6 ± 2	6.15 ± 1	<0.001
Transportation IADL dependence	129 (39)	64 (55.7)	53 (41.4)	12 (13.6)	<0.001
Drug IADL dependence	65 (19.6)	34 (29.6)	29 (22.7)	2 (3.3)	<0.001
BADL mean score	6.4 ± 1	5.9 ± 2	6.4 ± 1	6.8 ± 0.4	<0.001
Incontinence	22 (6.6)	10 (8.7)	10 (7.8)	2 (2.3)	NS
MMSE total score	25.26 ± 4.5	23.8 ± 4.9	24.8 ± 4.6	27.7 ± 2.4	<0.001
MMSE <24	123 (37.2)	61 (53)	53 (41.4)	9 (10.2)	<0.001
GDS-15 total score	6.3 ± 3.3	6.8 ± 3.4	6.5 ± 3.5	5.1 ± 2.7	<0.001
GDS-15 >6	170 (51.4)	66 (57.4)	73 (57)	31 (35.2)	0.002

Values are n (%) or mean ± SD.

BADL = basic activities of daily living; GDS-15 = 15-item Geriatric Depression Scale; IADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination; Other abbreviations as in Table 1.

198 (59.8) had at least 1 all-cause hospitalization. There were significant associations between gait speed and 1-year mortality (38.3%, 21.9%, and 9.1% in the lowest, intermediate, and highest tertiles, respectively, $p < 0.001$) and between gait speed and hospitalization for HF (48.7%, 36.7%, and 25%, respectively, $p = 0.002$) and all-cause hospitalization (71.3%, 58.6%, and 26.6%, respectively, $p = 0.002$). On survival analysis, **Figure 2** shows the cumulative risk across tertiles of gait speed in all-cause death (log-rank test $p < 0.001$) and HF (log-rank test $p < 0.001$) and all-cause hospitalization (log rank test $p = 0.002$).

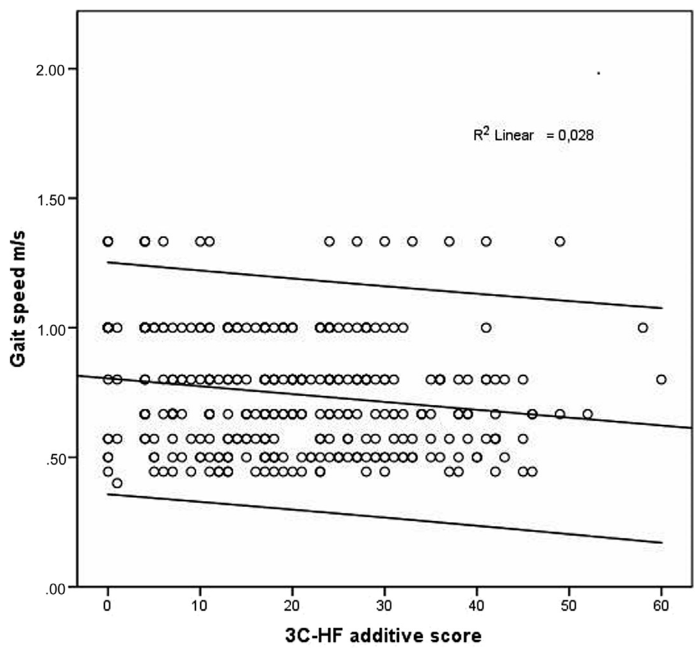
On multivariate analysis, slow walkers had an increased risk for death compared with fast walkers (**Table 4**); other independent predictors of 1-year all-cause mortality were age, lower systolic blood pressure, LVEF <20%, anemia, New York Heart Association class III or IV, and absence of beta-blocker therapy. Gait speed was also an independent predictor of hospitalization for HF and all-cause hospitalization (**Table 4**).

The incremental value of gait speed when added to 3C-HF score was also assessed. **Figure 3** shows the reclassification of mortality risk when tertiles of gait speed were added to 3C-HF additive score ranks. Among the subgroup of 3C-HF score patients at highest risk (more than 31 points), slow walkers presented a 4.75-fold increase in mortality compared with fast walkers. In the lowest risk group (<11 points), the increase was a 6.4-fold. When added to 3C-HF score, gait speed significantly improved the accuracy of risk stratification for all-cause death (AUC increase from 0.71 to 0.76, De Long test $p = 0.02$) and nonsignificantly for HF admissions (AUC increase from 0.68 to 0.70, $p = 0.12$) and for all-cause death and/or HF admissions (AUC increase from 0.70 to 0.72, $p = 0.10$) (**Figure 4**). Reclassification, assessed with NRI, showed a significant increase in predictive accuracy by adding gait speed to 3C-HF score to predict all-cause death within 12 months as well as HF hospitalizations and all-cause death and/or HF hospitalizations: respectively, NRI = 0.49 (95% confidence interval: 0.26 to 0.73; $p < 0.001$), NRI = 0.37 (95% confidence interval: 0.15 to 0.58; $p < 0.001$), and NRI = 0.43 (95% confidence interval: 0.22 to 0.64; $p < 0.0001$).

DISCUSSION

As the population ages, HF is becoming increasingly common, with a high burden of disability, morbidity, and mortality. In daily practice, prognostic stratification of older patients with HF allows the selection of subjects with different risks for clinical adverse events, to identify predictors of survival and to optimize management. To accurately guide clinical decision making, risk models should be appropriate for populations representative of those cared for in clinical practice, including patients with advanced age, multiple chronic conditions, poor quality of life, and frailty. Traditional cardiovascular risk models have usually been developed using datasets derived from

FIGURE 1 Correlation Plot of Gait Speed and Mini-Mental State Examination or Cardiac and Comorbid Conditions Heart Failure Score



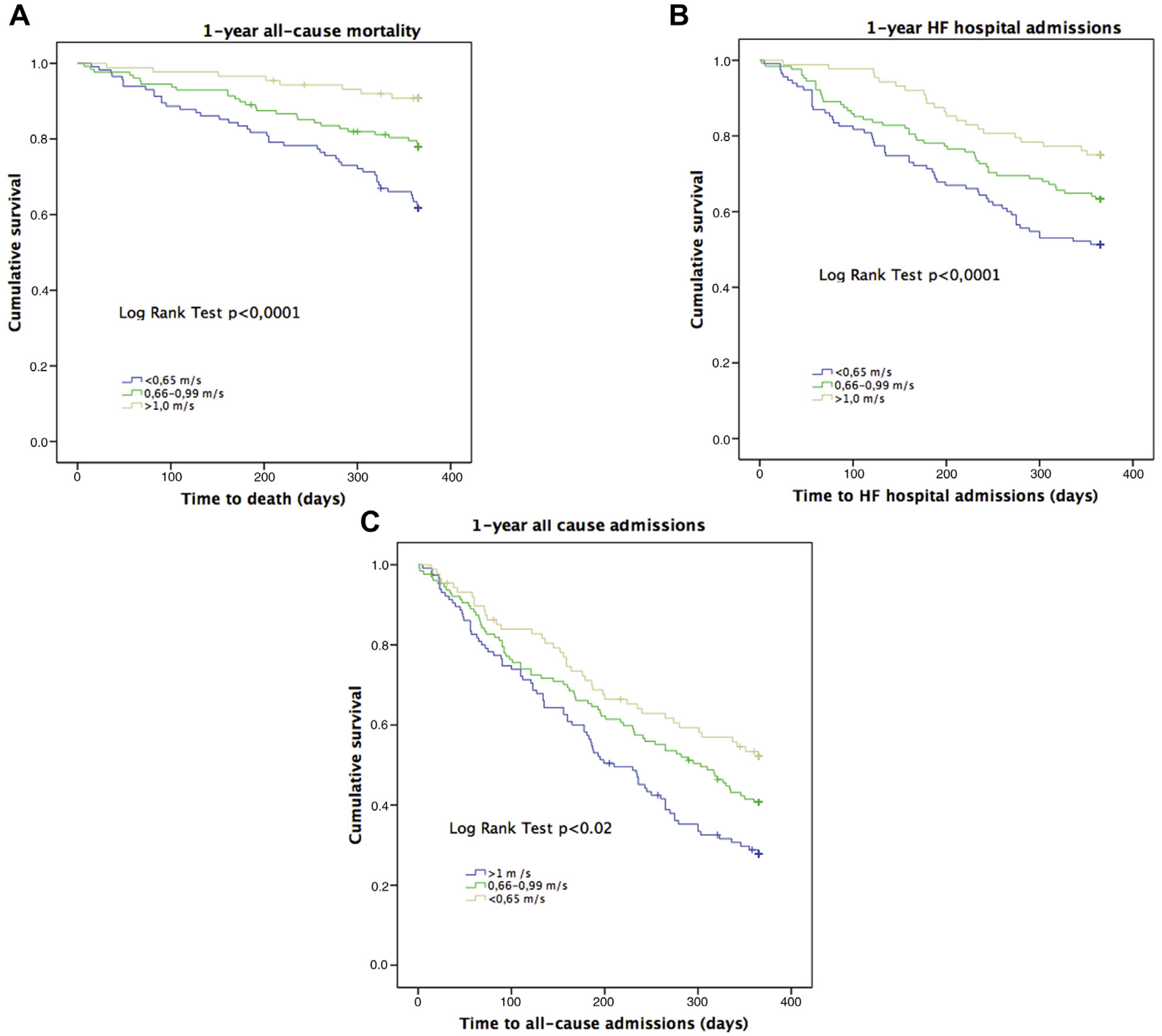
There was no significant correlation between gait speed and the clinical risk score, suggesting that gait speed represents a distinct domain that was not considered in the prognostic Cardiac and Comorbid Conditions Heart Failure (3C-HF) score.

TABLE 3 Multivariate Analysis (Logistic Regression): Variables Associated With Gait Speed (Lowest Tertiles Versus Highest Tertile)

		95% CI		
	OR	Lower	Upper	p Value
Age	1.075	1.015	1.140	0.014
LVEF	0.975	0.950	1.000	0.048
Permanent atrial fibrillation	4.068	1.940	8.532	<0.001
MMSE score <24	9.725	2.248	42.065	0.002
GDS-15 score <6	1.807	1.032	3.163	0.038
Anemia (hemoglobin <12 vs. ≥12 g/dl)	2.096	1.148	3.824	0.016

CI = confidence interval; OR = odds ratio; other abbreviations as in **Tables 1 and 2**.

FIGURE 2 Kaplan-Meier Curves for All-Cause Mortality, Heart Failure Hospitalizations, and All-Cause Hospitalizations, According to Gait Speed Tertiles (≤0.65, 0.66 to 0.99, and ≥1.0 m/s)



(A) All-cause mortality; **(B)** heart failure (HF) hospitalizations; and **(C)** all-cause hospitalizations. Patients in the lowest tertile had significantly poorer survival and more HF and all-cause hospital admissions than those in the higher ones.

younger populations and selected older patients with few comorbidities and geriatric syndromes (3). Because chronic HF perturbs skeletal muscle and body composition (20), giving rise to the phenotype of "cardiac cachexia" in extreme cases, it is not surprising that a large proportion of these patients exhibit frailty traits. Gait speed has been found to be a robust component of frailty syndrome (7-9,17).

The results of this study confirm that a significant proportion of patients with HF have impairments in gait speed and that slow gait speed is independently associated with worse clinical outcomes. In our study, nearly 35% of patients showed severely reduced gait speeds that were significantly associated with an increased 1-year event rate, independent of conventional HF prognostic factors. This finding is in agreement with those of previous studies carried out in different clinical settings, as well as in the community, demonstrating that slow gait speed and frailty scores are associated with disability, death, and increased hospitalization (9,21–25). Lo et al. (22) also recently demonstrated that slow gait speed (<0.8 m/s) and impairments in instrumental activities of daily living were independently associated with mortality.

It may be hypothesized that slow walkers are at higher risk for hospital readmission because they also present impaired cognitive functions, depressive symptoms, and dependence for basic and instrumental activities of daily living (namely, regarding the use of transportation and medications) (24,25). Such conditions do significantly influence their self-care capabilities (**Table 2**).

Besides confirming the association with mortality and hospitalizations, this is the first study to test the incremental value of gait speed in predicting prognosis in older patients with HF in combination with a validated clinical risk score. When added to the 3C-HF score, indeed, gait speed improved its prognostic accuracy, allowing us to reclassify patients in more appropriate risk categories (**Figure 3**), possibly because it adds key parameters not previously considered. A similar result was reported in older candidates for cardiac surgery by Afilalo et al. (26).

Although methodological issues are still unresolved (27,28), gait speed can be reliably assessed in a few minutes by nonprofessional staff members using only a 4-m walkway and a stopwatch (17); it is inexpensive and relatively simple to measure compared with other more time-consuming, multiparametric instruments for frailty and prognosis assessment. Moreover, some of these batteries also include markers of disability (defined as difficulty or dependency in activities of daily living), erroneously identifying disability with frailty, which is considered a distinct entity (29). The 4-m distance has been adopted by large registries and is a good balance between allowing patients to achieve a steady walking speed and not eliciting symptoms. The short distance and usual pace are well below typical HF cardiopulmonary limitations, making the focus of this test different from a typical stress test or 6-min walk test (30).

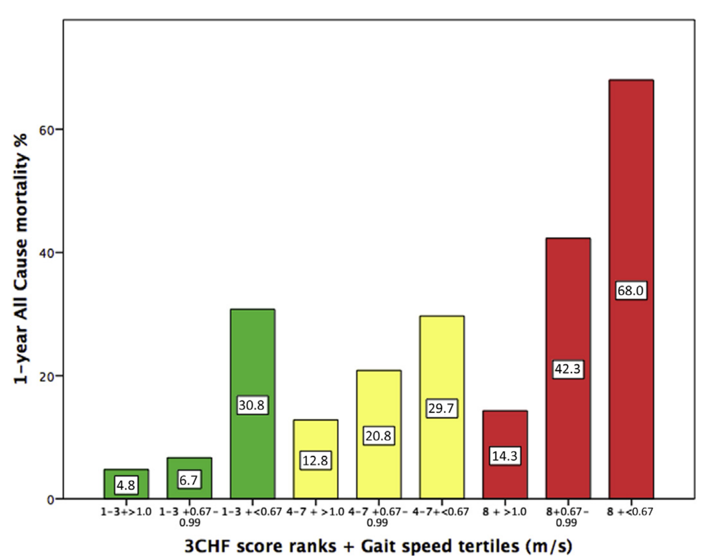
How may gait speed be used in cardiology clinical practice? First, an accurate assessment of the individual risk for adverse outcomes may allow tailored therapy and informed shared decision making, but more studies are needed on this issue to achieve better clarity regarding cost-effective and patient-centered options. Second, early detection of frailty may potentially lead to interventions aimed at preventing or reversing the development of frailty, such as regular physical exercise and balanced nutrition. According to our results, we can speculate that frail patients with HF may be enrolled in long-term management programs that incorporate geriatric assessment, HF clinics, and exercise, aimed at the prevention of functional decline and clinical

TABLE 4 Multivariable Regression Analyses (Cox Models)

	HR	95% CI Lower	95% CI Upper	p Value
All-cause mortality at 1-yr follow-up				
Age	1.049	1.005	1.095	0.029
SBP	0.980	0.980	0.993	0.020
No beta-blocker therapy	1.992	1.242	3.194	0.004
NYHA class III/IV (yes vs. no)	2.038	1.224	3.393	0.006
LVEF <20% (yes vs. no)	2.419	1.431	4.087	0.001
Gait speed (tertiles)	0.620	0.434	0.884	0.008
Anemia (hemoglobin <12 vs. ≥12 g/dl)	2.359	1.456	3.824	<0.001
Hospital admissions for heart failure at 1-yr follow-up				
No beta-blocker	1.760	1.225	2.530	0.002
NYHA III/IV	2.127	1.455	3.109	<0.001
eGFR <30 ml/min/1.73 m^2	1.605	1.098	2.346	0.015
Gait speed (tertiles)	0.697	0.547	0.899	0.004
All-cause hospital admissions at 1-yr follow-up				
Gait speed (tertiles)	0.741	0.613	0.895	0.002
eGFR <30 ml/min/1.73 m^2	1.455	1.059	1.997	0.021
NYHA class III/IV	1.422	1.067	1.894	0.016

HR = hazard ratio; other abbreviations as in **Tables 1 to 3**.

FIGURE 3 Reclassification of Mortality Risk When Tertiles of Gait Speed Were Added to Cardiac and Comorbid Conditions Heart Failure Score Ranks



Among the patients at highest risk (Cardiac and Comorbid Conditions Heart Failure [3C-HF] score more than 31 points), slow walkers had a 4.75-fold increase in mortality compared with fast walkers. In the group at lowest risk (<11 points), there was a 6.4-fold increase in risk for death in slow walkers.

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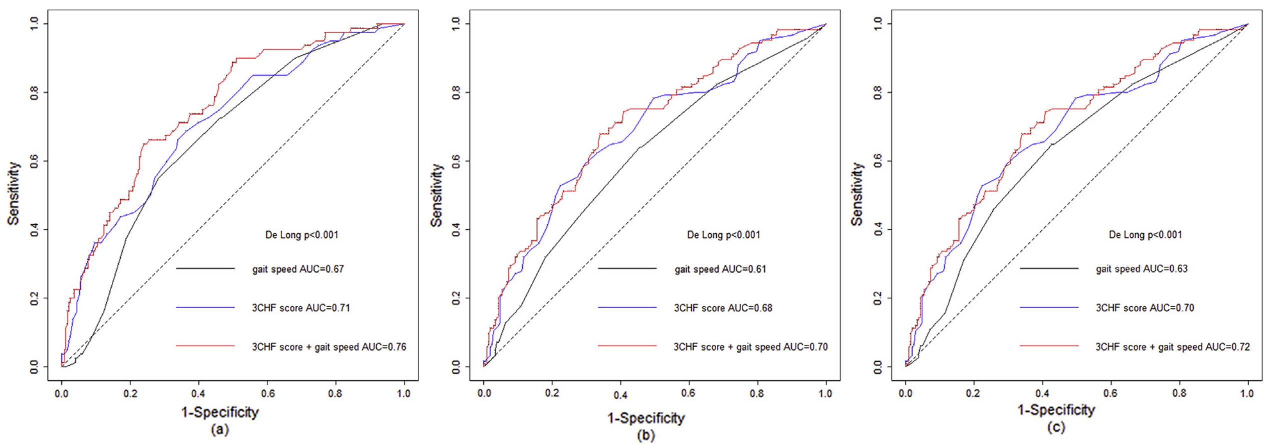
FIGURE 4 **Receiver-Operating Characteristic Curves for Gait Speed and Cardiac and Comorbid Conditions Heart Failure Score Alone and Gait Speed Added to Cardiac and Comorbid Conditions Heart Failure Score, as Continuous Variables**



Gait speed significantly improved the accuracy of risk stratification for all-cause death (left: area under the curve [AUC] increase from 0.71 to 0.76, De Long test $p = 0.02$) and nonsignificantly for HF admissions (AUC increase from 0.68 to 0.70, $p = 0.12$) and for all-cause death and/or HF admissions (AUC increase from 0.70 to 0.72, $p = 0.10$).

events (31-34). However, it has yet to be determined whether targeting frailty with interventions may actually improve patient-centered and clinical outcomes. Thus, the optimal design of these interventions and their impact on outcomes is still an area of investigation (35-38).

STRENGTHS AND LIMITATIONS OF THE STUDY. The strengths of the present study lie in the accuracy of the clinical, multidimensional, and instrumental evaluation; the clinical and hemodynamic stability of the patients at the time of assessment; the optimization of evidence-based treatments; and the completeness of follow-up. However, some limitations do exist. First, only subjects attending the HF clinics were evaluated, possibly excluding frailer patients; thus, the generalizability of our results to the whole population of older patients with HF may be limited, although the complexity of clinical conditions and the incidence of major events during follow-up suggest a high-risk profile for our patients. Second, frailty is a field of ongoing research and debate, and there is currently a lack of consensus on methods for measuring it. In contrast to multi-item scales, individual markers of frailty such as gait speed might be a means of screening; gait speed has been advocated as a single-item measure of frailty that often outperforms more elaborate and time-consuming scales and has been adopted in large registries and studies (7). We assessed usual, instead of fast, gait speed, assuming that fast walks do not have an advantage in survival prediction over usual-pace walks (39). We also used gait speed instead of the more complete Short Physical Performance Battery (40) because gait speed alone was equivalent or superior in some studies (39,41,42). Finally, the aforementioned tools reflect the clinical phenotype of frailty; alternatively, frailty has been measured in various indexes by counting accumulated deficits across multiple domains, such as the Canadian Study of Health and Aging Clinical Frailty Scale (43). However, the International Academy on Nutrition and Aging Frailty Task Force favored the clinical phenotype approach, stating that comorbidities and disabilities should be disentangled from frailty (44).

CONCLUSIONS

Gait speed, in combination with a validated clinical risk score, improves prognosis prediction in older patients with HF. Frailty assessment using gait speed is simple and inexpensive and suggests new strategies for intervention. Its measurement should be incorporated in the routine clinical evaluation of older patients with HF (7,45,46).

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PERSPECTIVES

COMPETENCY IN MEDICAL KNOWLEDGE: As the population ages, HF is becoming increasingly common, with a high burden of disability, morbidity, and mortality. A significant proportion of patients with HF are frail and have impairments in gait speed; slow gait speed is independently associated with worse clinical outcomes.

TRANSLATIONAL OUTLOOK: In times of financial restraints affecting national health services, an accurate assessment of the individual risk for adverse outcomes focused on a tailored therapy and informed shared decision making is warranted. Early detection of frailty in patients with HF may lead to interventions to prevent or reverse the development of frailty itself, such as regular physical exercise and balanced nutrition, to improve not only function and quality of life but also survival, if possible. Frailty assessment using gait speed is simple and inexpensive, and its measurement could be easily incorporated in the routine clinical evaluation of older patients with HF.

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KEY WORDS elderly, gait speed, heart failure, hospitalization, prognosis

APPENDIX For a list of the IMAGE-HF study investigators, please see the online version of this article.